Soy Protein and Formulated Meat Products

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Henk W. Hoogenkamp

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About the Author

Henk W. Hoogenkamp was born and raised in The Netherlands. Throughout his professional life he has been a proponent of transferring protein technology systems to the world's food processing companies. He has made major contributions to both food and meat processing, including his pioneering work in the development of sport nutrition protein supplements, in particular his groundbreaking research for milk protein and soy protein.

Henk's main interest focuses on developing new market opportunities, and he has been uniquely able to transfer his own ideas into innovative and creative solutions: for example, his success in making soy protein a strategic ingredient in menu meat and food items for the global powerhouses of franchised food restaurants. Despite the early scepticism of some US-dominated franchised fast food companies, his pioneering spirit enabled huge and lasting commercial success for the soy industry.

This book is written in Henk's unique and eloquent style, although it is not easy to translate his visionary view of technology into laymen's language. This is further complicated by the fact that English is his second language. Yet, this 'handicap' has proved to be a blessing, as his individual style of writing has become much valued by loyal readers all over the world.

On behalf of the world's leading dairy company DMV International (Campina BV) and soy protein company Solae LLC (a DuPont/Bunge venture), Hoogenkamp has written eight books, two film scripts and more than 400 articles. These books and articles have been published in more than ten languages. Henk Hoogenkamp is Senior Director Strategic Technology at Solae LLC.

The book truly is the culmination of a lifetime of research, travel and writing that has given Henk such a profound understanding of how the world's relationship with food and nutrition is evolving.

Preface

Unlocking the potential of Nature to improve quality of life is the single greatest challenge for soy protein nutrition. The functional soy protein industry is committed to product choices and marketing practices that will encourage healthy lifestyles, reduce the environmental burden and make it easier for consumers to eat and live better.

The real challenge for the soy industry is to find new and attractive ways to get more people to consume soy foods. To do that requires developing great-tasting, affordable foods, while at the same time educating the public about soy protein's nutritional and health benefits.

That effort encompasses four key areas: nutrition, marketing, consumer education and public advocacy. Although some focus areas are fully developed, this will be a long-term process and other components will require further fine-tuning. Soy protein suppliers – together with the larger food industry – must work together to help consumers develop healthy eating patterns. Many consumers do not truly understand healthy eating and are fed up with constantly hearing about dietary negative foods they are supposed to avoid. Instead, food companies and health authorities should provide information about positive food choices.

Is the meat, food and beverage industry part of the problem or part of the solution? Leading ingredient and food companies try very hard to be involved in both playing fields. These companies manufacture and sell ingredients and food brands which first entice the consumer to indulge and then offer products to shed accumulated weight. What people eat is ultimately a matter of personal choice. However, the food industry should at least try to make it an educated choice.

In Asian countries such as China, Japan, Thailand and Indonesia, even though the traditional cultures have featured soy foods for thousands of years, contemporary consumption of soy-based foods is generally decreasing as incomes foster a switch to processed meat and poultry foods. The latter is a rather strange observation, because in Western countries the opposite pattern is in vogue. There, high levels of meat consumption are now being modified, thanks to such soy protein alternatives as non-dairy soy milk and soy-based meat analogues.

At present, the key constraint that limits soy protein applications in these foods is soy's characteristic flavour, known as 'beany' or 'greeny'. Of less importance are the challenges of soy protein's unfamiliar texture and lack of certain functional properties. However, food scientists are working hard to overcome these constraints with novel methods such as enzyme and fermentation technology, extraction and separation and extrusion and heat treatments.

Going forward, traditional plant breeding and biotechnology will provide additional agronomic and quality improvement for tomorrow's soy protein, such as the development of high oleic acid soybean oil, which would offer premium nutritional value plus oxidative stability, and 'designer' soy proteins suited for specific food formulation applications.

Many people in Western countries had preconceived, and very negative, opinions of soy-based foods, a bias that kept people from sampling soy foods. Even today, if they try an innovative new soy food, many consumers are looking for reasons to condemn it. However, the tide is changing rapidly – especially with young women aged 18–30, who do not have an inflexible eating pattern and are eager to incorporate newer, healthier dietary choices.

That is where soy proteins play a key role. Today's soy protein ingredients offer a broad spectrum of high-performance functionality, as well as superior nutritive quality. The expertise surrounding soy protein manufacturing and marketing will be greatly enhanced by soy supplier companies that maintain a global presence. A core component in the strategies of such companies involves developing global leadership in integrating foods and ingredients to play a vital role in meeting consumers' nutritional and sensory expectations.

Likewise, meat, food and beverage processors must meet the challenge of creating affordable and great-tasting products without compromising quality or eating satisfaction. For many such processors, soy protein is the logical answer. No other protein source offers a better balance between economics and functionality, and taste and nutrition.

The major objective of *Soy Protein and Formulated Meat Products* was to write an authoritative textbook reviewing a broad area of recent advancements in meat processing technology coupled with the enormous complexity of changes in market dynamics. The book is written in a style which is comprehensible to both graduate students and professional food technologists with a good understanding of food science, but little specialized knowledge of application technologies of soy protein in general and processed formulated meat products in particular. The book also contains chapters discussing environmental changes and health-related diseases as a prelude to bringing these topics to the attention of non-technology skilled marketing specialists in a clear and concise manner.

Soy Protein and Formulated Meat Products combines the best of old and new. This publication reflects an extensive review of both proven and emerging soy protein technology in processed meat and lifestyle foods. The book includes basic guidelines on how to value the role of soy protein as a nutritive ingredient as well as a sound technology-driven solution for often complex meat formulations.

While this book does not eliminate the need for verifying the many formulations that are discussed, it does provide a better basis for the reader to jump-start a development project of a specific product. This book is written with the reader in mind and much effort has been given to include the most recent technological innovations. However, the book cannot guarantee that the formulations will work in every case, nor will the author accept responsibility for any problems that may develop from following its guidelines. This book only serves as a guide and it is obvious that common sense and good judgement are also needed.

The information contained herein is, to the best of our knowledge, accurate. The formulae and processing instructions and all other descriptions made are intended only as a source of information. No warranties, expressed or implied, are made. On the basis of this information, it is suggested the formulae should be evaluated on a small scale prior to full-scale production. The information contained herein should not be construed as permission for violation of trademarks or patent rights.

Henk W. Hoogenkamp

Foreword

In a world often dominated by threats (and acts) of terrorism, as well as a continuing flood of catastrophes – both real and imagined – the fundamental issues underpinning the crises that seem to preoccupy modern media are often not fully appreciated.

Such is the case with the challenge of feeding the 6 billion-plus inhabitants of Earth, not to mention the additional billions expected to swell the world's population in a mere two or three generations hence.

Yet providing sufficient food – and proper nutrition – globally is a challenge that, if left unmet, will surely exacerbate many of the more overt threats to worldwide safety and security the human family faces.

As citizens of developed, prosperous Western countries, it is sometimes difficult for those who have spent their careers in research or marketing capacities with any of the dozens of major food companies to properly prioritize the issues surrounding food production. The very profit motive responsible for fuelling an incredible explosion of food R&D, as well as a staggering growth of processing capacity and distribution infrastructure, tends to obscure the more pressing need to feed those many millions who don't have access to such bounty.

At the same time that the world's leading brand-name food marketers have succeeded in creating a food supply that is incredibly varied, universally wholesome and absolutely astonishing in its abundance and nutritional value, the irony remains that nourishing the population of the world's less-developed countries has been but a backdrop to the food industry's more immediate goals of servicing those consumers able to afford its products.

Indeed, few of the food industry's researchers, scientists and business leaders have felt compelled to address as an inherent responsibility the challenge of ensuring that all people in every country have access to healthy, nutritious foods in sufficient quantities and at reasonable prices.

That initiative has been left to government agencies and private-sector charities, a role certainly appropriate to those organizations, but a mission that cannot be dismissed by food manufacturers. Of course, the limiting factor in any food company's contribution to dealing with world hunger involves development of nutritious yet cost-effective food formulations.

In that effort, Henk Hoogenkamp has been a giant, a dedicated scientist, a skilled food product artisan and world citizen of integrity and vision whose accomplishments ought to fill a volume much lengthier than this one.

As Henk's friend, admirer and occasional chronicler, I had the chance to catalogue many of his professional milestones:

- He was one of the first meat industry leaders to identify and address the growing impact of vegetarian food preferences among affluent consumers, a trend that is now accepted as totally mainstream.
- More than a decade before the concept even materialized, he invented the term ‘lifestyle foods’ to capture the affinity that huge numbers of otherwise ‘conventional’ consumers in Europe and America were developing for non-meat food products.
- He pioneered the use of soy proteins as a key component of sports nutrition programmes for world-class athletes looking to optimize their performance.
- He campaigned tirelessly for acceptance of the many ‘ethnic’ formulations he developed to integrate Western food processing technology with the indigenous flavours and unique ingredients central to many traditional cultures worldwide.

Now comes yet another publication that combines Henk’s unique blend of potent philosophy and proven processing procedures. He has delivered a blueprint, if you will, not only for creation of food products that deliver high value at low cost, but has validated a fundamental principle that could serve as a catalyst in ameliorating numerous global problems: namely, that people as well as processors benefit when provision of adequate nutrition to all countries is accorded the priority status it deserves.

I feel privileged to have worked with and learned from Henk these past 20 years. His insights have enlightened me, even as his convictions have inspired me. I’m certain the knowledge he shares in his latest volume will have the same effect on his readers.

Dan Murphy
Vice President for Public Affairs
American Meat Institute
Washington, DC, USA

Foreword

O yes, we are living in a world that is continually changing, and for most of us the rate of change is accelerating. A great advantage when surveying the ever-changing landscape is to have the benefit of a writer with unparalleled experience and insight. That is why Hoogenkamp is such a compelling read. Never content to leave well enough alone, he is always willing to challenge the status quo, thinking outside of the box while drawing the ire of his peers. Though he is often early, he is often right. All of this is proof that it is never a bad idea to get the observations of someone who is looking into your business and challenging your preconceptions.

The power and the glory may belong to the marketers, but there is no substitute for being a good food technologist and this is one area that differentiates this author. It is worth recalling that the biochemistry of meat, conditioning, and tenderization, meat-borne pathogens, starter cultures and fermentation are as complex as you will find in the food industry. The author can make it all disarmingly simple to understand, but each situation is different and the author can tackle any situation. The author could mention several practical accomplishments, including his work in the arena of protein and sports nutrition culminating in an honorary Doctorate from the Institute of Sports Medicine in Bucharest. He is associated with cream bases for liquors and, of course, the introduction of soy protein in the most famous burger chain of them all.

The author was early putting the consumer in the centre of this complex universe. He successfully identified developing and changing lifestyles and interpreted these in terms of how the food industry and its products would have to change. The author's industry immersion from technologist to innovator with major food companies, to commentator, has led to the global view presented here. Today's consumer is location- and time-free and this is the dynamic that demands that food developers build more functionality into our food products. We are called graziers and nomads, demanding solutions for our new lifestyles. Whether we want health and wellness or low-carb, we all want it now. The author will take you by the hand and tell you how that can be done. Now, at last, the reader can have it all … now.

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The Soy Journey

Is it possible to keep a secret for about 5000 years? It appears likely, because it took that many years to bring the soy health message from the Chinese dynasties dating back to 2838 BC right to the third millennium of modern times.

The long history of the little round bean is a fascinating story. It is still not exactly known who first cultivated soy, only that the journey of soy started somewhere in Asia. The Japanese, Chinese, the Koreans and Manchurians claim that they were the first to uncover soy's rich nutritional potential. The first reference to soybeans was found in a book entitled *Pen-Ts'ae-Kung-Mu* written by Shen Nung dating back to 2838 BC.

The Chinese called the soybean 'Ta Teou', which translates as 'Big Bean', and this precious bean was one of the five sacred plants: soy, wheat, rice, barley and millet. There are reliable reports that the Chinese cultivated soybeans as far back as the 11th century, but other legends date back more than 3000 years ago, when a Chinese tribe got lost in the desert and found the soybean as the only food to survive.

Whatever the truth, Asians have been eating soybeans as part of their staple diet for at least 5000 years, both as fermented and non-fermented foods. Non-fermented soyfoods typically include fresh-cooked green soybeans, dried soybeans, toasted soy powder, soynuts, yuba, tofu and soymilk, which is rapidly growing in popularity. Fermented soyfoods can be categorized into regional delicacies, such as miso, tempeh, soy sauce, naso and a plethora of salad dressings and sauces. Many unique regionally influenced soy food preferences developed over the centuries.

Tofu

Indonesians calls it 'tahoe', Thai people know it as 'tao hoo', Filipinos refer to it as 'tokwa', but most famous became the product named tofu. This Chinese word means 'meat without bones' or 'meat of the fields'. Tofu as we know it today is solely made from soybeans and is one of the world's most nutritious foods. To many people, the soybean is the best of all vegetable proteins, ranking alongside eggs, meat and milk as a premium choice of nutritive quality.

Recent breakthrough studies confirmed that the soybean is more than a high-yielding source of premium protein. Soybeans also contain relatively high amounts of phytochemicals, such as genistein, daidzein and glycitein. Epidemiological studies have suggested an association with lowered risks for prostate, breast and colon cancers, reduction of cholesterol, improved bone health, a delay in the onset of osteoporosis, reduced blood pressure, protection against heart disease, and an easing of menstrual and menopausal symptoms.

All these recent discoveries of health benefits are actually nothing new for Asians. For thousands of years Asian cultures have been using soybeans for medical purposes. The yogis from a civilization that flourished in the valley of the Indus used soybeans to supplement their meatless diet and prevent protein deficiency. The Chinese emperor Liu An of the Han dynasty is reputed to have created tofu around 200 BC. Thereafter, some time between the sixth and the eighth centuries, Buddhist monks took soybeans from China to Japan. However, it was only in the 12th century that Buddhist monks began operating vegetarian restaurants and that tofu became available outside the religious communities.

A New Soy Journey

Soy is a hairy-stemmed, annual plant of the legume family. This native plant of Asia came to the USA in 1804, when the beans were used as inexpensive ballast on clipper ships en route from China. Initially, soybeans were used to make soy sauce, but during the US Civil War, soybeans found a new niche when they were roasted and served as an alternative for coffee beans.

In the early 1900s more palatable varieties arrived from China, and gradually soybeans made a transition from forage to food, though it is fair to say that the growth in popularity also was boosted by the consumption of soy oil used in margarine and vegetable fats.

Soybeans have been commercially grown in the USA since 1922. The early years of soybean commercialization in the USA, prior to World War II, were fuelled by interest in soy oil. Soy protein was considered a by-product and mainly used as animal feed. Food shortages during the war stimulated research into the suitability of soy protein for human consumption. This led to the development of a vegetable protein in the simplest form with a protein content of 50%. Soy flours are high in soluble carbohydrates which give the product the 'beany' flavour that most people find objectionable and may cause digestive problems. In the early 1950s development of food-grade soy protein isolates began. Soy protein isolates are highly digestible sources of amino acids, whereby all soluble carbohydrates are removed, providing a very good flavour profile.

By the late 1950s, processing technologies advanced to enable soy flours to be made into textured soy flour (TSF) commercially, and later, by 1975, to allow thermoplastic extrusion of traditional soy concentrate (TSPC).

To decrease high processing costs of soy protein isolate while maintaining functional properties, functional soy protein concentrate (FSPC) was successfully developed in the 1970s. These third-generation soy proteins have a protein content of 70%, recovering almost all of the soybean's protein and eliminating the soluble carbohydrates which are known to cause objectionable flavours. The remainder is mostly non-soluble carbohydrates or dietary fibre. Soy protein concentrates are also low in sodium compared to most soy protein isolates. Major advancements in technology since 1995 have created significant further improvements in protein purity and flavour profiles for both soy protein isolate and functional soy protein concentrate.

As a protein source, soy protein has the highest attainable protein score of 1.0, as determined by the internationally accepted PDCAAS method (Protein Digestibility Corrected Amino Acid Score). PDCAAS (Table 1.1) has been adopted by the Food and Drug Administration in the USA upon the recommendation of the Food and Agricultural Organization/World Health Organization (FAO/WHO). A score of 1.0 means that 100% of the essential amino acids required by a 2–5 year old child (i.e. the most stringent protein requirements) is digested in that protein score. All proteins with a PDCAAS of 1.0 are considered equally high in quality and meet all of the essential amino acid requirements of humans. (See Henly and Kuster, 1994.)

The environmental versatility of soybeans was clearly demonstrated by Henry Ford. Beginning in 1935, his Ford Motor Company used soybeans to create plastic and in that year soybean plastic was used in every car Ford built. The visionary applica-

Table 1.1. PDCAAS of selected food proteins.[a]

Protein source	PDCAAS[b]
Soy protein isolate	1.00
Casein	1.00
Egg white	1.00
Beef	0.92
Kidney beans (canned)	0.68
Rolled oats	0.57
Lentils (canned)	0.52
Groundnut meal	0.52
Whole wheat	0.40
Wheat gluten	0.25

[a]Protein quality evaluation, report of the joint FAO/WHO expert consultation (FAO/WHO, 1989).
[b]Values for Supro® brand soy protein isolate, The Solae Company, as determined through actual analysis.

tion breakthrough initiated by Henry Ford is now referred to in the 21st century with such descriptive names as energy conservation, environmental protection and recycling.

Although essentially of sub-tropical origin, the soybean now is cultivated as far north as a latitude of 52°. Today, soybeans are the second-leading US agricultural crop, and one-half of the world's soybeans are grown in the USA. However, other countries such as China, Argentina and Brazil are rapidly gaining in importance as major soybean producers.

The soybean plant belongs to the legume family. The bean is able to utilize the nitrogen in the air through the action of bacteria on its roots. The whole soybean is 30% carbohydrate (of which 15% is fibre), 18% oil, 14% moisture and 38% protein. Soy protein contains all essential amino acids needed for human health.

With a little imagination tofu – or bean curd – can be seen as the predecessor of concentrated forms of soy protein ingredients. Tofu is traditionally made by soaking beans overnight in water, grinding the soybeans to a pulp and cooking this with added fresh water. The pulp is then extracted and the remaining fraction coagulated with calcium or magnesium salts to create soymilk. After the curds and whey are formed, the whey fraction is drained off and the curds are pressed in a cheesecloth box with extra weight applied on top. This drives out the remaining whey and strong bonding results, forming a block of tofu.

The entire process is remarkably similar to dairy cheese production technology. The Westernization of tofu in the early 1950s laid the groundwork for the production of soy protein products that ultimately resulted in the availability of highly nutritive and functional proteins.

Looking back at those early days, it now can be concluded that the initial positioning and marketing of these soy protein ingredients failed miserably. Especially for the World War II generation, in both the USA and Europe, considerable damage was done by positioning these textured soy ingredients as a cheap replacement or 'imitation meat'. For a generation that just had gone through the horror of a devastating war, the last thing on their minds was to be reminded again of the phobia surrounding wartime hunger and the need for surrogate foods.

Soy from Forage to Health Wizard

After many years of inactivity, the food and meat industry finally has started to educate consumers that soy-containing food and meat are great tasting products that can be easily incorporated into everyday life. Soy protein in pure form as a characterizing food, such as soy milk, or as a functional ingredient is increasingly used in creative products that capitalize on the modern consumption trend fuelled by the global decline in home cooking and time-pressed consumers.

Soy-based foods lately have become the darling of the media. In fact, there is plenty to write about soy's oestrogenic effects, antioxidant effects and effects on cardiovascular health, not to mention its positive effects on reducing hot-flushes of peri- and post-menopausal women. The October 1999 ruling of the Food and Drug Administration allowing health claims for foods containing 6.25 g of protein per serving has created interest among both food and meat processors and consumers. The FDA reported that clinical studies show that about 25 g (four servings of 6.25 g) of soy protein a day is needed for a clinically significant effect on total cholesterol levels. More specifically, clinical research demonstrated a reduction of total cholesterol of 9% and a reduction in low-density lipoprotein (LDL), or 'bad' cholesterol, of 13% with dietary consumption of the above levels of soy protein. (See Anderson *et al.*, 1995.)

Coronary heart disease (CHD) is the number one killer in the USA and EU countries, affecting almost equal numbers of men and women. The FDA estimates that some 52 million Americans of 20 years or older are prime candidates for dietary intervention to lower blood cholesterol. Each 1% drop in total cholesterol translates into a 2% drop in the risk of developing cardiovascular disease.

Many years of clinical studies have provided a wealth of information about the effects of soy protein on blood cholesterol concentrations in humans. Adults whose daily diets included moderate amounts of soy protein had significantly reduced LDL blood levels, but that intake level hardly affected high-density lipoprotein (HDL), or 'good' cholesterol, levels. However, the explanation of the hypocholesterolaemic mechanism remains elusive.

It is generally recognized that soy foods contain a number of anticarcinogenic compounds. Researchers currently believe that isoflavones in particular are the compounds most likely to protect against cancer, especially in inhibiting the initiation stage of carcinogenesis. Genistein has been shown to suppress the growth of a wide range of cancer cells. There is a growing belief that the anticancer effects of soy may be due to the combination of compounds of isoflavones, trypsin inhibitors and other biologically active micro-compounds.

Much research has been done to explain the interactions between soy protein and its naturally occurring phytochemicals, specifically isoflavones or isoflavonic phyto-oestrogens. Isoflavones, referred to as plant oestrogens, are weak oestrogens that mimic hormonal oestrogen in certain bodily functions, while performing like antihormones in others. The former helps explain the improved cardiovascular health that results from consumption of soy protein; the latter explains why the incidence of breast cancer and endometrial cancer is much lower in Japan, where more vegetables, tofu and polyphenol-containing green teas are consumed, compared with the typical American diet.

Therefore, soy protein and its isoflavones may be a natural alternative for the millions of women who are on hormone replacement therapy. Oestrogen replacement therapy can reduce the risk for osteoporosis, yet on the other hand these oestrogen hormones may also increase the risk for the development of breast cancer and uterine cancer: a double-edged decision for women. Soy protein, with oestrogen-mimicking activity, could provide a natural option with the potential to impact positively on the health of large groups of society.

All Soy is Not Born Equal

There are a number of nutritive and nonnutritive components that occur naturally in soy which appear to contribute to cholesterol-lowering effects. Some of these components include isoflavones, saponins, phytic acid and protease inhibitors, as well as the protein itself. For example, the protein itself may be responsible for some health benefits. Specific amino acids, which are the basic building blocks of protein, may have biological effects. Additionally, these amino acids combine to form peptides which could, again, potentially have health benefits. Lastly, these peptides combine to form globulins, or storage proteins, which are currently under study because consumption has been related to cholesterol lowering. Most soy proteins provide a concentrated form of these protein components, and are specially processed to retain important bioactive components.

Isoflavone levels and ratios in soy protein-based foods vary depending on the variety of soybeans used, growing conditions and soil, as well as on how the soy protein is processed. Thus, isoflavone levels can vary from crop year to crop year, batch to batch or from one supplier to another, if not specifically controlled. It is important to recognize that variation does exist when comparing various soy protein sources, as more and more research is indicating the importance of naturally occurring isoflavone levels in delivering consistent health benefits. These discrepancies can cause communication problems with the target audience. For sustaining success it will be essential to address the issue of why certain soy products contribute to improved health and why others do not.

For example, much additional research is still needed to explain the mechanism by which soy protein intake lowers cholesterol. Initially, it was believed that the antioxidative isoflavones were the active ingredients. This assumption proved wrong when pure isoflavones were given in pill form. Ongoing studies are now focusing on the soy protein's co-factors and their bioavailability.

The methods used for purifying soy protein greatly influence the recovery of naturally occurring flavonoids. Soy protein isolate is water-washed and thus retains 90% of available isoflavones. Soy protein concentrate may be extracted using ethanol, which washes out about 30% or more of the phytochemicals. Textured soy protein retains about 50% of isoflavones.

Proactive Challenges

Improved understanding of the ingredient-interactions and manufacturing technology and capability have allowed significant taste, flavour and texture innovations. Especially for processed meats, how to pack 6.25 g of soy protein into a single serving in order to meet the FDA and USDA labelling requirements will be a major challenge.

A possible label example could read as follows: 'Made with Heart Healthy Soy Protein – Diets low in saturated fat and cholesterol that include 25 g of soy protein per day may reduce the risk of heart disease. One serving of this product provides at least 6.25g of soy protein'.

For a typical hot dog or a deli sandwich, this will be a difficult task to accomplish, unless the serving size is increased and/or the lean meat percentages are decreased. Furthermore, it is also doubtful if the public is in need of yet another subcategory of packaged sausage or hot dog. Formulated meat and chicken patties have more room for manoeuvre, but it is expected that so-called integrated foods containing soy protein-fortified meats such as a burrito or other single-serving handheld food will emerge as solutions while meeting the consumer's desire for taste and convenience. The latter will ultimately decide if soy can be delivered in ways enticing to informed and demanding customers. But the evolution will not stop here. It can be expected that additional cross-boosting nutraceutical or functional food or meat products will emerge. For example, soy-containing processed meat products or meat-free foods may be integrated with lycopene, a carotenoid that gives tomatoes their red blush, and that is associated with lower risk of several types of cancer, such as prostate, lung and stomach cancer.

Actually it is a 'contradictus in terminus' (Latin wording for: 'terminology of contradictory words') that on one end of the equation there is a strong growth for vegetarian or lifestyle foods and on the other side there is a more sophisticated world's growing taste for meat and dairy produce. However, it is true that a growing number of people believe that the consumption of animal proteins is an environmentally wasteful use of nature's resources.

The dairy industry is an exception and has recognized the need to be proactive and has successfully introduced, for example, bioactive yoghurts and immune-modulators such as the protein fraction lactoferrin. The processed meat industry is lagging behind in marketing similar health benefits, such as the bioavailability of zinc and iron and the high quality of protein. Why allow the emerging functional food category to monopolize the glory of media attention? Why can't a processed meat product qualify? Is it that the industry lacks proactive thinking?

Perhaps the time has come to seriously think about integrating meat as an ingredient in a 'package of health'. The FDA ruling in the USA and the Joint Health Claim Initiative in the UK is a good start. Allowing health-claims labelling for soy-based products may be just the beginning of many similar developments to come.

However, realism is needed because of growing environmental concerns of groundwater exhaustion and nutrient depletion if there is an endless increase in meat production for a rapidly expanding world population. If not managed properly, increased meat farming could cause the loss of thousands of hectares of valuable wilderness and the irreplaceable loss of wildlife habitat.

Soy protein offers unique opportunities to address some of the emerging concerns, providing high quality and good-tasting meat products that meet the growing consumer awareness and demand for soy protein, while offering processors a unique platform for a new category of products.

The soy industry continues to raise consumer awareness of the many potential health benefits. There is little doubt that additional funding and investments in nutritional soy protein research ultimately will expand the range of scientifically based health claims. As a result, it is expected that new opportunities for both food and meat companies will be created.

For example, in the past years, nutritional sciences have conducted a comprehensive evaluation of the available scientific evidence on the relationship between the consumption of soy protein-based foods and the reduced risk of developing these three types of cancer: breast, prostate, and colon.

As such it is expected that the USA FDA will start an internal scientific review in order to clear the way for a ruling allowing a qualified health claim about the relationship between soy protein and reduced risk of certain cancers.

At long last, in 2004, soy is universally embraced as a health-enhancing ingredient. The unlocking of the health benefits of soy has resulted in significant growth of soy foods and soy protein inclusion worldwide. To summarize, consumers are increasingly aware of the potential role of soy protein in:

- Heart health (cholesterol reduction).
- Bone health (increased bone density).
- Menopausal symptom relief (reduced hot flushes).
- Cancer prevention (breast, prostate, colon, thyroid).
- Performance nutrition (faster muscle recovery).
- Weight management (satisfying appetite).

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2
Soy Protein Essentials

Protein is available from both plant and animal sources. However, in terms of economics, sustainability and nutrition, the soybean is the most efficient source, combining superior nutritional value with a wide range of functional properties. Soy protein provides high bio-availability and delivers a full and complete range of essential amino acids, including the frequently limited lysine.

Environmentally speaking, more prudent management of world resources will be of paramount importance in sustaining health at affordable prices for a rapidly growing world population.

Evaluation of dietary patterns suggests that there is a need for reorientation in societies that have enjoyed unprecedented advances in living standards since the early 1960s. Looking back over a period of almost 50 years, a negative development can be seen in the steep increases in meat consumption at the expense of grains and cereals. This adoption of a more Western diet in many countries has resulted in an increase in weight and obesity which displaces the healthy benefits of plant-based foods. In general, a Westernized diet contains high levels of calories and fats and low levels of dietary fibre. Soy protein is a very helpful tool to bridge the gap between traditional diets and the need for nutritionally balanced, affordable and easy to consume foods for modern, time-pressed societies.

Soy protein is increasingly considered around the world as a cost-effective way to nourish people. These vegetable ingredients and foods play a prominent role in the formulation of further processed food.

Health Claim

Especially after the USA Food and Drug Administration approved a health claim in 1999, human consumption of soy protein foods and foods containing soy protein ingredients accelerated in all food segments. In 2002 a similar health claim received endorsement when the Joint Health Claim Initiative (JHCI) concluded that 'the inclusion of at least 20 gm of soy protein per day, as part of a diet low in saturated fat, can help reduce blood cholesterol levels'. Lowering the concentration of blood cholesterol is associated with the reduction in risk of coronary heart disease, which is the prime cause of premature death in the UK adult population. The JHCI is a non-governmental independent organization consisting of representatives from consumer protection groups, food law enforcers and the food industry. (See Erdman, 2000.)

These endorsements have been of paramount importance and have propelled soy protein foods into the arena of functional foods or nutraceuticals.

From 1995, soy food sales have increased dramatically and, as a result, mainstream food companies have taken ownership of many of these emerging markets. Consumer attitudes towards soy foods have been positively affected by media reports about health benefits, especially the isoflavones. Women's health issues have been the major driving force in the rapid popularization of soy constituents, soy foods and traditional reformulated foods to which soy ingredients and/or bioactive components have been added. New lines of research are looking promising with respect to the prevention of some cancers. In humans, at high concentrations, genistein is very effective at eliminating specific gene expressions in prostate cancer cells. Additionally dietary soy or genistein could optimize the synthesis of the key vitamin D metabolite and as a result could control tumour growth and possibly even contribute to tumour prevention.

Soybean is the only legume or vegetable that is used in baseline food products that contain nutritionally relevant amounts of phyto-oestrogens because they bind oestrogen receptors. Other plants contain bioactive components as well but are not used in baseline nutrition. For example, hop extracts are sold as a food supplement claiming a similar effect, but they are not often used as a functional ingredient in food and meat manufacturing.

The naturally occurring constituents of soybeans have a molecular structure that is strikingly similar to the human hormone oestrogen. Genistein is the main isoflavone in soybean, and the oestrogen-like properties of isoflavones prompted speculation that soy protein might be an attractive alternative to conventional hormone replacement therapy for women. Women's health issues such as breast cancer, osteoporosis and premenstrual syndrome, and menopausal symptoms resulted in enormous interest when isoflavone supplements became available either in pill form or in combination with other nutrients and biologically active components. (See Kotsopoulos *et al.*, 2000.)

Phyto-oestrogens are a subcategory of oestrogen-like plant compounds. The three main isoflavones found in soy are genistein, daidzein and glycitein. Not only has recent research shown that the weak oestrogenic activity of isoflavones can offer relief in menopause symptoms, but it has indicated its potential to delay, prevent and treat osteoporosis (which is a common health concern for mature women), breast cancer and to lower the occurrence of prostate cancer and colon cancer. Studies have also revealed that soy germ is a source of folic acid which is linked with decreased risk of various forms of vascular disease, and neural tube defects in fetuses. (See Messino and Barnes, 1991.)

Soy is also a natural supplier of vitamin E. This antioxidant vitamin is present in the form of d-alpha-tocopherol, which the body retains much more effectively than synthetic vitamin E.

It is clear that slowly but surely the complex soy matrix is being unravelled, exposing the synergies between food consumption and health benefits.

Various Options

Besides the importance of health considerations, there are many functional properties to consider when developing food and processed meat products. Important functional considerations are, for example, hydration, fat absorption, water-holding capacity, solubility, emulsification, gelation and texture enhancement.

In the past, soy protein foods and soy ingredients were often viewed negatively by consumers because of off-flavours created by raffinose and stachyose oligosaccharides. However, because of the availability of biotechnology, engineering improvements and new enzymatic technologies, major flavour and functional advances have been accomplished. Newer generations of soy protein concentrates are increasingly used as equivalents of soy protein isolates in a variety of emulsified meat products.

Most soy protein ingredients are used in low concentrations for functionality. A small percentage of addition gives a large percentage of results. Emerging new soy protein ingredients have significantly toned down the typical soy taste, and the premium soy protein isolate (90%) in particular has made great strides forward in terms of flavour blandness. These highly functional ingredients couple superior taste and solubility and possible high inclusion levels to optimize the economics of food formulas while safeguarding health attributes. New ideas and application technologies will, when executed well, ultimately improve profitability and provide sustainable competitive advantage.

Soy protein ingredients (Table 2.1) are not only very cost-efficient protein sources, but also owe much of their functional power to a high affinity for fat and water, together with an ability to immobilize these components.

Soy protein isolates have specific properties that cannot be matched by functional soy protein concentrate. Especially in products that have a high inclusion level, soy protein isolates are often a better solution in terms of gelation, texture and flavour profiles. The same is true for applications that require very low levels of additions and when superior flavour is of the utmost importance, for example delicate food products that need functional performance in yoghurt, cheese and non-dairy creamers and whole muscle foods.

Progress in soy manufacturing technology now allows water wash separation of the protein which subsequently retains the naturally occurring isoflavone contents of soybeans resulting in functional soy protein concentrate. This protein is ideally suited to products that need a moderate inclusion level in emulsified meat products as well as for health and nutrition boosters for existing foods.

Rapid technological progress allows the use of soy protein concentrate and soy protein isolate in as diverse areas as binding fat and water in sausages and processed cheese and as an ingredient in formulated solid and liquid food for weight management applications such as ready-to-drink diet shakes and food bars.

As far as functional properties of soy protein ingredients are concerned, it is outside the scope of this book to fully explain the influence of thermal, mechanical, chemical and enzymatic variables. In terms of emulsification capability of soy protein ingredients, it can be noted that physical and chemical manipulation of the soy curd greatly influences these properties. For example, heat, proteinase treatment, pH-levels influencing cross-linking, and ionic strength control, and antioxidant additions are being used to provide food manufacturers with the best possible performance and solutions to stability and organoleptical characteristics. (See Wilson, 1995.)

Bulk Markets

The main protein in some food products, including bakery foods and meat analogues, comes from wheat and soy ingredients. For a great many years the soy protein industry has struggled to find acceptance, as flavour and texture posed considerable challenges to research and development teams across the world.

Other than the already known health benefits of soy protein with bioactives for

Table 2.1. Composition of soy protein products (percentages).

Constituent	Defatted flours and grits		Concentrates		Isolates	
	As is	mfb*	As is	mfb	As is	mfb
Protein (Nx6.25)	52–54	56–59	62–69	65–72	86–87	90–92
Fat	0.5–1.0	0.5–1.1	0.5–1.0	0.5–1.0	0.5–1.0	0.5–1.0
Crude fibre	2.5–3.5	2.7–3.8	3.4–4.8	3.5–5.0	0.1–0.2	0.1–0.2
Ash	5.0–6.0	5.4–6.5	3.8–6.2	4.0–6.5	3.8–4.8	4.0–5.0
Moisture	6–8%	0	4–6%	0	4–6%	0
Carbohydrates (by difference)	30–32	32–34	19–21	20–22	3–4	3–4

*mfb: moisture-free basis.

heart health, these proteins are the most satiating nutrients. It has been reported that higher protein intakes in hypo-caloric diets appear to preserve lean body mass preferentially, at the expense of fat tissue.

Much like the airline industry, manufacturers of soy protein ingredients use yield management to optimize profit. The use of soy protein isolate (SPI) in emulsified meat products is under continuing competitive threat from soy protein concentrate and certain functional modified food starches. For manufacturers, the application of soy protein isolate in emulsified meat products is therefore increasingly considered the low end of the market and consequently much emphasis is given to turbo-charge the development of applications at the high end of the soy protein market, such as whole muscle meats, beverages and food bars.

Despite the major growth in recent years of soy protein in food and health foods, processed meat products use about 70% of the world's total production of functional soy protein ingredients. Of this category, the sub-category emulsified meat products represents about 50%. Although it is true that the use of soy protein isolate has seen a gradual decline in value, the category as such is still a formidable market, and certainly can be considered a lifeline market segment that deserves to be treated with strong technological support from the soy protein industry.

Although impressive, this should not be a surprise if it is taken into account that meat is the traditional protein source in the Western diet. The growth potential of this well-established processed meat market is limited. Novelties in the rather traditional processed meat market are hard to find. After all, all the fat and water binding for these products can be invented only once. It is clear that the industry is in great need of finding new and rewarding application opportunities for healthy alternatives rather than just for binding fat and water in emulsified and whole muscle meat products. Meat analogues and food bars could be a possible future category where soy protein can be used to provide great-tasting and healthy solutions.

The food and health food applications, including dry blended and ready-to-drink beverages, represent about 25% of the market for functional soy protein ingredients. In 2003, the EU market has seen a 20% growth in the consumption of soy beverages and this market increase is not showing any signs of slowing down. Improvements in processing technologies now allow the creation of a SPI with excellent sensorial properties. In particular, ready-to-drink beverages such as soy-yoghurt, soy smoothies, weight management and nutraceutical pro-biotic beverages, will greatly benefit when new types of flavoured soy protein isolate are introduced. These new developed proteins retain the typical soy beany taste in the final product, while providing a smooth mouth feel very similar to dairy protein.

For all food segments, soy-based products have captured double-digit market growth in recent years, and healthier eating habits are the driving force behind increased sales. The sales of meat analogue products and soymilk in particular have been increasing nearly 40% annually in the past few years. For the modern consumer, a lot is at stake, especially the chance to add quality years to life, rather than growing old in poor health. As public awareness rises, market opportunities will follow suit. These opportunities are created by strong scientific evidence coupled with increasing consumer awareness.

Consumer research demonstrates a demand for healthier foods and today's shoppers engage actively in selecting good-tasting, health-enhancing, environmentally friendly foods that go beyond what has been available previously. Moreover, consumers are increasingly aware of the health benefits of soy protein in:

- Heart health and cholesterol reduction.
- Menopausal symptoms relief.
- Increased bone density.
- Cancer prevention (breast, prostate, thyroid and colon).
- Sport nutrition, including faster recovery.
- Weight management.

Protein Choices

The little soybean is a powerhouse of nutrients:

- Protein 38%.
- Oil 18% (of which unsaturated 85%).
- Insoluble carbohydrates 15% (dietary fibre).
- Soluble carbohydrates 15% (including oligosaccharides).
- Moisture, ash, vitamins, minerals 14%.

Soybean oil contains 61% polyunsaturated fatty acids, which consists of 54% linoleic and 7% linolenic acid. Monounsaturated or oleic fatty acids make up about 24%. The remaining 15% are saturated fatty acids, of which 11% is palmitic and 4% is stearic.

Soy is the only legume that contains the nine essential amino acids in the correct proportion for human health. Soy protein therefore is categorized as high quality, complete protein. Its nutritional benefits include being a good source of phosphorus, potassium, B vitamins, zinc, iron and the antioxidant vitamin E.

As an ingredient, the most elementary form of soybean is soy flour. Soy flour and grits are the least refined products and have the highest level of nutrients. Soy flour is made from roasted soybeans ground into a fine powder and contains 50–54% protein. To improve dispersion and emulsification a blend of soy oil and lecithin is usually added to defatted soy flour. Soy flour comes in three forms: full-fat, defatted and lecithinated. Natural or full-fat soy flour contains natural oils present in the soybean. Soy flour is gluten-free, which will influence the properties of yeast-raised breads. Soy grits are very similar to soy flour, except that the soybeans have been roasted and broken into coarse particles. Although soy flours are rich in naturally occurring nutritive components, these ingredients do not have an appropriate flavour profile for use in delicate applications such as dairy systems and many types of processed meat products. The main application of soy flour in human nutrition is in bakery.

A very recent development is the use of the highly nutritious composition of the whole soybean. New spray-drying systems now allow the retention of the natural dehulled whole beans in microfine particle size with a bland flavour and smooth mouthfeel. These microsize white powders have shown good potential in dairy analogue foods such as soy milk-based beverages, frozen desserts and cream cheese. The key components of soybean – the proteins, okara, isoflavones, phytosterols, prebiotic sugars and oil – are retained in the naturally occurring forms. Typically, the protein content on a dry basis is 40%, total fat 20% and total dietary fibre 11%. It can be expected that these vitamin- and mineral-enriched whole soybean powders will ultimately become a good alternative to dairy full-fat and non-fat milk powders.

The processing of soybeans starts with cleaning, cracking and dehulling. Cracked soybeans are rolled into full-fat flakes. These flakes are the basis for ground and powdered full fat flour. However, very often oil is removed from full-fat soy flakes using solvent extraction (hexane). Defatted soy flakes remain and these are the basis of a number of speciality functional ingredients like soy protein concentrate and soy protein isolate. More heat treatment usually equals less functionality, though new enzymatic and fermentation technologies allow major modification of protein properties.

Soy protein concentrate usually contains 65–72% protein. These functional ingredients are typically produced using ethanol, acid leaching at iso-electric pH, and heat-water leaching. The main objective of the manufacturing process is to remove oligosaccharides in the defatted soy flour. Both acid leaching and ethanol extraction systems are often used. The soluble oligosaccharides are removed from the protein curd by decanter centrifugation. A possible negative in ethanol extraction systems is that soy isoflavones are partly removed also. On the other hand, ethanol-treated soy protein concentrate separation usually results in cleaner flavour profiles and a whiter colour compared to acid leaching. Soy protein concentrates are low in sodium and proteins can be modified by enzymatic treatment to allow lowering of viscosity for applications such as brine injection in whole muscle meats. Soy concentrates are a highly digestible source of amino acids and retain most of the beans' dietary fibre. The remaining fibre can provide additional structuring support in processed meat products and fast viscosity increase during processing. The latter is a serious consideration when fine tuning the production time/temperature protocol.

Soy protein isolates have 90% protein calculated on a dry basis. Soy protein isolates are prepared by solubilizing and separating protein out of the flake followed by precipitation at the iso-electric point. Soy protein isolate is the most refined type of protein. These proteins are premium ingredients and nearly all fat and fibre and nearly all soluble carbohydrates are removed.

Soy protein isolates have superior performance in a great many food applications where delicate taste and functional considerations are of importance.

Soy protein isolate is a high quality, complete protein and is manufactured under strict specifications to maintain the integrity of its active bio-components. Soy protein may also be lecithinated to improve dispersibility and to reduce dusting. Both gelling and non-gelling varieties are available, as well as varying grades of viscosity.

Soy Matrix

Soy ingredients can be divided into the following categories:

1. Soy flour (40–50% protein).
- Full fat flour (40% protein).
- Defatted flour (50% protein).
- Textured soy flour (TSF).
- Enzymatically enhanced instant soy flour with increased bioavailability.

2. Soy protein concentrate (65–70% protein).
- Functional soy protein concentrates (FSPC).
- Textured soy protein concentrates (TSPC).
- Textured vegetable protein crumbles (TVPC) (a textured combination of TSPC, wheat gluten, egg albumen, starch, gums and flavours).

3. Soy protein isolate (90% protein).
- Soy protein isolate (SPI), including soy protein blends with added functional ingredients such as phosphates and calcium.

4. Soy (dietary) fibres.
5. Soy lecithins.
6. Soy isoflavone concentrate.
7. Soy oil.

Soy Protein Applications for Human Consumption

1. Soy flour.
- Cookies.
- Cakes.
- Doughnuts.
- Breads.
- Bagels.
- Pizza crust.
- Tortillas.
- Muffins.
- Pasta noodles.
- Egg roll skins.
- Cereals.
- Dumplings.
- Crackers.
- Sweet and savoury spreads.

Soy flour applications and properties needed:
- Replacement for non-fat dry milk powder.
- Replacement for egg albumen.
- Water absorption.
- Browning.
- Freshness.
- Texture and tenderizing.

2. Soy protein concentrate.
- Fibre-containing protein structuring medium in emulsified meat products.
- Fat- and water-binding in processed meat products.
- Improving the appearance, texture and juiciness of meat products.
- Protein fortification in bakery foods.
- Protein fortification for special foods such as pasta, noodles and breakfast cereals.

- Providing fibrous texture in coarse ground patties to provide natural bite and chew.
- Retention of moisture during reconstitution.
- Structuring ingredient for textured foods, including textured cereals and pizza toppings.

3. Soy protein isolate.

- Infant formula.
- Weaning foods.
- Protein enrichment for special foods such as school lunch programmes.
- Water retention in cooked whole muscle meats such as corned beef and hams.
- Marinade diffusion in case-ready meats.
- Stabilizing ingredient for fat and water in emulsified meat products such as hot dogs, bolognas and sea food.
- Texture modifier for coarse ground meat products such as hamburgers and chicken patties.
- Structuring agent for lean meat (chunk) replacement in dry fermented sausage and co-extruded snack sticks.
- Protein source for weight management foods.
- Protein source for sport nutrition, including muscle repair, maintenance and building.
- Protein source and moist retention in food and health bars, including use in crunchy nuggets.
- Replacement of milk protein in fat-filled powders.
- Replacement of milk protein (caseinates) in non-dairy creamers.
- Main protein source in soy milk, soy yoghurt and soy nutritional beverages.

The Choice Between SPI and FSPC

A much debated issue in the world of meat scientists and technologists remains the issue of functionality and performance between SPI and FSPC. Often these debates are initiated and challenged by the purchasing and/or R&D departments who are in search of more cost-effective solutions.

For a great many years, the performance of SPI in emulsified as well as in coarse ground meat products was clearly superior in terms of fat and water binding, texture and flavour contribution. However, the introduction of FSPC has dramatically changed the landscape of soy protein ingredient selections. Nearly all emulsified and coarse ground meat and poultry products now allow a weight-for-weight replacement substituting SPI for FSPC. Minor modifications might still be necessary to fine-tune specific formulas when substituting soy protein ingredients in order to optimize end-product specifications and yields.

Functional ingredients when first introduced into a market usually gain market share by emphasizing an economic advantage or value. This is how milk proteins such as caseinates historically allowed manufacturers to reduce processing costs and how soy protein isolate later replaced sodium caseinate in most meat applications. More recently, functional soy protein concentrates were introduced as cheaper alternatives for soy protein isolates. As markets develop, the 'hunted' ingredient either moves to a higher value application or, when that fails, loses its profitability and/or market share.

The established soy industry is likely to focus its soy protein isolate development and application efforts on health foods, including meat-free products, and on further strengthening the application know-how of functional soy protein concentrates. But then again, the terminology might soon become obsolete. The emerging soy protein industry in developing countries such as China and India is probably impacted by strategic national food politics because more emphasis is given to the still existing protein shortage in the domestic diet.

Most soy protein manufacturers use a market-driven pricing policy. In other words, the soy protein companies try to market ingredients according to the dynamics of specific individual countries. Instant data exchange has made these kinds of price differentiation rather more difficult. However, generally speaking, the price of SPI is up to 50% higher than that of FSPC.

It is expected that large meat processing companies in particular will opt to substitute SPI for FSPC in order to achieve significant cost benefits.

Under such a scenario, the soy protein manufacturers are likely to try to increase the price points of FSPC in order to reduce the price imbalance. Other dynamics that will influence future soy protein pricing are the growth of the use of SPI in food applications and the surge of soy protein manufacturing capacity in low-cost soybean producing countries such as China and India. To allow equilibrium in market capacity versus pricing, the anticipated growth of SPI usage in food and beverage applications will need to offset the decline of market share in processed meats. If this does not happen, the price imbalance remains with subsequent negative consequences for the profitability of soy protein manufacturers.

Legislative considerations also can play an important role in the selection criteria between SPI and FSPC. A number of countries have specific requirements and implement a maximum percentage of non-meat proteins for formula inclusion. In these situations, the use of FSPC is often preferred because of the previously mentioned presence of soy fibre.

Example: A maximum addition of 2% *pure protein* translates to 2.20% of SPI on weight basis and 2.60% weight basis of FSPC. In this example, FSPC not only is considerably more cost effective, the soy ingredient also provides additional soy fibre which will further enhance product stability and texture compared to SPI. Finally, 2% *pure protein* translates to 4.0% soy flour on weight basis. However, the flavour profile of soy flour generally is not suitable for inclusion in processed meat and poultry products.

Certain applications remain for which SPI remains the ingredient of choice. For example, soy protein granules made by using SPI are clearly superior in comparison with FSPC. The patented process of combining, under certain conditions of friction, temperature and protein properties, 1 part of SPI and approximately 3.3 parts of water, uniquely mimics the texture and appearance of lean meat when used in coarse ground meat and poultry patties as well as in dry fermented sausage.

The above-mentioned legislation limits the full utilization of this meat-mimicking capacity of soy protein isolate. Indeed, soy protein isolate should no longer be seen as just a functional ingredient but as an intrinsic and equivalent part of the meat-mix, able to replace far greater amounts of meat than allowed by the often restrictive legislation. Especially in Europe, codes of good manufacturing practice favour the *status quo* in the market and limit innovation.

Extruded Soy Ingredients

It is no secret that those who are involved in food processing and marketing must be ready and able to reshape and reinvent their business. There are simply too many challenges, hurdles and uncertainties to ignore change, and reshaping businesses is necessary to create higher values. In this context it is probably safe to say that ingredient technology is the quickest to be implemented and the least expensive from the standpoint of capital investment. Ingredient application research often acts as a catalyst and this certainly is true for the use of functional soy protein ingredients that meet consumers' growing demands for better nutrition, great taste and environmental sustainability.

Texturized soy products have a number of important purposes such as providing nutrition options for large numbers of people within defined food cost budgets. Texturized soy protein (or TSP) actually is a generic term used to process, by means of extrusion technology, meat-like structures simulating lean meat when rehydrated and cooked (Fig. 2.1). TSP products are increasingly used in cereal, chocolate and health bars, where the 'nuggets' mainly serve to provide a crunchy texture while keeping a certain amount of moisture over a prolonged shelf life.

There is a wide range of textured soy products, such as various forms of textured

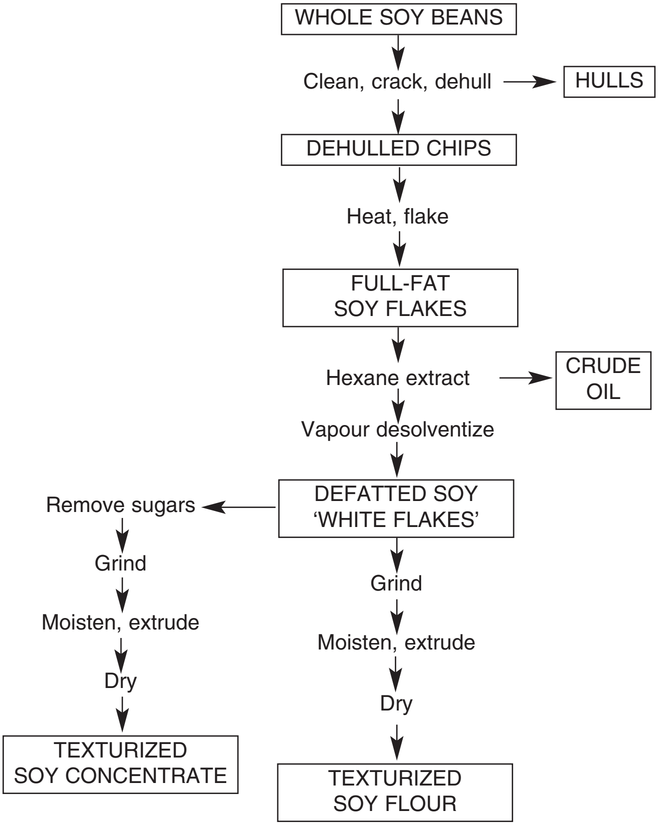

Fig. 2.1. Flow sheet for production of texturized soy proteins from whole soybeans.

soy concentrate and textured soy protein made from defatted soy flour. Textured soy proteins are specifically designed for use in ground meat systems. There is little doubt that innovative food and meat product development favours the use of TSPC, though for cost-critical products such as certain food service hamburgers, pizza toppings and hot dogs, texturized soy flour still remains a much sought after alternative. TSF is made by processing defatted soy flour through a cooker-extruder. This process allows the creation of many different forms, colours and sizes. The basic forms of TSF contain 52% protein (on an 'as is' basis) as well as dietary fibre and the remainder of the soluble carbohydrates. These soluble carbohydrates often cause unwanted flavour changes in the final product. Compared to texturized soy flour, texturized soy concentrate has a much improved taste profile and the reduction of non-digestable natural sugars such as stachyose and raffinose has an added benefit of eliminating flatulence in some individuals.

TSF can only be used as a filler in a limited number of meat products. Its inclusion is also limited because it has a softening effect on the finished product. Usually 1 part of TSF will absorb 2–3 parts of water.

TSPC is processed from soy concentrate by passing the protein solution through a cooker-extruder. Depending on the typical extrusion system used, a superior fibrous texture is created. These products are higher in cost but have much improved flavour profiles and also maintain texture integrity longer when used in a complex meat or meat analogue system. For optimum performance, TSPC needs to be rehydrated, and usually 1 part of TSPC can absorb 2.5–3 parts of cold water. The hydration time of textured protein depends on particle size and ranges from 5 to 90 min. Vacuumization will decrease the hydration time of textured soy protein.

Hydration ratios of TSF and TSPC can be further improved slightly by using warm water. However, the downside of using warm water for hydration is the need to cool down to less than –8°C before the hydrated textured soy can be used for final blending with the other meat components. When hydrated, texturized soy protein particles are subject to the same microbial hazards as other high-moisture products such as meat, and subsequently should be handled with care to avoid premature spoilage.

Soy proteins are the culinary chameleons of the modern world which not only enhance and extend meat products, but also provide health benefits when consumed in sufficient quantities. In comparison with TSFs, TSPCs usually are better suited to precooked meat products that will undergo subsequent reheating.

Textured soy protein ingredients are available as flake, crumble and chunk. In terms of relative hardness, soy flakes are the softest. Crumbles are softer than granules. Extruded soy granules are chewier compared to soy flakes and soy crumbles. Textured soy flour (52% protein) is not necessarily inferior to textured soy protein concentrates (65% protein) with regards to hydration and water-holding capacity. Usually TSF and TSPC perform similarly in many applications. However, in kettle-cooked foods, the texture of TSF may be softer compared to TSPC. TSF will contribute to more typical soy flavour than TSPC and therefore spice and seasoning adjustments might be necessary to mask unwanted flavours.

Textured soy protein colours:

- Uncoloured.
- Light caramel.
- Caramel.
- Malt.
- Red-brown.

Technical improvements in vegetable protein chemistry and the development of extrusion technology will speed up the introduction of meat analogue products enormously. Despite early handicaps, meat analogues have improved greatly over the last few years. In particular, innovative high moisture extrusion technology permits the formation of meat analogue structures that uniquely mimic meat characteristics, both in terms of organoleptic properties and health attributes, such as protein profile. Following steam cooking, extruded products (including soy fibre) should ideally be maintained in a frozen state until point of further manufacturing. High-moisture-extruded particulates provide superior flavour and textural properties and allow the integration of a multitude of protein and carbohydrate interactions ingeniously blended with flavours and nutritional enhancements such as vitamins and minerals. Semi- or high-moisture-extruded chunks provide superior flavour and textural properties and allow the integration of a multitude of soy protein interactions with starches, egg albumen, methyl cellulose, wheat gluten and pea protein, ingeniously blended with flavours and nutritional enhancements. Extrusion technology has reached a point where it is difficult to distinguish between breast of chicken and breast of chicken analogue.

Today, these protein–carbohydrate interactions may be made with a certain degree of flexibility, with soy protein isolate, rice protein, maize protein, wheat protein and/or lupine protein. Moving these products out of the strict vegetarian definition will open up new opportunities, but a holistic approach will still be needed to satisfy the flavour requirements of lifestyle consumers.

These developments will revolutionize the way industry looks at meat analogues. High moisture extrusion technology can be used to simulate meat cuts. A realistically or topographically shaped analogue breast of chicken can be formed in-line and boxed for worldwide shipment. There is little doubt that high moisture extrusion will become a cornerstone for tomorrow's food supply.

Vegetarian foods make up one of the fastest growing categories for the food and meat industry. The highest growth comes from soy milk, whose benefits are especially relevant for the current generation, as well as for the rapidly growing number of people who are lactose intolerant.

As a side note, it is necessary to mention also the availability of mycoproteins. These proteins are made from *Fusarium venematum*, a soil fungus grown in vats. Mycoproteins are all-natural vegetable proteins belonging to the mushroom family. Mycoproteins offer a strikingly authentic meat-like texture, though the real growth of this category is in a number of very interesting consumer products such as burger and sausage analogues, which are mainly a combination of mycoprotein and soy protein crumbles.

To summarize: Soy proteins have travelled a long way. Soy has made a successful transition from a cheap filler some 40 years ago to great-tasting, life-enhancing and affordable foods, becoming part of the world's everyday environmentally sound and sustainable food choices for the third millennium. Mission impossible to 'de-bean' the bean has finally been accomplished, and as a result a plethora of improved existing or innovative soy formulated foods will become available for nearly all of our food choices. From that point, it is only a small step to incorporate health-enhancing ingredients such as phytochemicals to position the meat-free product and food bars as functional foods. It is rather strange that the technological breakthroughs of extruded meat analogue chunks both in semi-moist as well as in dried forms have been initiated by entrepreneurial individuals and pioneering companies.

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3
Soy Protein Paradigms and Dynamics

The resurgence of sausage specialties came as a niche market on the heels of many years of slowly changing traditional products into mass-produced counterparts targeting mass markets. It is obvious that the typical sausage formulas of the 21st century bear little resemblance to those of the 20th century and are even further removed from the 'original' formulas of the 18th and 19th centuries. Advances in technology in both equipment and ingredients, coupled with strong scientific back-up, have allowed meat processors to gradually change formula make-up. Most of the changes are driven by the availability of new technologies and the need to drive down costs.

However, it is also fair to say that consumer demands and perceptions also have changed. One only needs to look to their desire to have lower amounts of animal fat, sodium and nitrite. Least-cost formulations are nearly always driven by the desire to improve upon the bottom line, and access greater flexibility and freedom in manufacturing variables. It is an empirical curve and expensive lean meat replacements often generate most savings.

For many years, meat processors were occupied with only one thought: to reduce the content of lean skeletal meat in order to lower formulation costs. The availability of premium functional ingredients, combined with superior technology and equipment, has indeed allowed quite significant replacement of lean meat. Meat replacement, however, can only go to a certain point before the original product characteristics, such as texture, colour and flavour, start to fade. Many of the formulae changes have been prompted by the need to improve economics. However, care should be taken that such changes are not detrimental to the consumer's perception of value and quality. Consumers are the ultimate judges.

The good news is that a plethora of sausage creations are thriving among the younger generation. A worldwide resurgence in sales of specialty sausage and meat products is encouraging. In many cases, an original sausage recipe has been developed into a wide quality range of products to address changing lifestyles.

The success of mass marketing, such as the food service restaurants, brought renewed interest among entrepreneurs who saw opportunities for quality niche products and have recreated a wide selection of meat products based on old-time favourites. With the availability of many flavours and textures, and myriad possibilities to develop, such as combination or 'integrated foods', the potential for innovative meat products is tremendous.

Understanding Formulations

Some of the formulations in this book are classic. Many of the formulations have evolved over a great many years into regional variations and flavour preferences. The purpose of this publication is to provide the reader with an overview of what is available in the many areas of product differentiation. Hopefully, this will trigger creativity in developing even better ideas and more refined processing techniques.

In the Appendices, important information is provided concerning process variables such as thermalization. The Glossary defines the most frequently used industry terminology, along with processes and technical references.

The formula variables in *Soy Protein and Formulated Meat Products* (Table 3.1) are just too many to mention. For every formula there are at least ten alternatives, which allow the meat processor to individually optimize the formula and process according to variables such as meat availability and ingredient preferences. Seemingly subtle changes in mixing time can have a significant impact on the finished product. Therefore, the processing instructions are only indicative and should be fine-tuned and optimized according to specific local situations.

It is not the recipe that is the secret. Rather, it is the functionality of the total ingredients system in conjunction with packing, equipment and skill levels of the operators that makes the difference between an average meat product and an excellent one.

Partnerships

There is a growing trend to involve suppliers of ingredients and equipment in the product development team of the food and meat processor. If managed carefully, these multi-talented teams can move ahead quickly, thereby reducing go-to-market time considerably. This can be seen as a form of outsourcing, which also allows the utilization of internal resources within a food or meat processing company in a more productive way. By teaming up internal expertise with outside professional knowledge, companies can move forward from a reactive to a proactive environment faster and more efficiently. The degree of success depends on the quality of the innovative idea and the speed to market that the ability of marketing professionals translates into business opportunities.

As technology boundaries shift, it will be increasingly necessary for core specialists to work together in project teams. These joint projects should focus on critical R&D and marketing requirements for creativity, go-to-market speed and quality. Supplier consolidation of strategic functional ingredient companies experiencing increased needs for convenience solutions, ultimately will shift focus from single ingredient delivery to total product solutions.

Table 3.1. Applications where functional soy proteins can be used.

Category	Type of product	Functionality
Ground (un)cooked products	Hamburger/patties	Improves fat and water stability
	Meat balls/bratwurst	Improves cooked yield
Emulsified products	Hot dogs/frankfurters	Improves bind values (fat stabilization)
	Bologna/mortadella	Improves organoleptical quality
		Improves cooked yield
Whole muscle meats	Cooked ham	Increases cooked yield
	Enhanced fresh meat	Improves bind between muscle sections
	Restructured meat	Improves tenderness
Dry fermented sausage	Salami	Accelerates drying
		Lean meat replacement
		Fat replacement
Meat toppings	Textured crumbles	Lean meat replacement
		Processing aid
Meat analogues	Hot dogs/patties	Improves structure, texture, stability
		Provides premium nutritive values

Together with improvements in meat processing technology, meat-free opportunities will evolve to the point of mass distribution. To capture future meat analogue market opportunities, creative and multifunctional teams need to be put into place. Unfortunately, all too often technology-driven excellence and innovations create a rather hostile environment in a company, resulting in bureaucratic gridlock. In order to allow innovative projects to move forward it is often necessary to remove people with negative attitudes and who seemingly resist change. To obtain results fast, quite often a small but dedicated hybrid and entrepreneurial-spirited team needs to be formed, providing a nucleus from which new business opportunities can grow on the basis of joint responsibility rather than personal accountability. Such an attitude enables easier cross-fertilization, know-how transfer and, last but not least, inspiration. The elite members of such a team need flexible rules, allowing thinking 'outside of the box' with an attitude to 'think big but start small', 'preach revolution but act evolution'.

Globalization of market dynamics, biotechnology, information technology (IT) together with consolidation and mergers will revolutionize the current *status quo*. However, these variables also will open up new niche markets for entrepreneurial talents.

Increased growth of customer base and increased customer demands will impact markets fundamentally, both positively and negatively. IT promotes free transmission of information, thus increasing speed of knowledge, including more transparency in market pricing. These elements can increase risk and uncertainty.

More than in the past, management experience in international markets, including strategic planning and business development, will become a vital component of success throughout all levels of segment leadership, such as R&D, brand management, human resources and visionary positioning to sharing in the profitability of the whole value chain.

Foodstores Impact

In recent years, the meat processing industry throughout the world has seen growth and consolidation, and so too has the retail grocery trade. Both the grocery and the meat processing industries have become global enterprises, crossing national borders.

Obviously there is a concern that the power of the grocery retailer is becoming too forceful and dominant. In certain countries, such as the USA, France, the UK and Germany, supermarkets are dictating product specification, packaging sizes and many other variables. This trend has resulted in often severe price concessions from the meat and food processing industry. Putting pressure on prices at the processing end of the market has become a common tactic and the processing industry is slowly coming to grips with the new scenario and adapting to survive in the changed economic environment.

Despite the current trend of seeking price concessions from meat processors, it is of importance for both supermarket and manufacturer to work in close partnership and harmony. Only then can inspiration for new product development be created, allowing both parties first hand knowledge of consumer trends, needs and wants. However, for a meat processing company the overriding question is to determine the market segments it wants to serve in order to optimize shareholder value and long-term sustainability.

At the same time, increasing pressure is mounting to provide supermarkets with 'stable to table' assurances for the fully audited traceability and quality of the meat products. Joining forces by developing partnerships will become vital, though the supermarket industry has to understand that a reasonable return on investment is a necessity to meet long-term business objectives.

The start of a reformulation process is relatively easy, but as further refinements are made it will become increasingly difficult not to stray from the original path of end-product specifications. Replacement of high-quality lean meats with less expensive skeletal cuts occurs, which ultimately leads to replacing a significant share of formula with the various forms of mechanically deboned meat, such as poultry, pork and beef. For high-volume meat products – especially emulsified meat products such as frankfurters and hot dogs – the quest is to select the least-cost protein solution. Initially, these protein selections were based on animal protein alternatives, i.e. lean pork replaced by pork trimmings, partial replacement by pre-emulsions of fat and water, and finally replacement by mechanically deboned meat.

Likewise meat species were replaced: beef by pork by turkey by chicken. Modern formulation can mostly disregard the species, since flavour diffusion technologies have been developed for many emulsified products and some coarse-ground meat patties, allowing the use of poultry but with the appearance and taste profile of pork or beef. Throughout these developments a plethora of non-meat ingredients followed on the heels of reformulation. Slowly but surely some of the functional ingredients have acquired mainstream acceptance and have managed to capture a percentage share of formulae.

In the early 1950s, major technological advantages were realized by incorporating sodium caseinate (a milk protein derivative) in fat:water emulsions to improve the stability of emulsified meat products. The main driver here was to utilize less favourable types of fat, such as pork leaf (flare) fat, beef fat and mutton fat, which otherwise could not be stabilized by the complex nature of solubilized myofibrillar proteins in the meat matrix.

Milk protein applications quickly reached beyond the stabilization of fat and became commonly used in whole muscle meats such as cooked ham, roast beef and fermented sausage. Milk protein conquered the world of meat processing, and it is generally accepted that it peaked in 1985. From that point a decline set in, mainly driven by steep price increases that reduced its economic value to the point that alternative solutions gained the upper hand. Vegetable protein ingredients such as functional soy proteins dominated these alternative solutions. However, the 'battle' of functional soy protein to be accepted as the protein of choice by a rather traditional industry lasted well over 20 years (1970–1990).

To understand the efforts of vegetable protein manufacturers to position soy protein as a functional ingredient with the same aura as milk protein, it is essential to look back in history to explain why the 's' word of 'soy' had such a terrible start. Although the word 'marketing' is American-coined, it was Americans who in 1954 decided to strategically position textured soy flour (TSF) to the Europeans as 'imitation meat'. For a generation that just had gone through the horror and hunger of World War II, the word 'imitation' set off an unprecedented negative association. It has taken three generations to overcome this.

How bizarre to see that just as soy protein was to change from a negative to a positive due to a worldwide avalanche of the health benefits of soy protein nutrition, genetically modified (GM) soy products appeared on the scene in 1996. It can be considered a major marketing blunder by biotechnology companies to push through a plan to ambush uninformed customers with foods and ingredients without first engaging in a meaningful discussion. This unilateral decision has created major damage to the positive reputation of superior functional vegetable protein ingredients. Back to square one, so to speak.

Some of the major suppliers of soy proteins were victims of the intensity of the negative name association surrounding biotechnology. At first there was little they could do, but after reality set in, a proactive attitude enabled them to answer consumer concerns by making available 'Identity Preserved' functional soy protein ingredients. Although the availability of Identity Preserved vegetable proteins is a step in the right direction, the overriding question that needs answering is to which impact the word 'soy' will be connected by the consumer. This development needs very careful monitoring, but it is likely that ultimately the ecological, nutritional and economic superiority of vegetable proteins will regain its stature as the protein of choice for processed meat products.

Apart from the above reflections and opinions, there is little doubt that vegetable protein ingredients such as soy protein isolate have proved beneficial in a large number of processed meat products. The value of functional soy protein ingredients is threefold:

- It provides technological solutions by stabilizing fat and water in processed meat systems.
- Because of its unique meat-mimicking properties, lean meat replacement is feasible.
- It provides superior nutritive value at lower pricing than equivalent animal protein alternatives.

Soy protein ingredients are now established as a protein of choice throughout the world. Their effectiveness has been proved by billions of hot dogs and other sausage products all over the world. Additionally there are many reformulated cooked ham products and fermented products, such as salami, that contain these functional ingredients. However, perhaps the greatest potential value of these vegetable protein choices is in further processed meat and food products for food-service applications such as franchised fast food stores. Perhaps the single biggest accomplishment of vegetable protein is that at the start of the 21st century hundreds of millions of formulated meat patties are sold as a result of the characterizing properties of soy protein ingredients. This trend will set the standard for new creative challenges and many more opportunities will be developed to meet the demand for affordable nutrition by a rapidly growing world population without sacrificing the organoleptical quality people have come to expect.

Food and meat products do change over time, although these changes are more gradual than many food marketers believe. Food evolution is also the result of cost considerations to meet certain price points consumers are prepared to pay at one end of the spectrum, and to product expectations that must be met at the other end of the spectrum. Ultimately, a compromise between price value and optimum quality expectations is needed to achieve lasting success in terms of repeat purchases.

Competitive Angle

In this respect, suppliers of functional ingredients sometimes forget that the replacement theory also can affect their own functional ingredients that had been used to replace another previous muscle protein source or functional ingredient. For example, soy protein isolates were replaced by the cheaper soy protein concentrate. It is a rule of thumb that the higher the unit price and the higher the inclusion level, the greater the risk of replacement by an alternative solution. To satisfy demands of senior management, R&D nearly always singles out or targets the highest price and/or highest inclusion level to generate the maximum savings. At times, something is even deliberately held back in order to have some additional reformulation possibilities for the next round of cost savings.

Real competitive advantage can only be obtained if the functional ingredient industry understands the true needs of the end-consumer and the dynamics of point-of-sale interactions. Too often the functional ingredient industry acts distanced and is less concerned about the ultimate value delivery. Both the ingredient supplier and food manufacturer must shift their emphasis from lowest price to total solution if real and sustainable competitive advantage is to be gained.

The consolidation of world brands will open new opportunities for both the larger and specialized portfolio companies who have global manufacturing and supply capabilities, yet are keen enough to create a streamlined, marketing-oriented organization to add higher ingredient value and total solution answers in order to stay competitive. Subsequently, close partnerships in which multi-talented teams participate and the ability to identify emerging opportunities will ultimately work to keep a commanding position.

Advancement in technology and changes in end-product specifications allow the consideration of alternative solutions. For example, soy protein isolate and modified food starch in combination may offer better results than the single ingredient usage alone.

Whatever the reason for changes in formulations and marketing, R&D must always keep in mind that they cannot dilute end-product specifications indefinitely. There is a limit to meat replacement. Customers do notice, and there is nearly always a competing product available that does meet expectations.

That is why the example formulations in this book can be considered typical for specific countries and regions of the world. What is considered a high meat inclusion level in Asia is not necessarily considered high in Europe. On the contrary, the latter is certainly also true for functional ingredients such as soy protein, hydrocolloids and modified food starches. The formulae in this book are typical and every effort has been made not to single out functional ingredients as the only possibility for achieving satisfying results. Nevertheless, time-tested functional ingredients usually offer benefits in terms of yield, process tolerances, availability, technological support and competitive pricing.

The globalization of the marketplace presents many challenges for both the food and processed meat industries. It is safe to assume that unrestricted trade and liberalization of food legislation will continue to evolve at an ever-increasing speed. It will therefore be of paramount importance to anticipate changes and to adapt interactive technologies and marketing communications to maintain and improve upon leadership positions. At the same time, the need to satisfy shareholders and optimize profits will force many companies to reconsider their current positions so that they remain competitive in providing value-building blocks that ultimately will deliver foods at their most economical and nutritional values.

The widening of global markets to segmented food and meat product innovations will create a broadening of the availability of functional ingredient solutions. Today's essential functional ingredients might be obsolete tomorrow, and it is likely that alternative solutions will be based on functionally integrated multi-purpose ingredients. In order to remain competitive in terms of product development solutions, nutrition and economics, producers of functional ingredients need to anticipate the changes that are driving the marketplace.

Much more than in the past, food service and other food marketing companies expect ingredient suppliers and processors to create new products. There is fierce competition between suppliers of strategic ingredients to attract the attention of the customers, especially knowing that the inclusion level of these ingredients often is relatively small. Most often, these ingredients are either new to the market or have a relatively high value surcharge. It is very difficult to succeed in this highly competitive arena, and persistence, together with a 'finished foods' mentality, is the key factor in achieving optimum results. A key predisposition is the need for frequent interaction between the supplier and the client throughout R&D, marketing and in-plant production assistance.

For muscle food manufacturers, much will be at stake and momentum can switch very rapidly if changing environmental issues aren't identified and addressed in a timely manner. The innovative food product of today can become traditional and even obsolete tomorrow, and there are many examples where newly introduced processed meat products have changed the playing field. The pace of change doesn't show signs of slowing down in the near future.

For example, the need to satisfy consumer demand for calorie-restricted foods has accelerated the time-consuming process of changing food legislation. Governmental agencies have recognized that relaxation of legislative hurdles needs to follow the sometimes dramatic changes in food processing technology.

Old is New

Interactive technologies that combine functional ingredients, including flavours, colours and fragrances, have the potential to become new benchmarks for food designers. In these situations, the once dominant meat sources have almost completely lost their importance and have actually become functional ingredients on their own. The lack of typical characterization and identification of processed meats has provided opportunities to create innovative foods that are drifting far away from tradition and ethnic preferences. Cross-cultural foods will ultimately develop for coming generations that will show little or no appreciation for the foods that their grandparents once loved, although it is likely that calorie-laden 'Old World' specialty sausages will always remain a focal point for people who have the urge to indulge and are looking for special occasion foods. As long as good-tasting sausages are available, demand will continue.

Packaged meats, including emulsified meats and lifestyle foods, will experience major changes in both concept and product development as a function of the many innovative solutions that address production, economics and sensory requirements. Manufacturers of processed meats will sooner or later have to face a dilemma – a crossroads so to speak – and it will be necessary to strategically position their strengths for tomorrow's opportunities. Or to put it bluntly: meat manufacturers should be looking for the high road of continuing demands for the current range of meat and poultry products, or opening up for diversification and positioning new concepts as segmented products for specific consumer needs. The decision is not easy to make.

The future of formulated meat, poultry and lifestyle foods will also demonstrate a shift to nutrition management. It can be expected that micro-ingredients will be added to meat or vegetarian foods in order to improve their vitamin and mineral profile, enhance digestibility, support antiviral and antimicrobial activity to strengthen the immune system, and incorporate the use of cryostabilization compounds, such as polydextrose. For example, the combined use of dietary antioxidants such as dried plums and soy protein. These functional ingredients provide isoflavones that are high in oxygen radical absorbance capacity (ORAC) and apart from providing organoleptical benefits such as moisture retention, antimicrobial properties, flavour and texture enhancement, these micro-nutrients may help to slow the process of ageing in the body and brain.

Even within the same formula, competition for percentage of formula share is very intensive: mechanically deboned meats are being replaced with by-products, which are replacing skeletal meats. Functional limitations ultimately will be decisive, and the least-cost provider will grab the real growth opportunities.

The ongoing effort to lower food costs has forced many processors to change quality specifications with a subtle degradation of sensory product characteristics. As with many other non-foods, there is a tendency to create extremes. The 'middle-of-the-road' quality will probably disappear, and these products will be forced to position themselves at either the upper or lower end of the price spectrum to satisfy consumer needs. Many low-cost foods have degraded to the point that palatability has become questionable. Ultimately, the consumer will reject these products for something else. It is therefore imperative to base cost-driven reformulation on sound, reliable functional ingredients that allow replacement of a portion of the lean meat while maintaining texture and without losing sight of nutritional considerations.

Price is always a consideration, but consumers are not willing to trade out taste for lower prices. Consumers demand foods that satisfy their primary needs: taste, taste and taste only. Only after these basic needs have been satisfied are people willing to listen to the sublime message of health, value and convenience.

A surge of non-traditional products will pick up steam, but people nearly always will come back to basics. A sit-down dinner is one of these basics, and probably one of the true remaining joys that people have, even though the percentage of people who agree that it is important to eat a regular and traditional meal continues to decline. Let's not forget that humans have an obstinacy and strong determination when it comes to giving up foods they love. Many of the foods of yesteryear will be with us in the future.

A significant proportion of people in Western countries are working longer days and this could lead to eating four times a day, not to mention that grazing and snacking are quickly becoming a way of life. No wonder hand-held foods, including food bars, are the fastest growing segment, not least because it is estimated that about 20% of all meals consumed away from home are eaten inside the car.

Shifts in demographics and psychographics will also impact the traditional lunch menu of today. The typical lunch hour is disappearing, and increasing numbers of people choose to do things other than eat during the mid-day break. Instead, people increasingly eat 'on the job', and the latter is also true for eating breakfast at the office desk. Strangely enough, as people grow more dependent on technology, there is an unmistakable shift to perishable and natural foods. Refrigerated foods coupled with convenience, environmentally friendly and generally affordable foods, will become the norm for the next 10–20 years. This development is a strange ironic twist: techno-literates are in search of the goodies and reliable qualities of Mother Nature.

Of course, an elite and strongly motivated group of consumers exists who try to live their lives based on the recommended dietary guidelines. For these people it has become important to add life to their years, rather than simply hope to add years to their lives.

There is no denying that consumers in modern society have shifted their eating patterns. For example, for a specific group within modern society, the consumption of red meat, eggs and milk continues to decline, and people are actively cutting back on fat and cholesterol. However, at the same time it has become obvious that despite all predictions that were voiced a few years ago about massive change to healthy eating, the teens and young adolescents of today have just about had enough of forced health and fitness issues. They have started to resent dogmatic health advice and tasteless foods.

Despite an avalanche of health-related messages by special interest groups, such as dieticians, to cut back on fat intake, consumers have finally come to realize that fat intake is their problem and not the fault of the foods. There is no such thing as bad foods, only bad eating habits.

Modern societies often demand convenience and indulgence, which actually means that the 'natural' food solutions are not always practical. Diets have become very complicated, and all logic seems to fail in trying to explain behavioural patterns when food is brought into the equation. Modern consumers will increasingly reject the nagging notions that continuously remind them about eating sinfully. Almost all food marketers have positioned at least some of their mainstream food products on the periphery of the health food market. Despite much media attention to baby boomers' obsession with healthful food and fitness, only a small portion of adults have adopted a lifestyle that includes good diet and exercise. (Baby boomers reflect the post-World War II generation.) The future will increasingly be dominated by so-called convenience foods, in which 'health' need not always be translated into nutritionally superior foods. Increasingly, people will start looking for 'no-brainer' foods, and it can be expected that a growing connotation of perceptual satisfaction and self-esteem needs to be communicated.

In recent years it has become obvious that a healthy diet is closely or intimately associated with the pure enjoyment of eating. People want to feel good about themselves, and the taste of foods plays an important role in sustaining well-being. Increasingly people are convinced that health and diet can go hand in hand with superb taste. Although the majority of modern consumers know that a healthy diet should be low to moderate in fat, only about half of all consumers have the willpower to make long-lasting changes in their diet. At the same time, consumers are much more demanding, insisting not just on health benefits and great taste, but also on instant gratification, convenience, choices and fresh food selections.

Thus, it is too early to write off the 'not-so-good-for-you' foods. Perhaps consumers are truly confused about what to believe from the multitude of contradictory health messages. Just to make a statement, consumers occasionally want to fulfil their desires and reward themselves with indulgence, if only to show their independence in an effort to claim their own territory in the complicated world of survival of the fittest. So, therefore, marketing companies are increasingly confronted with consumers who happen to live in a paradox. Seen from a consumer perspective, things are getting better and worse at the same time. For example, a career can be a sign of success and accomplishment, yet at the same time be viewed negatively for not allowing sufficient quality time to be spent with family and relatives. For those that are 'cash rich–time poor', this paradox can cause friction and a sense of loss of control.

Demographic Changes

Changes in demographics are creating important food trends, but these demographic changes are not universally the same throughout the world. In the developed countries there is generally an ageing population that is more health conscious and has more discretionary money to spend. At the same time, some segments of society remain at the other end of the economic spectrum; it is the age of both prosperity and austerity. These separate segments will drive out average-priced quality and force food marketers to position the foods at either end of the scale.

Traditional family meals are disappearing rapidly. Instead, people more often eat alone without the pleasures of relaxation and dinner table conversations. The huge availability of food, food service, home meal replacement and a well-stocked refrigerator has created a society where consumers expect instant fulfilment. The consumer's social context of food and diet will continue to provoke sociological changes and galvanize both corporate and family cultures.

Also, the rise of women in the workplace has shifted food purchases significantly, and new concepts such as home meal replacement foods, also called comfort foods, are not just restricted to the USA any longer.

Comfort foods is a term for home-style cooking that is prepared by food marketers and full-service restaurants and mainly purchased by working mothers feeling guilty about not having the time to cook for their families. Home meal replacement can be defined as the business of providing convenient, homestyle-quality meals that consumers would prepare for themselves if they had the time, energy or know-how. From these definitions, it follows that meal purchasing decisions increasingly are made on the same day, even just a few minutes prior to purchasing. Thus, a more holistic food service mentality will replace traditional thinking, with the result that 'meal solution centres' will become the norm rather than the exception for future generations.

The typical function of restaurants and food stores will see major changes in the years to come, especially with regard to making customers believe that they purchased homemade, made-from-scratch meals, while in fact this might not be true. 'Homemade' can refer to several different preparation methods such as heat and serve, or thaw and serve, and speed-scratch-cooking. The perception of a homestyle environment, taste, health, quality, quantity and convenience will remain very important.

Home meal replacement became a catch-all phrase when lifestyle started to clash with a full day at work and no time or desire for home cooking. It seems home meal replacement is evolving and moving toward 'ready-to-make' foods at the home kitchen. A recent new development is the arrival of the meal kits. These meal kits contain sub-packings of fresh components such as rice, sauce, vegetables and cooked meat. All the customer has to do is assemble (for example, stir fry), heat and eat. A meal kit can be prepared in the same time needed to heat a traditional ready meal in an oven or microwave.

Increasingly, food retailers are competing with food service by offering genuine take-away solutions. However, a small but distinct difference is that food service operators offer meal solutions that are ready to take home and eat, while food retailers generally focus on meal components that still need some assembling and heating at home.

It is likely that the once dominant centre-of-the-plate position of processed meat and poultry products will change, and traditional meat cuts will be transformed into formulated foods in which meat serves as an ingredient, rather than the characterizing product. It can also be expected that protein-enhanced lean meat cuts will replace a significant portion of both traditional fresh cuts of meat. Protein-enhanced case-ready meats will take the guesswork out of cooking, while dramatically improving organoleptical quality. All signs indicate that functional and nutritional ingredients such as premium soy protein will be an important part of these developments.

Can't Cook, Won't Cook

Grocery stores will need to reclaim some of their lost territory and will focus on becoming the main competitors for the many styles of fast food restaurants. The food stores of the future will increasingly feature expanded made-to-order and ready-to-eat foods within a more extensive section of the store. The biggest psychological advantage is that consumers will actually see some of the foods being prepared by chefs. Purchasing decisions will be influenced by free sampling, recommendations and many pleasant food attributes, such as colour, appearance and smell. Based on emerging trends, it can be expected that choices at the food counter in the grocery store will be better, while prices will be competitive. It is only logical that as food retailers start to emphasize home meal replacement departments, they simultaneously will de-emphasize the traditional grocery elements.

The move towards home meal replacement concepts to create signature dishes will also increase pressure for branded products. In the struggle for the consumer's attention, the name brands stand the risk of losing their identity, simply because of the many comprehensive meal solutions that will become available.

Home meal replacement can be bought as a complete meal and/or as a meal component which will preferably have high and fresh quality, ease and convenience of availability, give value for effort and can be eaten instantly or slightly later. Changing lifestyles will drive most of the changes in the meal replacement business. People are looking for convenience, and they want to save time too. A possible downside to eating away from home is that people tend to graze more and eat less-nutritious food. For many people, the workload has become so intense that the traditional take-in lunch at the office or factory has been replaced by two or three meals away from home to satisfy the extended daily working hours. With two parents working and a busy schedule, home meal replacement will become a viable option to help people deal with these changes.

Another major development is the broad variety of novelty foods becoming readily available. At the same time, the decline in home-cooked foods, especially for dinner, is impressive. For quite a segment of the population, including some developing countries, cooking from scratch is fast approaching dinosaur status. This will open up entirely new market opportunities for the processed muscle food industry to vie for market share by developing value-added, work-free foods.

In 2003 the average American consumed about 152 meals away from home. Hours spent cooking have dropped more than 20% since 1985, and there is no reason why the growth of prepared foods shouldn't continue.

While there may be a subtle shift in where consumers spend their food money, an increasing portion of it is spent away from home. Whatever the format, fast food, casual dining restaurants and specialty culinary cuisine restaurants remain popular places for centre-of-the-plate meat, poultry and seafood selections. In times of economic recession people will trade down in their restaurant selection. However, people who are used to eating out do not easily make the switch back to food preparation in their own kitchen.

In the USA the ratio between at-home food consumption and away-from-home meals is about 50–50. It is expected that away-from-home food consumption will continue to increase. Menu diversification, including vegetarian choices, is the major driving force. To offset the so-called 'veto-vote' of a family member, food service operators frequently offer meat-free options. Quite often these vegetarian-oriented product offerings have a better-for-you image. However, restaurant owners and food service operators have usually great difficulty in pinpointing the true meaning of 'healthy'. Over the years, the definition has evolved from low calories and low fat to freshness and lean premium protein selections.

It really is sad, but the cooking skills of the first generation of the 21st century have dropped to the point that if a recipe calls for more than four or five ingredients, people won't bother to try to prepare it themselves. The many cooking shows on television are pure entertainment for viewers and are a substitute for spending time in their own kitchens. Elementary skills, such as cutting a dinner steak with a knife and fork, are disappearing, and therefore traditional meat and poultry foods need to be recreated into other forms and shapes of value-added products.

Grocery stores will probably opt to have certain foods prepared from scratch in-store, while other foods, such as salads, will be brought in from a central location. This will allow consistency of quality, differentiation and price competitiveness. Ready-to-eat, health-conscious food selections offered by food stores will be significantly wider than that offered by fast food restaurants. The footprint in retail stores given to chilled prepared ready-to-eat foods and meals is increasing rapidly. For certain consumer categories, food has become tied to fashion trends and fashionable cycles. It is only a question of time before large grocery stores start opening up drive-thru and/or special pick-up services to take the time factor out of the equation.

Value addition to food service products can be described as the skill of bringing raw, unfinished products closer to the point of consumption. The power of brands will increasingly influence consumer purchasing decisions, which are often based on emotional reasoning. These decisions frequently override the rational, logical reasoning driven by the left side of the brain. As a result, it can be expected that co-branding will emphasize the 'feel good' images of consumer's self esteem. Therefore, for the food service restaurants, casual dining, and kiosks or supermarkets, the offerings of value-added products and services will be increasingly dominated by psychologically driven purchasing attitudes. The food and the services with the highest total value will ultimately generate the highest profit. The latter is also true for packaging and point-of-sale presentations. Studies show that consumers formulate persuasive opinions at first eye contact with packaging and illustrations. These direct marketing elements are extremely important for the brand image and anticipated quality and wholesomeness the consumer expects.

The ultimate answer to the 4 p.m. question 'What's for dinner?' is freshly prepared ready-to-make or ready-to-eat meat and poultry foods together with vegetables and other condiments. These quasi-home-cooked foods offer pre-portioned prepared meat cuts which can be either cooked at home using real pots and pans for busy lifestyle people without all the preparatory work such as chopping, peeling and marinating. However, convenience and time-saving attributes are not the only factors consumers are looking for. Increasingly, preference is also given to products that offer nutritional benefits and exciting flavour profiles. Of all muscle foods, poultry has been the trendsetter of nearly all innovations, mainly because of its versatility of preparation and nutritional profile. Pork and beef is still catching up in this arena, but newer technologies such as soy protein enhancement of certain meat cuts drive new product development. Technologically speaking, the specific properties of functional soy protein allow less desirable meat cuts to contain a protein-stabilized marinade which significantly improves organoleptical quality and ease of cooking. These meat cuts are thus turned into 'tender ready' foods designed to be real timesavers.

In today's rapidly changing environment, the essential issue is not where the food is consumed, but rather where and how it is prepared. The shift of food spending away from the traditional grocery stores will continue to accelerate food service sales, including fast food restaurants. However, food service operators will see significant changes in the early years of the 21st century. Consumers will expect that their home meal solutions provide high-quality, fresh prepared foods at reasonable prices. With this concept, taste will remain the driving force, followed by nutrition, price and product safety. Co-branding partnerships will probably be implemented to generate savings that meet business objectives. Almost all incremental growth in food sales will be channelled through food service operators. This trend is potentially alarming for traditional supermarkets. For the processed meat and poultry industry, this trend signals an equally dramatic shift in the positioning of processed meat and lifestyle foods.

For example, spicier foods are obviously linked to cross-cultural influences such as travel and migration. However, it is also true that ageing people have decreasing taste-sensing ability and thus prefer food and meat products with a somewhat spiked spice profile. In the USA, chilli pepper consumption has doubled since 1980, and these changes will have an impact on how food and meat products are positioned to targeted consumer groups.

It is important to bring innovation and creativity to the food service business. Being Number One in a market category leaves no time for arrogance. It is imperative to keep the entrepreneurial spirit alive to allow new ideas a chance. This is especially true for the rapidly changing supplier–consumer relationship.

Food stores are becoming like restaurants and vice versa. This opens the door for a deeper penetration of branded franchised food service stores. Brand equity and brand expansion can only succeed if food value is successfully coupled with understanding and anticipating consumer needs and desires. These operating strategies need to embrace an intelligent, carefully scripted approach, including innovative product initiatives and a cost-management programme.

Even time-tested, proven menu foods are subject to changing consumer preferences and lifestyles. It will be increasingly important to have truly distinctive products that adapt to changing preferences for flavour, taste and 'feel-good' experience. Although pricing is an important tool to generate incremental growth or new business, aggressive, price-driven advertising is not necessarily the only focus point. To capture changing lifestyles for a wide selection of the population, the franchised food service industry will increasingly have to offer a combined experience of food and fun. Consumers who dine out expect food to be offered in a total value-package of entertainment, great taste, price and health.

There is also little doubt that the definition of convenience will continue to evolve, and since consumers' lives have become progressively more complex, the emerging trend clearly focuses on finding better ways of getting the food to the consumer. Food service operators are expected to create an ambiance of fun eating experiences to satisfy a broad range of target groups.

A significant part of this change will be attributed to the emerging trend of nutrition management. As people grow older, an inner urge to stay young will increasingly influence purchasing decisions where the focus will shift from 'taking the bad out' to 'putting the good in'. Special foods, such as designer low-fat processed meats and vegetarian meals, together with functional foods, nutraceuticals or 'vita foods', will supplement specific requirements for individual consumers. Under such a scenario, it can also be expected that an emerging product line will be the 'health-shake' solutions offered by fast food restaurants and on in-flight meals. These meal solutions will provide specific nutrients for people with a specific active lifestyle, or ageing consumers. These foods can contain high protein and high fibre coupled with, for example, antiviral and immune-boosting supplements and/or anticancer soy-based isoflavones.

For example, most Western diets are simply too rich in fat, fully refined carbohydrates and animal protein, resulting in conditions such as digestion problems. To alleviate these conditions, consumers often use medication such as laxatives. The downside is that the intestinal tract becomes less active, resulting in serious health problems. It is therefore important that foods contain soluble and insoluble fibres. Soluble fibres swell in the stomach and slow the stomach evacuation, while insoluble fibres reduce diet calories resulting in a shorter transit time and softer stool. It is expected that extruded meat-free foods containing wheat, soy and oat fibres are ideal for increasing the fibre content of the daily diet and counteract the ingestion of increased calories, subsequently preventing diet-related diseases. Many of these foods are still in the developmental stage, yet are getting close to market introduction. For example, semi-moisture or wet-extruded meat-simulating chunks have been introduced to the marketplace and are positioned as tasty, nutritionally and environmentally superior foods for sophisticated and demanding consumers.

In most countries, however, food regulation is still a major handicap for wider and faster acceptance of functional foods. As consumers move into older age, they become more concerned about health. In most developed countries, people over 50 years of age own most of the nation's wealth. This allows extra expenditure for dietary requirements. Both medical issues, such as cardiovascular diseases (CVD) and lifestyle issues, such as well-being, can be the driving motives. If long-term health benefits can be proved, it will become obvious that prevention of disease is less traumatic and also saves considerably on hospitalization costs.

There is a definite change in consumer focus from cure to prevention. Consumers have moved from a reaction mode to self empowerment, in which increased quality of life, health and emotional well-being are key parameters. Consumers search for convenience products that meet their hectic lifestyles and most of them believe that certain foods have benefits that go beyond basic nutrition. From here it is a rather small step to functional foods. This category can be divided into foods that are intrinsically healthy; foods that are fortified with additional nutrients; and foods specially engineered to obtain specific health benefits. To date only a few products have been introduced that have been clinically researched and documented as proven. The latter probably is also the main reason behind the lack of endorsement by physicians. Yet, at the same time, some marketing companies of nutraceuticals are frustrated by the lack of nutraceutical education at medical schools and universities for the medicine students. It is obvious that patients and consumers are looking to medical doctors for advice, however most of these healthcare professionals just don't know. Therefore, for functional foods to become generally accepted and successful, it will be essential to have strong and evident science-based information available that can be clearly and concisely communicated.

Future diet decisions most certainly will focus on positive food adjustment, rather than food avoidance. It is highly likely that food research in health and nutrition will continue to confuse the consumer, which subsequently results in ongoing diet fads. Although the functional foods will continue to change consumers' diets, it should also be taken into consideration that today's most popular foods will almost certainly still be popular 10 years from now. However, to improve upon convenience, the most popular foods will be made available at greater serving speed, which translates into greater simplification, pleasing both the food service provider and the consumer.

All the reasons cited above reflect the continuation of the consumer's exodus from the kitchen. An increasing number of people these days have never cooked a meal from basic ingredients. Consumers will increasingly seek more pleasure from everyday life, and the approach toward healthy eating will change from taking the bad out to putting the good in. Future food selections will be part of total nutrition management, which will be personalized, enabling people to specify their own nutrient requirements. A new food pyramid will certainly reflect the changes in society and environment.

Yet, the demand for new culinary experiences will open up potential adventures with ethnic foods and/or cross-cultural foods. For example, ethnic mixing will promote the creation of hybrid cuisine. Value will continue to be an important parameter in the consumer's decision where to spend food money. Restaurants will offer more food than is strictly necessary at relatively decreasing prices. The latter will narrow the gap between the costs of eating out versus eating meals cooked from scratch at home. In other words, there will be a decreasing emphasis on single ingredient components and an increasing emphasis on good-tasting, freshly prepared healthy foods at value pricing.

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4
A Long and Winding Road: a History of Meat Processing

Great-tasting sausage takes time to prepare and often busy lifestyles don't allow for the time and the mess in the kitchen. Pre-cooked sausage is the answer and new formulations together with in-plant thermal processing technologies have now been put into place to deliver ready-to-serve sausage which is juicy, tender and above all great tasting.

The same is basically true for refrigerated luncheon meats. Service-deli meats have been popular for a great many years and for some markets these products will continue to offer traditional favourites such as Parma ham and Old World mortadella and salami.

These deli meats come in many versions, though it has become clear that consumers have a strong desire for ultra-thinly sliced or 'shaved' cold cuts that look and taste as if they were freshly sliced at the deli counter. Often these premium whole muscle lean meats are in re-sealable, clear plastic containers, for example honey roasted and smoked turkey or brown sugar-roasted ham.

However, before detailed processing technologies and formulation variables are discussed, it makes sense to sidestep the future and indulge in history and read how sausage made the journey through the world.

The story of sausage, as every historian knows, is a tale of inspiration, innovation and intestines. Sausage, a cylindrical-shaped product, was invented to find a good use for the leftovers of premium muscle meat, preserved in animal casings by using curing salts, smoke and cooking. Without a doubt, sausage has evolved into a very diverse food product. With meat and fat and basic condiments, literally thousands of varieties have been developed and many of these sausages have been made since the very early days of civilization.

Climate, religion and local availability of ingredients influenced many recipes. Sausage has become a truly cultural 'link' to the world of fast-paced consumers who long to eat products that have been passed on from generation to generation. An anthropological déjà vu!

The meat industry is probably one of the oldest industries in the world. Some 12,000 years ago, at the end of the ice age, domestication of animals started in the Middle East. Some 8000 years ago, meat traders and butchers settled in Middle East towns. Probably the earliest appearances of slaughterhouses occurred in Egypt some 4000 years ago.

Sausage is one of the oldest forms of processed food. It is truly remarkable that by 589 BC, the ancestral Chinese made a kind of semi-dried sausage called 'lup-cheong'. This sausage contained small pieces of lamb, salt, sugar, green onions, pepper, wine and soy protein. In the later dynasties, lup-cheong sausage contained pork. Since the Chinese did not really care for the acidic flavours associated with fermenting lactic acid bacteria in dry sausages, about 10% sugar and 2% crude salt were used to act as a preserving agent. After stuffing in a 25 mm casing, lup-cheong was dried above a charcoal fire for about 5–6 h, after which it was ripened for about 7 days. This product was sliced and eaten together with steamed rice and stir-fried vegetables. About 700 BC, the Roman Empire became increasingly sophisticated with the development of salted meat and sausage to feed soldiers on the move over long distances.

During the Middle Ages most international meat trade was conducted between European countries. The first shipment of live cattle from the USA to Europe occurred in 1868. However, international meat trade really transformed with the development of chilling and freezing systems. It has been reported that in 1875 the first shipment of chilled meat from the USA to the UK took place.

At least 2000 years ago, the Egyptian dynasties, the Greeks, Romans and Babylonians were eating sausage varieties that later became classic products the world over. The original sausages most probably were blood sausage, liver sausage and coarse cooked sausage. The typical emulsified sausage and the genuine fermented dried sausage are a more recent development and can be considered as being of European origin. It also has been reported that Native Americans cut up dried meat into pieces that they mixed with dried berries. This combination was pressed into a cake called 'pemmican'. Also of interest is the way the Aztecs processed meat. The original 'machada', a form of dried beef, was crushed and shredded by stones until only fine meat fibres remained.

It is very likely that preserving whole muscle meats preceded sausage-making. The Armenians are credited with preserving whole muscle meats in a way that now has evolved into the famous delicacy pastrami.

Pastrami is a cured, whole muscle meat made from mutton or beef, the evolution of which goes back to Armenia, from where it travelled to Turkey before becoming popular in the USA. Literally translated, pastrami means 'pressing'. The original word in Turkish was basmak, which became bastimak. From there the word evolved into pasterma and pastrima or pressed meat. This word dates back to ancient times, when salted, whole muscle parts were transported on the sides of horses, literally bouncing excess water to the surface, drying and preserving the meat.

Meat preservation by fermentation, or by lowering the pH, has been done for at least 2000 years. During ancient times, the Egyptians utilized indirect acidification. They stuffed chopped and flavoured meat into animal intestines. The naturally occurring bacteria in the meat multiplied and consumed carbohydrates, producing lactic acid. The storage of the sausage in a warm place, together with drying and pH lowering, produced a stable product. (See Nitsch, 1993.)

Intimately linked with the journey or evolution of sausage is the journey of spices. In fact, the spice world has flourished for centuries and the search for new spices and herbs led to the discovery of new trade routes well before the Middle Ages. Spices were highly valued and apart from being used for flavouring, colouring and preservatives (antioxidants), our forefathers knew then about the medical use of spices and herbs to combat a wide range of diseases. Actually, modern pharmacology and apothecary finds its origin in the medical remedies provided by spices and herbs.

The role of spices in world history is undisputed. Spices and herbs have been used by mankind in a great number of applications such as medicines, embalming preservatives, perfumes, cosmetics and a host of food and meat products. Documented early use of spices and herbs dates back to ancient Roman and Greek times and ancient civilizations of China, India, Mesopotamia and Egypt. Around 600 BC, the Arabians organized lucrative spice trade routes from the Orient to the Middle East and Europe. The secrets of spice-growing regions were carefully restricted to the inner circle of the Arabian traders. In AD 40, the Romans wrote in their cookbooks about the culinary wonders of spices ranging from flavour enhancement to preservation and as aids to digestion. With the demise of the Romans, spice usage declined and did not see resurgence until the 12th century. For example, mustard is an ancient seasoning favoured by the Romans who introduced it throughout their rapidly growing empire. Many centuries later, the British developed a method to mill mustard seed into fine powder. Another old-time favourite is ginger. This seasoning is perhaps the world's longest used ingredient, dating back to some 3000 years BC. The Chinese traded this expensive product with the Greeks, who used it not only in meat and food products, but also for medicinal purposes, such as for the treatment of stomach cramps.

The founder of Islam, Mohammed, was involved in the spice trade until his early forties. In the 8th century, his army moved into Spain from northern Africa, not only conquering the Spanish monarchy but also influencing local cuisine by introducing new spices. Another example of the great importance of spices can be found from writings in the 13th century, when peppercorns were temporarily used as currency because of a shortage of gold and silver.

There is no doubt that the quest for spices greatly influenced exploration voyages to the Far East by famous navigators such as Vasco da Gama, Magellan, Columbus and Diaz. Extreme endurance, perseverance and hardship intermingled with golden rewards when new spice sources and territories were found, becoming the hallmark of new continents and ultimately for the world of meat formulations.

In very broad terms, spices can be defined as dried plant products used primarily to season food. Spices and herbs are closely associated. Herbs are the leaves and stems of soft-stemmed dried plants. Herbaceous plants usually grow in moderate climates, whereas spices generally are cultivated in tropical regions. For meat and poultry formulae, spices and herbs are the basis of a wide variety of seasoning blends, such as curry powder or chilli powder. Industrial seasoning blends often contain spice extracts mixed with sugar that acts as a carrier. Additionally, essential oils, which are aromatic, volatile spice components and oleoresins, which are solvent-extracted ground spices, bring characteristic flavours and aromas to processed meat.

Excess and Famine

If one wants to know how European people ate in the Middle Ages, one only needs to look at the many paintings of the Dutch artist Pieter Brueghel. Throughout the years between 1000 and 2000, times of plenty were followed by times of hunger. Famines instead of golden harvests often were the result of weather and war. Then there was the influence of city life and country life, not to mention the influence of the diet in the social hierarchy. The first known cookbook *De honesta voluptate et valetudine* was written by Platina, Italy, in 1465 (see Fig. 4.1 for example of cookbook).

Peasants, merchants, church clergy and nobility all had their position in the food chain. Peasants generally had to make do with a simple diet of brown bread with

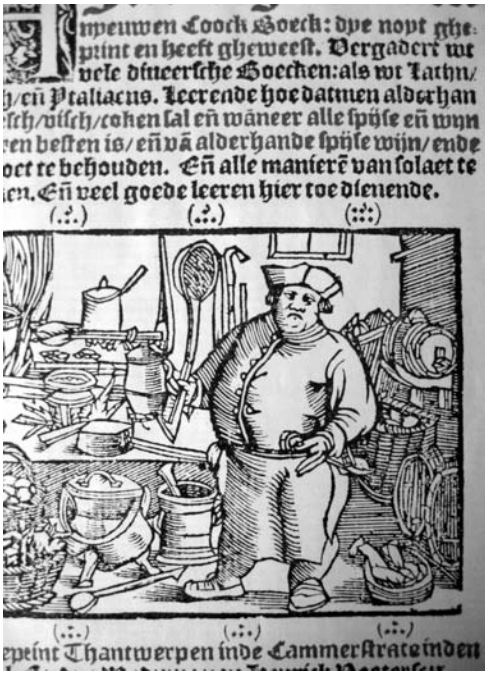

Fig. 4.1. Illustration from 'Eenen Nyeuwen Coock Boeck' (1560) by Gheeraert Vorselman, Medical Doctor, Netherlands.

bran, meat leftovers, including lungs, tripe and blood sausage, and eggs and vegetables. In times of shortage, bread flour was often diluted with rye, lupine and tree bark. Come to think of it, that's not a bad diet by today's standards. Nobility and clergy, on the other hand, enjoyed all the goodies, which the nutritionists of today frown upon: white bread, choice gingerbread and pastries, and select cuts of fat-rich meats, including liver and brain. Strangely enough, vegetables were avoided because these were considered as a food for the lower class, with asparagus being the exception. Asparagus was believed to be good for potency and to relieve constipation. Fruits that grew close to the ground such as strawberries were not eaten by the upper class either. Only fruit that grew 'close to heaven', such as apples, pears and apricots, were seen as a gift from God and were always present on the dinner tables of the happy few.

Of interest is the word 'course', which actually was coined in the Middle Ages. Course did not refer to a particular dish but rather to the amount of prepared food that one servant could carry on the course from kitchen to dinner table.

During those days it was common practice that royalty and nobility had the prime and sumptuous selections of foods served at the head of the table, while at the foot of the table generally low-quality courses were being served. As is still customary in parts of China today, in the late 17th century it was still good etiquette for people to reach into a common pot of cooked meat with their hands. The knife and fork as eating utensils did not make it to the dinner table until about 1550 and 1650, respectively.

Liquid food was an essential part of every meal in the Middle Ages: water, wine and beer. Beer often was flavoured with spices, such as cinnamon. There was also huge consumption of sacramental wines in convents and monasteries. The nuns and monks nearly always had choice foods available, brought to them by peasants in the hope of future reward in heaven.

The wide use of spices and herbs actually began in the Middle Ages and started to decline in the 17th century, when only pepper survived as the spice of the poor. However, in the Middle Ages talented chefs used a rich selection of spices: nutmeg, cloves, saffron, cardamom, cinnamon and even the colour sandalwood were available for exquisite food dishes. The use of spices as medicine dates back to the great Greek physician Hippocrates (460–370 BC). Perhaps the value of phytochemicals is not something uncovered by the third millennium generation after all.

The British, who preferred thick ales brewed from barley, also laid the groundwork for sweet dishes. The use of cane sugars preceded the use of beet sugar (1750) by almost 1000 years. The wider availability of sugar and honey created new delicacies such as nougat, marzipan and candied fruits and nuts. It is believed that the creation of confectionary emerged in Catalonia. Top-notch cooks were considered priceless and their skills and arts demonstrated for the host their social prestige.

Per capita meat consumption varied widely in that era as a factor of geographic location and the extent of prosperity.

Origins of European Sausage

Mortadella and bologna are uniquely associated with the Italian town of Bologna. Mortadella is derived from the Latin word 'mortarium' – as in mortar – and refers to a technique used to manufacture the original sausage. In the 16th century, Cristoforo de Messisbugo wrote the first known recipe and preparation process for mortadella. By the 17th century, mortadella was already well known throughout most of Western Europe. It is amazing to know that during this time the quality of sausage products was tightly regulated by the Salaroli Guild, whose statutes also contained by-laws to prevent adulteration.

1730 saw the introduction in Italy of the first acidified dried or fermented sausages, or salami, which actually means 'salted'. The ancient town Salamis refers to an association with salami.

Only 5 years later, the German town Göttingen reported the introduction of a

(a)  (b) 

Fig. 4.2. Drawings of a German meat factory (*c.*1720).

new style of dried sausage called mettwurst. This fermented product was made of coarse-ground pork and later became known as zervelat sausage. The same reports also indicated that these early products were transported in 1769 to Sweden, England, Holland, Turkey and even faraway places such as India. Apparently, the first salami sausages were exported from Italy to Vienna in 1775 (see Fig. 4.2 for example).

In 1835, two Italian sausagemakers settled in Hungary and started what is believed to be the first salami manufacturing plant, producing the early prototypes of the legendary Hungarian salami. With regard to the method used to preserve the sausages, many questions remain unanswered. It is not precisely known whether lactic acid bacteria were used by design or by chance to activate the fermentation process and thereby enhance keeping quality. Not much was actually known about the function of microorganisms until Louis Pasteur in 1856 revealed much of their mystery by inventing a process of heating liquids to destroy harmful or unwanted organisms. The process of pasteurization still ranks as one of the most important steps in today's food safety. Pasteur's discovery was preceded by Nicolas Apert, who in 1795 invented a way to preserve fresh foods and meats by heating and sealing in metal or glass containers. However, it took until 1896 before Fredrich Heine succeeded with the first production of sterilized or canned frankfurter sausage. In 1875 the German Meat Association (DFV) was established and in 1900 the German Sausage Manufacturers Association was formed. Processed meat production was a very important contributor to the economic climate. In the USA, it was not until 1923 that the USA automobile industry overtook the processed meat industry in terms of dollar value. (See Fischer, 1992.)

In 1920 DuPont invented cellophane and this breakthrough has pushed much of the technological innovations and design advancements.

It is clear that for the meat industry the Industrial Revolution started in the early years of the 20th century. The meat and processed meat industry benefited tremendously from improved physical distribution, especially railroad and highway connections, and the development of the mechanically refrigerated rail car and truck in the 1930s which allowed products to move faster and further. (See Rixson, 2001.)

It is no coincidence that the processed meat industry simultaneously developed with the dairy industry. There is a strong parallel between these industries, as the manufacturing of margarine by processed meat companies in Western Europe dates back to 1882 (see Fig. 4.3 for example). In a way, that was a logical development, since margarine production was possible year-round, whereas processed meat products could not be successfully produced during the hot summer months.

Before 1870 the European meat-pro-

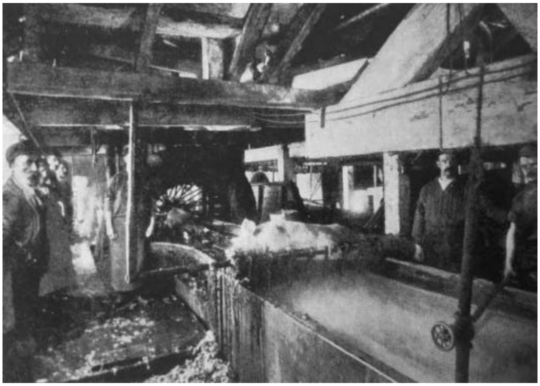

Fig. 4.3. A scalding tank in an Irish bacon factory at the beginning of the 20th century.

cessing companies were very labour-intensive and seldom employed more than ten workers. The introduction of steam-powered equipment in 1880 drastically changed the scene forever, and from that moment onwards, meat processing grew rapidly into a true industry (see Fig. 4.4 for example). Technological breakthroughs, such as the introduction of the bowlchopper (cutter) in 1895, accelerated not only growth of processed meats but also greatly improved the quality and variety of product selections.

The introduction of chilling equipment during 1894–1900 had a similar impact on shelf life and availability. Immediately after World War II, steam cooking cabinets were introduced and replaced the cooking kettles that until then had been the equipment of choice to pasteurize or cook meat products. The first smokehouses with cold and hot smoke capability were introduced in 1963. Four years later electronics allowed automated smoking and cooking. This development was completed in 1969, when the first universal smoke and cook cabinets were introduced, and in 1974 this technology was further perfected with the introduction of the continuous smokehouse.

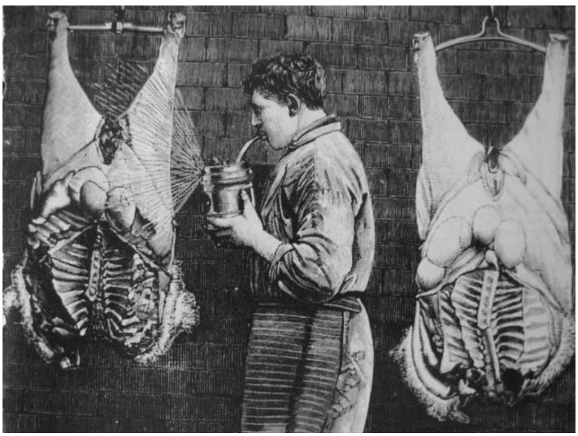

Fig. 4.4. Device to spray fat on a carcass to provide a glistering white appearance. It replaced the old practice of spitting fat directly from the mouth.

Of major impact also was the introduction of vacuum packaging in the early 1950s. Vacuum packaging began after DuPont pioneered the flexible oxygen impermeable film 'Saran' shortly after World War II. Vacuum packaging allowed a significant increase in product quality and shelf life, especially for hot dogs and sliced deli meats.

Another invention that significantly impacted modern meat processing was the introduction in 1957 of the sausage-clipping machine. Although the first bowlchoppers were introduced in the very early 1900s, it was not until 1953 that wheel-emptying devices were invented, followed by the first vacuum bowlchopper in 1956. These seemingly small improvements significantly improved the quality of emulsified meat products, while also allowing the use of innovative functional ingredients and lesser quality cuts of meats.

Sausagemakers of those times instinctively knew that a fresh batch of sausage mix would ferment more rapidly when a portion of an already fermented batch was mixed in with the new batch. The practice, also called back-slopping, is still frequently used today, although now infusion or inoculation is a more scientific method. Although it is true that in 1940 the first patent was issued for the use of lactobacilli as starter cultures in fermented sausage, only since 1954 have scientists understood how lactic acid starter cultures perform in the fermentation process.

What's in a Name?

It is only logical that food products produced in different parts of the world were given different names to identify the sausage in the local language or dialect. As mentioned, the Chinese called their sausage lup-cheong. In Italy names like lucanica, tomacula, farcimen and salsiccia, and also botuli – later unfortunately associated with the food poisoning called botulism – became everyday household words for regional sausage delicacies. Salsiccia, or salsus, is Latin for 'salted', or to be more precise, 'rubbed with salt'. Salsiccia became sausage in English, chourica in Portuguese, saucisse in French, sosis in Turkey and salchicha in Spanish.

In the Slavian language, sausage was called kolbasar, which means 'various meats'. This word most likely originated from Hebrew. Like the original salsiccia, the word kolbasar spread throughout the region and became kolbasa in Russian, and kielbasa in Polish. It is interesting to note that the Serbo-Croat word kobasics is a combination of the Hebrew and Latin names.

Still, many sausage names carry a reminder of home, such as loukaniko in Greek, nam in Thai, and longaniza in the Philippines. The German word for sausage, wurst, is famous all over the world and frequently used to characterize quality products. But the word itself cannot be traced so easily, even though documents from AD 1100 indicate that the Germans produced lebarwurst and pratwurst.

Most probably the word wurst developed from wurzel, which means rotating or twisting around, since forming a sausage requires that the casing be turned around. Some people believe that wurst may have originated from Latin, namely uert, which evolved to ward, wurzel and wurst. Because of the strong pioneering spirit of the Germans, especially in developing emulsified meat products, it is no surprise that the word wurst became regionally adapted, becoming virstle in the Balkan countries, wuerstel in Italy and worst in Holland.

Origins of the Hot Dog

The city of Frankfurt, Germany, claims to be the birthplace of the 'frankfurter' sausage. It's said that the frankfurter was developed there in 1484, 5 years before Columbus set sail for America. This claim is disputed by the city of Vienna (Wien), which refers to the name 'wiener' as the first hot dog. Since there are usually many explanations about the origins of foods, rather than simply accepting them as truth, it is advisable to preface them with a commonly told story.

There is little doubt, however, how the name hot dog originated in the USA. The term hot dog was coined in 1901 at New York City's Polo Grounds, and referred to the type of 'dachshund' sausage (hund is German for dog). These 'red-hot' sausages were sold from a push cart, with rolls and sauerkraut. Uncertain how to spell the word dachshund, a sports cartoonist simply coined the term hot dog. In 1904, the hot dog bun, invented by a St Louis baker, was introduced during St Louis Louisiana's Purchase Exposition. The world famous Nathan's hot dogs were first sold in 1916 at a stand in New York's Coney Island. Ground meats with salt and spices are some of the oldest foods in the world. European immigrants brought the frankfurter-style sausage and many other deli sausages to the USA around the turn of the 20th century.

Art and Science

The 20th century witnessed major improvements in the arena of meat processing technology. In 1906, the first Federal Meat Inspection Act took effect in the USA. A year later sodium nitrite became a popular additive for ham curing, though it took another 20 years for artery pumping of brine into the ham muscles to come into common use. When it did, that technique revolutionized ham manufacturing and reduced processing time to only a few days.

The use of ingredients, and spices in commercial pre-blends, dates back to 1895. The first phosphate patent for processed meat products dates from 1948, followed in 1949 by the discovery of ascorbic acid as a potent additive to accelerate cure and colour stabilization. In 1952, the world-famous German meat scientist Prof. Hamm detailed the influence of phosphate in meat emulsions. The Danish researcher Ludvigsen revealed in 1954 the presence of 'muscle abnormalities', which years later in 1968 were first termed as PSE (pale soft exudative). It is clear that these discoveries had significant impact on everyday meat processing.

Retail sales of frozen meat cuts began in 1930. The technology for freezing meat was basically the same as that developed by Clarence Birdseye in 1914 for quick-frozen vegetables, making many available year-round. Frozen TV dinners appeared around 1954. Liquid smoke was introduced in 1961, followed by the appearance of the corn dog, a batter-coated hot dog, in 1969.

As these discoveries illustrate, meat science is relatively new, beginning as a result of the Industrial Revolution. Although some meat technology reports date back to the second half of the 19th century, the real impact of meat science did not come of age until after World War II. Before that time, the manufacturing of meat products was mainly done on the basis of experience. The art of meat preservation and sausage-making was passed on from generation to generation, and for many centuries not much changed. It is truly amazing that people who lived thousands of years ago, without any knowledge of chemistry, were able to use ingredients such as salt, nitrate, nitrite, sugar and preserving methods such as smoking, cooking and air drying to their full potential.

Many modern-day sausage products are still based on the principles discovered by our forefathers. There is a clear relationship between the disappearance of 'house slaughtering' of hogs and the beginning of industrialized slaughtering. With the demise of house slaughtering, much practical meat processing experience was lost. During the last part of the 19th century through to the first half of the 20th century, increased population, increased meat consumption, increased disposable income and increased trade spurred new technologies. The city of Chicago in particular played a key role between 1850 and 1950 with the development of many innovative processes related to industrialized slaughtering of livestock.

Pathogenic Microorganisms

There is no cure-all solution to prevent microbial contamination. It will take a unified effort to solve the problems of food spoilage and food-borne diseases. In terms of media awareness of food-borne diseases, one of the single biggest events in the 20th century occurred in 1993 in the USA when *E. coli* O157:H7 made hundreds ill and left four people dead from eating undercooked, contaminated hamburgers. Media headlines accentuated the problem of food-borne diseases, perhaps almost to the point of paranoia.

As a result of the media attention, more scandals have erupted, including controversies surrounding growth hormones, BSE (bovine spongiform encephalopathy, or mad cow disease), dioxin, salmonella, listeria and the use of irradiation. The massive media attention made everyone aware of food-safety dangers, especially in relation to meat and meat products. It forced a rather conservative and dogmatic meat industry to change its attitude and adapt to a more pragmatic and proactive management approach, including open and straightforward consumer dialogue and consumer relationships. The sequence of some of these microbial hazard incidents resulted in the passage of the Pathogen Reduction Act and implementation in the year 2000 of HACCP programmes throughout the USA meat industry.

Incidents of food poisoning are becoming more prevalent. Product recall, financial consequences and especially the loss of consumer credibility are media darlings. It seems that modern lifestyles and the demand for greater convenience and speed of serving are helping to worsen the problem of food contamination.

There is growing concern about antibiotic resistance in humans. Scientists have attributed the growing strength of microbes to the overuse of antibiotics in people and agriculture. Antibiotics have many options for a line of defence against microbial diseases. However, increasingly, immuno-suppressed people in particular show symptoms of a weakening reaction to antibiotics. For example, listeria is rather difficult to diagnose by doctors, but can be fatal for populations with a lowered immunity. Despite the progress of diagnostic medicine, most food-borne illnesses are of unknown origin. It is even hypothesized that viruses are filling niches vacated by listeria and salmonella. Out-grow and the further processing industry, food service and consumers need to come to grips with the seriousness of this emerging problem. There is much the food and meat industry can do to safeguard against the old and newly discovered nemesis of food-borne bacteria and pathogens. The pathogens that cause problems in the food and meat industry are salmonella, listeria, campylobacter and *Escherichia coli*, *Clostridium perfringens* and *Staphylococcus aureus.*

Bacterial food-borne diseases arise primarily because of mishandling of meat and its products by the food handlers at the food service stations and the consumers in the confinement of their kitchen. However, the reputation of the food manufacturer or restaurant chain is greatly damaged when its products are responsible for the confirmed outbreak of food-borne diseases. The control of human pathogens is therefore of extreme importance. Control factors for microorganisms in meat can be divided into intrinsic ones, such as salt and pH, and extrinsic ones, such as temperature and packaging.

E. coli O157:H7 is a bacterium that can produce a deadly toxin. *E. coli* organisms have been identified for many years, but were identified only for the first time as a food-borne contaminant in 1982. The strain *E. coli* O157:H7 in particular has made many headlines since then. This bacterium is usually found in the intestines of humans and animals and can survive in the faeces of animals for months. Some strains cause dangerous, even life-threatening infections. Clean slaughter policies, including carcass steam-spraying or irradiation or cold-pasteurization, have been put in place in many countries. *E. coli* O157:H7 can survive on stainless steel equipment and tools, which makes strict cleaning practices essential. Usually contamination levels are low and difficult to pinpoint. It is therefore essential to ensure that processing procedures are strictly enforced, including preventing recontamination of the finished product. Unlike *Listeria monocytogenes*, the acid-tolerant *E. coli* O157:H7 is sensitive to heat and salt and is not likely to multiply on stainless steel, floors and drains in refrigerated areas. There is a looming danger of these pathogens developing resistance to antimicrobials and antibiotics.

Campylobacter jejuni and *E. coli* are arguably the fastest growing cause of food poisoning in the world. *Campylobacter* certainly is the most common food-borne illness, causing diarrhoea. Campylobacteriosis is often associated with Guillain-Barre Syndrome, a nervous system disease in humans. The incubation period for the pathogens is between 2 and 10 days. Most of the incidents are attributed to eating undercooked chicken meat, whereas the balance of the incidents are related to the consumption of raw milk, water, eggs, other meat products and contact with pets. Water and chicken meat are, however, major sources of contamination and usually linked to faecal contamination. It is not known how this pathogen can contaminate the muscle meat, though the most effective method to avoid illness is by thorough cooking to an internal temperature of 82°C, because this microorganism is sensitive to heat and drying. Irradiation and thorough cooking of poultry is actually the only safe way to avoid this type of food-borne hazard.

L. monocytogenes is one of 13 known species and this bacterium is commonly present in the environment. It was identified as a human pathogen in the early 1980s. From the known serotypes or subtypes of *L. monocytogenes*, only three affect human health. Unlike other pathogens, listeria will grow in temperatures of 3°C or less, while it is also more heat resistant than other bacteria such as *E. coli* and salmonella. Listeria will not survive pasteurization, but listeria is salt tolerant and resistant to freezing. The listeria bacterium can cause particular health risks for people with increased immuno-compromised conditions such as pregnant women, the elderly, cancer and AIDS patients. Listeria is present in cattle and poultry as well as humans. It also can be found in sewage, stream water and vegetables. The listeria bacterium can establish itself in processing environments and be promoted by food production and contact with workers. Listeriosis is the name of the disease produced by the consumption of listeria-tainted food.

The total elimination of listeriosis from food and meat is certainly impractical and probably impossible. Therefore, the critical issue is not how to prevent listeria's presence in food and meat, but how to control its survival.

Clostridium botulinum is another heat-resistant, spore-forming anaerobic bacterium that is toxic in food and meat products. These bacteria can survive at temperatures as low as 3°C, and the toxin produced by these microorganisms is not heat-sensitive. *C. botulinum* will not produce toxins in low pH conditions and when sodium nitrite is present. However, non-cured meat products, such as breast of turkey, are at risk, and subsequently these categories of products require the addition of other ingredients to reduce the risk. Sodium or potassium lactates, possibly in conjunction with sodium diacetate, are alternatives.

Salmonella is a bacterial group named after the scientist Salmon, who discovered it more than 100 years ago. Salmonella produces a bacterial infection that can be transmitted through contaminated poultry, eggs and food. Environmental sources of salmonella include soil, water, insects, raw (shell) fish and dairy products, and contaminated processing equipment and tools including utensils. Salmonella is the second most common infection. Salmonella belongs to the Enterobacteriaceae family and depending on the type involved can cause severe diarrhoea, fever and abdominal discomfort. Salmonella is an invasive organism that can escape the confinement of the intestines and cause serious bloodstream infections, especially in the immuno-weakened such as the elderly and infants, and infected people may suffer from recurrent episodes. The salmonella bacteria cause salmonellosis. Although salmonella is very heat sensitive and can be eliminated by heat processing, it has been reported that slow chilling can create new incubation conditions, allowing the organism to regroup and strike again. Therefore, post-pasteurization should include rapid chilling procedures.

Clostridium perfringens is another heat-resistant organism that will survive a wide temperature range. *C. perfringens* will produce an enterotoxin in the intestine resulting in diarrhoea. It is an anaerobic spore which under time and temperature conditions can multiply. Like salmonella, post-pasteurization temperature reduction is a critical step in the processing procedure.

Staphylococcus aureus can produce heat-stable toxins that are particularly liable to develop when insufficient fermentation takes place in products such as dry or semi-dry fermented Genoa salami. Staphylococcus contamination can originate from human contact or as a contaminant of the raw meat itself.

Bacillus cereus, mainly present in cereals and rice, survives temperatures as low as 7°C, while *Yersinia entrocoltia* can survive in vacuum-packed red meat products and meat patties at temperatures as low as 1°C.

Early detection of pathogens is critical because it allows the meat processor to make decisions quickly and decide on essential further processing steps, such as fully cooking the product to eliminate the contaminants.

Consumers rightfully want safe food. Yet at the same time there is a strong trend towards high-quality foods with minimum processing and minimum use of 'chemical' or unnatural additives or ingredients. Consumers are also not yet embracing irradiation (or cold pasteurization), which does not make matters easier for the food manufacturers. Chemical compounds with antimicrobial properties are very effective in controlling the transmission of human pathogens and the growth of spoilage bacteria from meat. However, the drive for 'fresh' and 'natural' does not always favour these substances as the first line of defence. The modern consumer is shying away from chemical-sounding additives and technologies they don't understand. 'Fresh foods' often need to have a 'green' label, and for these products it is increasingly necessary to look for innovative alternatives. The known antimicrobial ingredients are spices and herbs, especially rosemary, sage, cloves, pepper, nutmeg and oregano. Also plant essential oils such as cinnamic acid, which is an unsaturated fatty acid, have shown inhibiting activity against the growth of *L. monocytogenes*. Perhaps dairy's glycoprotein lactoferrin also can be considered a useful antimicrobial. Much work still needs to be done to formulate the right cocktail of natural antimicrobials.

From the above it generally can be concluded that apart from adhering to good manufacturing standards, thermal processing is critical. The latter includes rapid chilling. Additionally, it is of utmost importance to avoid recontamination of ready products. This does not stop when the finished product leaves the plant. Once the finished food product leaves the direct control of the processing plant, post-processing breakdown and failures such as temperature irregularities can occur. Even more important today, attention should be given to the food handler at the final preparation stations, such as the franchised fast food restaurants, being carefully trained, instructed and monitored to avoid any actions leading to food-borne health risks. Though intervention technologies are good tools for keeping meat free of pathogens, perhaps the meat industry's oldest wisdom still stands tall: 'Keep it fresh, keep it cold, and keep it moving'. (See Taylor, 1997.)

Oxidative Rancidity

Apart from microbial contamination, another major concern is the development of oxidative rancidity. Oxidative deterioration requires minimization or elimination of oxygen in food. The presence of oxygen in food actually influences both shelf life in terms of the development of rancidity, and the possible development of harmful microflora. When exposed to light and oxygen, many products undergo irreversible chemical changes. Colour and flavour are negatively impacted, especially in foods that contain susceptible fats and oils. The result often is the development of off-flavours and odours, which makes the product inedible. Oxidative rancidity can be controlled by the addition of oxidation inhibitors and antioxidants. There are natural and synthetic antioxidants. Examples of the latter are BHA and BHT. In combination these additives are more powerful than individually. Examples of natural antioxidants are extracts such as from rosemary and sage. However, also tocopherol and citric acid have these properties. It is obvious that natural antioxidants are a natural fit for many processed meat products such as pork breakfast patties and Italian sausages.

It is almost a logical consequence that processing methods also influence oxidation. Typical processing sequences such as for batter and breaded chicken actually tend to jump-start oxidation. High oil temperatures cause this during par-frying or full-cook frying, which draws oil into the breading and possibly also into the substrate. Additionally, minimally processed meat products might be susceptible to oxidation damage, especially if these products do not contain sufficient amounts of bacteriostats such as salt and phosphate.

A special remark is necessary on the influence of salt. Increased salt levels will make processed meat products more microbially stable. However, increased salt levels also trigger or instigate oxidative rancidity. So here is a dilemma that needs very careful fine-tuning. As opposed to salt, phosphate and, to a certain extent, also soy protein isolate, have antioxidative properties, especially in coarse-ground meat products.

Packaging Hurdles

Once the processed meat or food product is ready for packing, it is often suggested multiple barriers against oxidation be created. Oxygen can develop from within the packing in slow releases from within the meat or food product, and by permeating through the package from the outside environment. It is critical to use either vacuum packing systems or select modified atmosphere packing in addition to the required antioxidants in the formula for building hurdles that help prevent oxidative deterioration. For modified atmosphere packing it is therefore essential to select a film that prevents the escape of inert gas out of the package as well as the penetration of oxygen into the package. Inert gas flushing usually is a combination of nitrogen and CO_2, the latter being believed to have certain antimicrobial properties.

The anticipated shelf life influences the ultimate decision on how to package the processed meat product. Naturally, if a long shelf life is needed, perhaps with some safeguards against temperature abuses, it will be necessary to combine all available hurdles to provide contamination protection (Fig. 4.5).

Casings

Originally, all sausages were stuffed in natural casings. The smaller diameter sausages such as the frankfurter used sheep casings. For larger diameter sizes, hog casings are still being used. These natural casings are derived from the intestinal tract of sheep, hogs and cattle. Because of increased production speed and the need for uniformity in size and weight, collagen and cellulose casings have taken over most of the market. These products can be seen as analogue or manufactured casings, offering similar properties to the natural casings. Manufactured casings are made from reconstituted natural material, though sometimes also reinforcing material is used such as cellulose fibre. Collagen casings used for small diameter sausage are edible, whereas the biodegradable cellulose casings, the large collagen and reinforced fibrous casings are tough and need to be removed before consumption. These casings help to

Fig. 4.5. Film-packed meat products. Source: Convenience Food Systems (CFS).

form a 'skin' on a skinless sausage and are very suitable for use on fully automated stuffers that often are in-line with continuous smokehouse processors. Man-made cellulose casings were introduced in 1926. Machine-made cellulose casings ended the industry's dependence on irregular supplies of natural casings, thereby greatly boosting market penetration.

Small-diameter cellulose casings are permeable for smoke and water, but impermeable for fat. Cellulosic casings are made from high-grade wood pulp and or cotton linters. Since these casings are primarily designed for fast automatic peeling, it is important to use strong coherent meat emulsion with the ability to form a second skin just beneath the casing during thermal processing, hence the name 'skinless sausage'. Regenerated collagen casings are made from the corium layer of beef hides and basically contain the same material found in natural casings. If handled correctly, these casings provide a tender skin with excellent knack and snap. Peelable cellulose casings which are permeable to smoke, air, moisture and organic acids, serve also as the base for cellulose casings. Fibrous casings are often reinforced with fibre to create stronger dimensional stability. Fibrous casings are often coated with release agents, and are available in permeable and impermeable forms. Moisture-proof fibrous casings are another variation and these are used for sausage products that need to be scalded, water- or steam-cooked. The use of analogue casings will remain important for modern sausage manufacturing, and innovative technologies such as co-extrusion and acidity-moulding will become viable options. Natural casings preserve an 'Old World' image and are ideally suited for differentiating certain all-meat products. They also allow market segmentation, and offer strong bases for new creative technologies that will drive change in further processed meat products. Product quality, convenience, health and cost management are some of the key elements that need to be addressed through creative technologies.

Processing Evolution

Considering the rapid changes that have taken place, it is likely that some existing processed meat products will undergo conceptual changes in the marketplace. Some processed meat products, for example, co-extruded dumplings, hot dogs, and hors d'oeuvres, pizza pepperoni, and even luncheon meat will evolve to a point at which they are no longer perceived primarily as a meat product, but rather as an integrated food product. New processing technologies, coupled with innovative non-meat proteins that behave very similarly to lean meat, will allow non-traditional food processors to enter an emerging market using meat as an ingredient rather than the characterizing component. All original and traditional reformulated sausages containing low or no fat have become mainstream in only a few years, joining a growing specialty field that plays to a generation far removed from its ethnic roots. Exquisite combinations of meats, fruits, functional protein and seasoning are the modern answers to a food product that drew heavy criticism from dieticians only a few years ago. There is a strong worldwide preference for flavoured meat products, especially the subtle combinations of distinctly sweet seasonings coupled with fruits such as apples or sweet cherries. In the whole muscle meat category, extra value is created by flavourings such as maple, honey and pineapple.

Basically, the same is true for hand-held wrapped pocket foods. This category has expanded into a wide array of products for people who have little time or desire to sit down for the meal occasion. Hand-held wrapped foods originated in the Orient, where they were known as 'lumpia' or spring rolls. Today, these products come in many varieties, from tortillas to a growing selection of mix-and-match foods based on ethnic preferences, flavour and taste. Wrapped foods or hand-held foods perhaps can be considered as the beginning of the demise of meat as the main focus point in a meal. Instead meat is 'hidden' in wrap fillings and stuffings that only serve as a characterizing ingredient with significantly less emphasis on the species, such as beef, pork or poultry. Because of the rapidly emerging technologies for simulating meat textures and meat flavours by means of functional soy proteins, hand-held wrapped pocket foods, also known as 'finger-foods', will be one of the main areas for accelerated growth opportunities in the future.

A similar development can be seen with other 'outside-the-bun' foods, such as burritos, quesadillas, chalupas and nachos. These are all authentic flavourful Mexican products offering consumers excitement and value to otherwise dull eating experiences.

The new conceptual thinking of processed meat foods as tasty and convenient products will accelerate consumer demand and serve as a catalyst for many new and exciting applications for which the soy protein of ancient times has established itself as the protein of choice for a new generation of products.

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5
Lifestyle Foods Paradigms

For most people living in the Western countries eating food is an enjoyable experience. However, the world of food, nutrition and diet is increasingly confusing for consumers. Fact and fiction have become blurred and it is no wonder that people need reassurance, guidance and support if innovative food systems are to have sustaining power. In the same Western world there is also a growing dissatisfaction with the limitations of modern medicine. Modern consumers are increasingly likely to be health proactive and inclined towards self-medication. Macro social changes such as change in household structure and the greater pressure on time availability will impact lifestyle. Rising health care costs will put significant pressure on health care management and affluent consumers are expected to purchase foods and services that deliver preventive solutions rather than wait for the inevitable and respond to diagnosed maladies in an effort to improve their quality of life. To put it differently, life expectancy increase has changed socio-economic parameters, not least the desire for longevity without morbidity. (See Leveille and Guralnik, 1999.)

Chronic diseases, including cardiovascular conditions, diabetes, stroke, cancers and respiratory diseases, account for almost 60% of the 56 million deaths annually, and 46% of the global disease burden can be improved if the dietary, nutritional and physical activity habits of the world's population, particularly in the developing areas, are altered significantly. In a study conducted by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) of the United Nations, an expert group noted that a diet low in energy-dense foods that are high in saturated fats and sugars and abundant in fruit and vegetables, together with an active lifestyle, are among the key measures to combat chronic disease. The energy consumed by a person each day should match energy expenditure. Evidence suggests that excessive consumption of energy-rich foods can encourage weight gain. The WHO is preparing to issue a global strategy on Diet, Physical Activity and Health, with the overall goal of improving public health through healthy eating and physical activity. Soy nutrition fits exceptionally well in a modern diet that addresses the needs for balanced nutrition and improving health conditions. (See Manson and Hu, 1999.)

A never-ending flow of controversy surrounds both the meat and the formulated meat industries. It ranges from microbial and health hazards to alleged high fat content and its cardiovascular disease-promoting effects. For many decades the formulated meat industry has been in a re-active mode, allowing the food and dairy industry to gain valuable marketing advantages. To the general public, perception is reality and manufacturers of formulated meat products need to be proactive to avoid negative perceptions by the public.

It is perhaps a sign of the times, but there is an unmistakable worldwide trend that consumers are becoming more environmentally aware and this is translated to innovative or alternative food choices and selection criteria. This trend is coined 'lifestyle foods' and generally means an individual food choice prompted by a multitude of reasons. Within these developments a rapidly emerging counter-trend is taking place caused by the immense popularity of the Atkins diet, which simply advocates a carbohydrate-restrictive diet to fight overweight and obesity. These trends will make it even more difficult for authorities, the medical profession and health experts to communicate the consumption of ideal food selections to the general public. These conflicting health messages truly confuse the consumers who, as a result, start to follow their own instincts and/or are encouraged to start successful diet protocols with proven results.

Lifestyle foods are not necessarily vegetarian foods, though it is probably true that vegetarian foods are often selected because of psychologically driven reasons. These psychological reasons are either intellectually driven, or find their origin in emotional reasons. It appears especially that young adolescent girls are often influenced by purely emotional reasons to eliminate (red) meat from the diet. Parents find it almost impossible to argue with these emotions and often the mothers, in order not to lose bonding with their daughters, share these emotions and start to show similar behavioural attitudes. In this respect it is important to note that franchised food restaurants increasingly offer so-called 'veto-foods'. These restaurants have lifestyle foods, including carbohydrate-controlled selections, on the menu to satisfy the criteria of a select group of customers that can influence the decision-making of others.

Functional Food Evolution

It is a small but significant step to translate reactive health to proactive health. Foods containing bioactive components that impart health benefits beyond basic nutrition can be seen as foods with a health bonus. The purported benefits are improved and enhanced physical or emotional health. Lifestyle foods are often associated with so-called functional foods. Vita foods or nutraceuticals are words with a similar meaning. Functional foods describe products containing functional components or ingredients that have health benefits. Over the last few years there has been a subtle, albeit marked, change in how consumers relate to health and well-being. In the last two decades of the 20th century, the food companies translated good health as 'taking the bad out', such as eliminating fat or sodium. However, at the beginning of the third millennium a clear change of definition has occurred by 'putting the good in'. For example, adding synbiotics, such as prebiotics like inulin fibres or probiotics such as lactobacillus and other immune modulators like dairy's lactoferrin, a bioactive milk protein playing a role in the body's immune system response, will be common-place.

It is obvious that the quest for people in the Western world has changed from surviving to managing health. Active seniors have a strong desire to live long and prosper. Quite often these are conflicting goals as lifespan increases. There is a lot of truth behind the somewhat ironic statement: 'Americans want to die in perfect health'. There is little doubt that longevity is accounted for by better nutrition, hygiene and managed healthcare. The key question about ageing populations is: will they live longer and healthier, or will longer years of life be accompanied by more years of disability?

Functional foods have become a science on their own, and will lead the way in preventive health care. The overall aim is to build a strong defence and achieve a natural balance within the body. For example, an immune defence system protects the body from harmful bacteria. In this sense it can be hypothesized that antimicrobial agents like antibiotics will be used differently in the future to block receptor cells and thereby prevent pathogens from adhering to host cells. This is an example of preventing microbial diseases rather than curing an existing infection. The latter is important because increasingly drugs lose effectiveness because the microbes they fight become resistant. Antibiotics are only effective against bacterial infections and are useless against viral infections. In developing countries people underuse these drugs, whilst in affluent countries very frequently antibiotics are overprescribed or used for the wrong reasons, i.e. to cure viral infections. Developed countries must drastically reduce the use of antibiotics, especially in animal use to promote health and growth of livestock and poultry. Overuse of antibiotics can create resistant microbes which can spread through the food chain to humans. If no solution is found, the last line of defence in curing bacterial infections could be imperilled and threaten the health of millions of people.

Functional foods will play an increasing part in keeping well through diet and exercise. Advances in technology might add several more years to life expectancies. The human genome project is nearing completion, and this roadmap will further accelerate the identification of substances that affect and optimize lifespan, without the negative side effects of degenerative diseases. Or in other words: 'Growing old healthily'.

How old is old? People are reaching advanced ages, in the 80s to the 100s. About 600 million people, or 1 in 10, are 60 years or older. By 2050, that figure is expected to reach 2 billion. By then the numbers of elderly will be greater than children aged 14 and under. One in five Europeans are over 60 and in a few years 1 in 4 will be over 60. In contrast, in Africa 1 in 20 is over 60 years of age. Medically speaking, health experts will increasingly be confronted with the issue of maintaining life versus controlling health costs. For people who are middle-aged now, advances in biotechnology and immunology over the next 10 years will add many 'bonus' years to their lives. That is to say, for those of us who are fortunate to live in the affluent countries.

Genetic mapping and screening will increase lifespan even more, especially if regeneration of human body parts – the creation of hybrid cells – is medically implemented. Revolutionary technological breakthroughs will have the potential to both harness and serve mankind. Choices will need to be made between a soft or an aggressive path approach to procedures such as gene-replacement therapy and the development of made-to-order genes. It is obvious that many philosophical and ethical issues still need to be resolved. Perhaps it is far off, but functional foods and gene mapping will ultimately be associated with the physical and emotional well-being of the human race. Discussions are under way in various governments to ensure the technology will be available to the masses.

There should be little doubt that there is a slow evolution towards genetic screening together with individual nutrition management, to develop the best programmes for maximizing each person's lifespan in which both quality of life and quantity of years are taken into consideration.

Will We Be Enjoying Meat in the Future?

Can meat be part of lifestyle foods? Despite the emotional, environmental and animal welfare controversy, the answer is a resounding yes.

Meat and meat products are universally liked throughout the world and it is always remarkable that per capita consumption increases in developing countries when income increases. Obviously, people appreciate meat, including formulated meat products, especially if for economic reasons they have been deprived of meat for a prolonged time. (See Briggs and Schweigert, 1990.)

In affluent societies, people seem to take the availability of meat for granted, although the 'red meat' choices, such as beef and to a lesser extent pork, have been under scrutiny for a number of reasons. Animal rights activities, along with allegations of high fat and the presence of pathogens, such as salmonella, *E. coli*, BSE and chicken flu or chicken pest, have undermined people's trust in the wholesomeness of meat.

The preparation of meat also requires

cooking skills, something that in modern society is not automatically passed on from parent to child. Additionally, the meal opportunities of families have changed with, as a consequence, the individualization of food. The demand for nutrition-on-the-go is growing, prompted by the rapidly emerging 24-hour economy.

Still, food is culture and culture is food. It is a sign of the times that restaurants increasingly offer meals in the setting of entertainment gimmicks, if only to replace the old-fashioned dinner table conversations of family members.

Chicken and seafood is ‘white’ and therefore offers increased consumer appeal. Compared with beef, lamb and pork, poultry is generally the cheapest animal protein source and has definite advantages for cross-flavouring. Chicken can actually be used to partly replace beef and pork using flavour diffusion technology. But red meat such as beef and pork will not lose its dominant position on the dinner plate for many years to come, although there is a noticeable trend toward meat being used as an ingredient rather than being the centrepiece on the plate. Meat in the form of characterizing ingredient can be used in a number of existing as well as new foods. It is likely that the least-cost muscle protein will be selected for these applications. In addition innovative soy protein technologies allow these meat selections to be augmented without affecting organoleptical and nutritive parameters.

Moreover, environmental issues, such as the availability of clean water, might eventually have detrimental effects on meat production, especially red meat. The competition for clean, fresh water will intensify in the decades to come and could eventually hurt meat production in both economic and population growth areas. This will inevitably have a major impact on the global grain trade and the type of animal protein produced. Nevertheless, global animal protein demand is unlikely to diminish. Water shortages could be the most likely factor to alter animal protein supplies, with the most efficient proteins – poultry and aquaculture-grown fish – taking priority over beef and pork. It takes about 7 kg of grain to raise 1 kg of beef, 4 kg for 1 kg of pork, 2.2 kg for 1 kg of poultry and just 1.7 kg of feed for 1 kg of farm-raised fish.

Seen from a different perspective, countries that suffer from water shortages will probably improve efficiency by simply importing grain. It takes 1000 tons of water to produce 1 ton of wheat, which explains why North Africa and the Middle East are the fastest growing wheat-import regions in the world. When China begins to import additional quantities to conserve water resources for urban development, the world grain balance may be affected.

Since 1950, the world population has increased from 2.5 billion to 6 billion, and it is expected that 8 billion people will occupy planet earth by 2020 (Fig. 5.1). How can societies ensure that the number of people stunted by malnutrition falls rather than rises? Despite prosperity in the USA and the European Union, poverty rates have

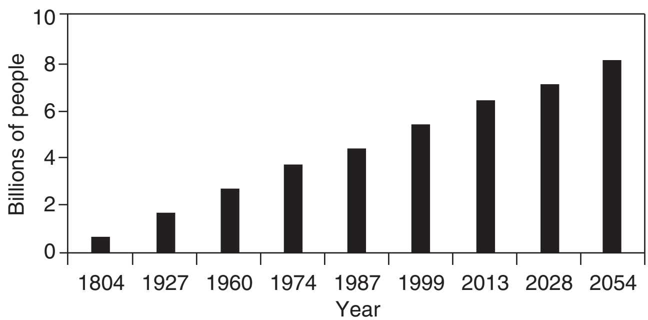

Fig. 5.1. World population milestones. Source: United Nations Population Division.

dropped only marginally. Throughout the world a growing gap between the rich and poor is developing. Those at the bottom are sinking deeper, and it will be essential to slow the increasing inequity between rich and poor. Otherwise, a potential basis for anarchy could develop.

Aquaculture

Aquaculture offers a source of affordable animal protein for both the world's poor and hungry as well as for affluent consumers who need to adopt a different dietary pattern. It also can be seen as an ideal substitute for rapidly diminishing global fishery, depleted by over-fishing and the destruction of fishery stocks. Commercial agriculture has developed over centuries, while large-scale commercial aquaculture is only some 30 years old. As people get older and have more disposable income, they usually eat more fish. In real terms, over the past 30 years seafood prices have risen sharply, whilst that of other animal protein sources such as beef, pork and chicken have declined.

Major sociological and economical changes will affect the quality of our lives and the direction of the food industry in the next few decades. It is likely that by 2015 aquaculture-farmed fish will overtake the world's beef output. Aquaculture is probably the world's fastest growing form of food production, and it is estimated that about half of the fresh and frozen seafood consumed by Americans is farmed. These healthy protein choices from the 'blue revolution' are increasingly teamed up with soy protein ingredients to develop innovative mainstream foods such as tuna-spreads and surimi-based foods for health-oriented consumers.

Malnourishment

Despite the promise of aquaculture and other food-production technologies, about 1.2 billion people are chronically malnourished in developing countries, and an estimated 2 billion people are affected by micronutrient deficiencies, such as iron deficiency and vitamin A deficiency, which leads to vision impairment and blindness. It is estimated that about 2 million children under 5 years of age die of vitamin A deficiency every year. In sharp contrast, about 1.2 billion people are overnourished, eating too much saturated fat, refined sugar and salt and inadequate amounts of polyunsaturated fatty acids, antioxidants, fibre, phyto-oestrogens and other micronutrients.

In the next 50 years, policymakers will no longer focus on providing for more people; rather, they will need to provide more for people. For example, increasing millions of people are living in countries facing chronic fresh water shortages. With about half of global population growth from now till the mid-century occurring in the developing countries, such as India, Pakistan, China and Indonesia, intensive efforts are needed to assure that poorer countries progress far enough economically to help their children grow up with the same economic opportunities as their rich-country counterparts.

Does 2050 seem far away? Think again! Nearly half of the world's population is presently under the age of 25, with close to 2 billion under 15. With an increased life expectancy, those living outside of Africa and some Asian countries can be reasonably certain of being alive in 2050. These demographic trends will no doubt influence domestic and international policies, including figuring out how to support ageing populations with managed healthcare systems and two-tiered food programmes ranging from affordable nutrition for people living in the economically depressed countries and the development of functional foods for more affluent societies. If these issues are not addressed it will have devastating effects and destabilize world society as a whole.

Soy Protein Benefits

In recent years soy protein and its naturally occurring isoflavones have received an avalanche of publicity. From being a well-appreciated food in Asia dating back to 5000 BC, the soybean and its spin-off products had been in a culinary backwater for a long time. Soy has come full circle; now, at the onset of the 21st century, soy is propelled into the limelight following the ruling of the Food and Drug Administration (FDA) to allow certain foods to carry a health claim linking soy intake to a reduced risk of coronary heart disease. But there is more to it!

Soy protein and its naturally occurring isoflavones – especially genistein and daidzein – has a weak oestrogen effect and competes with the body's sex-hormone oestrogen for access to cells. Soy isoflavones have about 1/1000 the strength of oestrogen, itself a strong promoter of reproductive tumours, such as breast and uterine cancer. Phyto-oestrogens (plant oestrogens) are present in soyfoods such as tempeh; tofu and soymilk may serve as 'natural' replacers for oestrogen supplementation recommended by physicians, such as the drug tamoxifen.

Apart from the known antioxidative vitamins A (beta-carotene), C and E (alpha tocopherol), evidence is emerging about the benefits of phytochemicals, or plant-produced chemical components, such as those found in soy protein, clover and tea. The polyphenols in tea – especially green tea – are more potent antioxidants than the vitamins A, C and E. Most oncologists know a lot about cancer, but very little about food and nutrition. But as science quickly unravels the secrets of phytochemicals it is obvious that for some degenerative diseases the answer is food.

Despite the high quality of managed health care, American deaths from breast and prostate cancer are up to 30 times the rate of countries like Thailand, India and Japan. After a comprehensive analysis, the American Institute for Cancer Research concluded that about one-third of all cancer in the USA is attributed to poor eating habits.

Many of the answers are embedded in the secrets of plant chemistry. However, people should not kid themselves that specific plants or diets are going to prevent diseases such as cancer. Major clinical studies are still needed before we will have definite evidence on which foods, and in which proportions, will offer protection against a certain malignancy.

Natural plant foods and plant-based supplements offer alternatives for post-menopausal women to reduce osteoporosis and relieve menopausal symptoms, such as night sweats and hot flushes, without the reported side effects, including increased risks for breast cancer. Many women worry about the influence of hormones as life advances. Once thought of as primarily a man's problem, coronary heart disease is now the leading cause of death in both men and women. Among those 50 and over, more women than men die from CHD. Obesity, high blood pressure, blood lipid abnormalities such as elevated cholesterol, osteoporosis and impaired glucose utilization leading to Type 2 diabetes mellitus are also increasingly a cause of concern, especially for people living in affluent societies. (See Weggemans and Trautwein, 2003.)

It is clear that in the next decade confusion and disagreement over diet and dietary supplementation will continue to influence food purchasing decisions and eating habits. However, there is no reason not to adopt a cuisine that incorporates scientific evidence already known. Science is clearly linking plant-rich diets to avoidance of modern degenerative diseases.

Soy-based products have captured double-digit market growth in recent years and healthier eating habits are the driving force behind increased sales. In particular, the sales of meat-analogue products, soy protein-formulated health bars and soymilk have increased significantly. For these categories there is no market growth slowdown in sight yet. For the modern consumer a lot is at stake, especially the chance to add quality years to life, rather than growing old in poor health. As public health awareness rises, the market opportunities will follow suit. These opportunities are created by strong scientific evidence and these subtle but definite changes are not just driven by plant foods but include also the health benefits of some more emerging nutraceuticals:

- Oligosaccharides, which stimulate growth of gut bacteria.
- Peptides, which increase mineral absorption and reduce calcium loss.
- Lactic acid bacteria, which promote immune systems.
- Polyunsaturated fatty acids, which reduce cardiovascular disease, including blood cholesterol.
- Calcium and phosphorus, which improve bone strength and dental health.
- Milk glycoproteins such as lactoferrins and lactoperioxidase, which have antibacterial and antiviral properties. Glycoproteins can also prevent the growth of pathogenic organisms in the gut and control iron binding, while controlling antioxidative processes causing cell and tissue damage.

Taste Expectations

Eating and diet habits change over time as a result of socio-economic factors. Already it is evident that ultimately the dogmatic attitude of some American franchised fast food companies can not be sustained in most international markets. For a plethora of reasons, consumers have demanded change and forced the fast food companies to loosen the strict formula guidelines and adapt to local or regional flavours at food costs that are affordable for the general public.

Food service may lead in culinary trends, but its nutritional correctness lags behind that of retail. This is largely attributed to the absence of nutritional labelling on food service products, but definitely is also influenced by the mindset of consumers, who seem to have a double standard when it comes to purchasing food in a grocery store and when eating out.

For example, everybody will say they want to eat healthily, though when decision time comes in the restaurant, the food ordered often doesn't match the intentions. Subsequently, the success of food is ultimately driven only by taste. Everything else takes second place. There are endless opportunities for creating new and exciting foods and beverages. However, the secret of success in the marketplace is repeat business. It's as simple as that!

For both the food provider and the consumer, it is difficult to manoeuvre. Changes are sometimes temporary and will impact decision making for the short term only. For example, carbohydrate-restricted foods are only offered by the franchised food industry to offer customers a choice and hence avoid the 'veto-vote'. However, it also can be argued that diet changes are only temporary and may force the food service companies to reposition marketing strategies again. These trends are further complicated by rapidly changing demographics.

Nutraceuticals

It is no secret that the hidden motives of functional food development are often tied to increased profitability. Industry experts expect it to be a hot market for the next two decades. The reasons are quite clear: an ageing population that has a strong incentive to take proactive charge of their health, and an individualized, 'do-it-yourself' mentality that is fuelled by the growing evidence of the link between diet and health. Most probably, the biggest advantage of self-controlled health management is the reduced dependence on prescription drugs. As the demarcation zones between food, nutraceutical and pharmaceutical blur, a possible erosion of the pharmaceutical market may occur. These changes will happen slowly, though with the rather revolutionary speed of change in communication, such as Internet access, it can be expected that increasing numbers of people seeking health-related answers will become more knowledgeable and conversant in appropriate self-administered health management.

Consumers of lifestyle foods are mostly well-informed people who like to make choices based on easy-to-understand information and logic. In this respect, it should also be noted that a growing demand for ‘instant’ medical attention and treatment and a decreasing tolerance of pain and discomfort are becoming prevalent. For example, people may be becoming increasingly susceptible to viral and bacterial infections and weakening immune systems. Well-informed people will not hesitate to purchase functional foods that can improve these conditions.

There is increasing awareness of the larger role of foods in general, and nutrient and non-nutrients in particular. For example, although the influence and relevance of micronutrients as well as non-nutrients in preventing disease is still unclear, there is overwhelming epidemiologic evidence showing a protective effect for vegetable and fruit consumption on the development of cancer. Additionally, many new opportunities will arise for products that have positive effects on health and performance. There is a definite need for scientific evaluation and confirmation of the safety or toxicity of micronutrients. Intakes should fall within safety limits, in order to avoid the danger that people with self-diagnosed diseases become eager to increase dietary medication when self-selected products, especially in highly concentrated forms, are used and administered.

There are a number of definitions of functional foods. A functional food can be defined as a food or beverage that includes added nutritional benefits beyond what one typically would expect. Obviously functional foods should have clinical research data to back up product health claims, and in fact much research is still needed to substantiate the product claims of beneficial effects on emotional moods and cognitive activity for the dietary nutrients, design botanicals and phytochemicals that affect physical health and cerebral mechanisms in humans.

The favourable effects of functional foods range from improvement of psychological and mental processes to the advancement of proactive well-being, including the age-related decline of physiological or mental health. As such, functional foods can be seen as a desire by consumers for proactive applied health initiatives in daily life in order to gain desirable effects on mood, performance and physical well-being. Functional foods can be considered a segment of lifestyle foods. Clearly, there is a certain hierarchy based on the functionality these foods provide, including:

- Dietary support: Vitamins, minerals and phytochemicals usually can be incorporated relatively easily into an existing food product. Examples are calcium fortification or soy isoflavones, which have been linked in many epidemiological studies with improved bone health, decreased risk of colon–rectal cancer and a beneficial impact on hypertension and pre-menstrual syndrome (PMS).
- Performance support: These products require advanced know-how and technological investment. Examples include products that enhance physical or mental performance, such as energy bars, isotonic beverages, fruit-based smoothies and soy protein drinks.
- Maintenance support: These foods can be used in combination with other medical or dietary therapies. Examples are soy beverages and sterol-based spreads designed to lower cholesterol, or the antioxidant lactoferrin, which contains components to boost the immune system. Other examples are lutein and lycopene, which support eye and heart health.
- Prevention support: These foods or beverages are positioned beyond basic health claims. Examples are synbiotics for improved or balanced colonic microflora, improved immuno-capacity and reduction of oxidative stress. In this category the so-called ‘brain-foods’ can be mentioned. For example, herbal compounds such as extracts from the green leaves of the ginkgo biloba. Some phytochemical compounds show potential for affecting memory, learning and emotional behaviours, probably by scavenging free radicals in the brain and by improving neuronal and cerebrovascular functioning.
- Curative support: These are products that possess specific therapeutic properties

and most likely need to be used or administered under medical supervision. They include products aimed at treatment of cardiovascular disease, cancer and bone health. For example, biotechnology breakthroughs will permit development of anti-obesity foods and drugs. Ideally an anti-obesity food would decrease appetite and increase energy expenditure without serious side effects for long-term use and health.

The prevention and curative support products will be placed at the top of the pyramid and will have the potential to offer the highest returns for the companies marketing them. Nutritional product manufacturers and pharmaceutical companies target both types of nutraceuticals. The overlap between the emerging functional food industry and the pharmaceutical industry will intensify, although they require a high level of know-how and financial backing.

Nearly all current companies in this field have certain marketing weaknesses. In order to boost the success rate, it is likely that partnerships or acquisitions will emerge. It can be expected that pharmaceutical companies will increasingly target over-the-counter products, foods, ready-to-drink beverages and confectionery products as a delivery path of 'proactive health' to consumers. These companies have the resources to fine-tune the active ingredient technology and substantiate health claims to both regulatory agencies and consumers.

Communicating to Consumers

Heart disease and cancer are two of the leading causes of death, while microbial or viral diseases might appear in third place. Research has isolated a number of nutraceutical compounds that may aid in preventing diseases or slowing their onset. Legislation and regulations will have to play an important role, because health claims – such as statements that folic acid has been proved to reduce the risk of neural tube birth defects or that soy protein may reduce cholesterol – should be allowed only on sound clinical evidence to communicate a message to consumers.

Proper communication with consumers will be a decisive element in explaining the differences between food and functional food. The chances are that consumers will become confused by the functional food concept. When does a food become a functional food and vice versa? Although definitely more than a blip on the radar screen, the controlling agencies governing functional foods need to be flexible in adapting to new clinical evidence, yet firm in policing claims that lack medical or nutritional evidence.

Dairy processors already have developed a substantial following by marketing functional foods. One only needs to consider probiotic yoghurt containing bioactive cultures or beverages with added acidophilus, bifidus and prebiotic fibres such as inulin. Probiotics and prebiotics, together called synbiotics, have demonstrated beneficial effects on health and general well-being.

Premium soy protein ingredients show great potential for applications in special food products for the ageing population, in particular osteoporosis, which is a progressive disease without any visible signs and symptoms. Osteoporosis is therefore often called the silent epidemic and women are at greater risk of developing this disease after the menopause, when the ovaries produce less oestrogen. Oestrogen is important for maintaining bone strength and declining availability after menopause can cause the loss of calcium from the skeleton. Alcohol, smoking, lack of exercise, low intake of calcium and heredity are also known factors that can promote osteoporosis. Western women have a relatively low calcium intake and this often prevents them from reaching the maximum bone mass. Organic calcium such as citrate gluconate and lactate are more bio-available than inorganic calcium like carbonate and phosphate. Numerous studies have shown that soy isoflavones stimulate bone formation, suppress bone resorption and enhance calcium absorption and these tests demonstrated that soy isoflavone intake not only prevents bones from breaking down but also improves the production of new bone cells in menopausal women. A daily intake of calcium and soy isoflavones is an ideal solution for oestrogen replacement and thus is a natural remedy without the added risks of breast and ovarian cancer, cardiovascular disease and strokes seen in the treatment with synthetic hormonal replacement. (See Lee and Gomez, 2003.)

There are quite a few foods and beverages that can be created to provide supplements of premium soy protein and calcium fortification. Fruit-based soy smoothies are ideal vehicles to use these soy protein ingredients, including readily soluble isoflavones. Another example is soy milk. Soy milk is gaining rapid mainstream acceptance in Oceania, Asia, the USA and Europe. As the technology to improve the flavour of soy moves forward, further advancement of this functional food category can be expected, including meal replacement beverages.

Although the public is looking for black and white answers, it is evident that in reality the choices are increasingly difficult to make. Subsequently, consumers will increasingly look for positive nutrition and expect more from the food they eat, rather than look for foods to exclude. For example, healthy breakfast smoothies and lunch meal-beverages are a rather recent development based on traditional fruit drinks. The main difference is that viscosity is increased by real fruit addition, allowing easy-to-spoon or easy-to-drink characteristics. Preferably, the viscosity increase is created by the addition of natural fruit components rather than a few thickening additives that consumers have difficulty relating to. Since people are increasingly looking for painless ways to make diets healthier, fruit-based smoothies are ideal beverages to deliver premium nutrition. For example, a smoothie can be packed with botanicals and herbs, soy proteins and prebiotics to position the drink as a functional food. Great-tasting combinations can be created to boost phyto-medical health, with inclusions such as Echinacea, ginseng, herbal extracts, soy protein, vitamins, minerals and inulin fibre. Slowly but surely, these functional drinks are moving into mainstream food markets.

Future Positioning

Communication of functional foods between manufacturer and consumer can become severely restricted when legislation prevents or discourages descriptive or comparative health claims. For example, in EU countries direct comparison of health claims with a competing product is prohibited. And if consumers can't make quality choices, then there obviously is less need for the manufacturer to offer these premium solutions or introduce new innovations. A single and transparent pan-European framework is needed to promote consumer interest and confidence in functional foods.

Both the Nutrition Labelling and Education Acts (NLEA), and Dietary Supplements Health and Education Act (DSHEA) aim to reduce healthcare costs and improve the health of US citizens. However, manufacturers of functional foods need to decide whether to market the product as a food or as a supplement.

In contrast to the EU and USA, Japan has a system that allows approved products to make a specific health claim. These claims are regulated under the FOSHU law (Foods for Specific Health Uses). Under this system, established in 1991, products must contribute to health enhancement and specifically be consumed as regular food intake rather than in the form of a capsule or pill. FOSHU approval, in contrast to pharmaceutical approval, is for ordinary food with a specific health benefit that is proven safe in terms of non-toxicity, hygiene and microbial standards. It is striking to see that over 90% of Japanese health foods are made up of lactic acid bacteria products such as lyophilized bifidobacteria probiotics that are used to improve the intestinal environment, prevent diarrhoea, suppress infection and reduce cancer risks.

Subsequently, the demand for 'food minus' products, such as fat-free or low-cholesterol, will shift to 'food plus' and lifestyle foods that contain the added health benefits of fibre, protein, lactobacillus, omega 3 oils and a wide range of emerging 'phyto-health' boosters. True, objective information will become a key element, as there is a looming danger that consumers will become confused in making a choice between functional foods and functional claims. The USA is something of a nation of 'pill poppers' and the active ingredient(s) on which health claims are based might end up in concentrated form in a pill or capsule.

Some functional foods with high market expectations did not quite gain acceptance in markets such as the UK. Marketers reported that people dislike foods that are linked to an illness. For example, in the UK some degenerative diseases (obesity and diabetes mellitus type-2) are associated with lower socio-economic groups of society. Subsequently, instead of making a specific health claim, it is perhaps smarter to promote the presence of an active ingredient with a health benefit. Thus, the marketing message clearly would be: 'Food you love with a "better-for-you" bonus'.

Homo sapiens or *Homo sedens*?

If one thing can be learned from history it is that humans do not easily give up eating foods they love and to which they've grown accustomed. Apart from wider availability, processing know-how and the widespread use of functional ingredients, not much has changed in the last 3000 years. By popular acclaim, many basic foods have been around for thousands of years. Despite the fact that a few generations of religious policing have tried to ban the pleasures of wine and beer, these products are still enjoyed in ever-increasing quantities. In many countries wine and beer are safer to drink than water! As a matter of fact, some of the first laws in mid-13th century Europe were directed at maintaining the quality of wine, beer and certain meat products such as mortadella. Louis Pasteur's first experiments in food sanitation focused on preserving wine, not milk.

Homo sapiens, or perhaps better said *Homo sedens*, has a strong and stubborn dedication to real food, and often instinctively rejects foods that are over-processed and artificial. On the other hand, there is also a genuine desire for more convenience, which culminates in strong growth of easy-to-prepare and easy-to-eat foods. Still, humans have a great love and affection for the smell of freshly prepared foods such as bread, and will sacrifice convenience if necessary.

Eat to live, or live to eat? There is little doubt that modern degenerative diseases are partly the result of extended improper food management, such as compulsive eating or eating unhealthy food combinations. However, relaxation, laughter, enjoyment and providing ample time to enjoy a meal are perhaps equally important. No doubt avoiding stress must have to do something with good health also.

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6
Downsizing Super-sized Food

Will meat, fat and sugar-filled foods be nutritionally sustainable and have a future in a rapidly changing demographic landscape of overweight and obese consumers? The jury is still out, but it is certain that the world has witnessed an unprecedented shift away from traditional diets since the 1970s. Is the rise of the fast food industry as a global marketing force of energy-dense foods with high levels of hidden fat and sugar a coincidence or the real culprit of looming belt-bulging diseases?

For a starter, food companies in most developed countries should promote and serve smaller portions. The next step could be to be honest about the make-up of foods. Consumers have a basic right to be informed about scientifically proven benefits and possible harmful effects through labelling of food products.

Special attention should be given to the marketing campaigns directed at children. Children are a vulnerable group and food companies should not put these youngsters in a position of eating away from home with the newest toy gadgets on their mind. Every day, nearly one-third of US children aged 4–19 years eat fast food. It is not surprising that these fast food lovers consume more fats, sugars and carbohydrates and fewer fruits and non-starchy vegetables than youngsters who do not eat fast food. The difference is a whopping 187 extra daily calories, which theoretically translates into some 7 kg of bodyweight per year. These numbers should be reason for concern and an overall picture is emerging that fast foods bolster calorie intake and obesity risks in children.

Slowly but surely, reality sinks in and policymakers are taking action to protect children from fast food abuse, including efforts to limit soft drinks and snack food sales in schools, and to cut food advertising aimed at children. Finally, fast food companies are also taking notice and are taking responsibility by proactive engagement in offering healthier fare, including many soy protein formulated foods with a more balanced approach to calorie management.

It is of paramount importance that under the leadership of the United Nations Health Agency, Government regulators, healthcare professionals and consumer groups work with rather than against the collective food industry. However, on their part the food industry should take a hard look at themselves and determine if society reflects an image they want to portray? Probably not!

The battle against obesity and food-related degenerative diseases can only be successful through joint efforts of cooperation and sound science.

Overweight and Obesity

US society represents an example of how the world is misusing the true meaning of food. An alarming number of Americans are considered obese. The waistline of

Americans is expanding faster than that of people in other parts of the world.

There is a distinct trend toward overeating. Prosperity, lack of nutritional education, lack of physical exercise and, of course, the abundant availability of fat- and sugar-loaded foods at all times during the day can be considered the real culprits. Franchised fast food and family restaurants alike, and a growing number of home meal replacement products, all serve belt-straining meals. Increasingly, physical activity is the lifestyle change most likely to have far-reaching consequences in preventing coronary heart disease (CHD). (See Fajcsak, 2002.)

For example, about 25% of all women engage in no regular physical activity, while more than 60% of all women fall short of the recommended amounts of activity. This translates into a sedentary lifestyle for well over 50% of the American population with no physical exercise whatsoever. Society is changing rapidly from an environment where people work physically, to a large group of people who sit all day working at a computer or are glued to the TV watching cooking shows or sport entertainment.

With six out of ten Americans overweight or obese, it is no wonder that this category of people has started to impact on the entire food industry. The Centres for Disease Control and Prevention states that approximately 21% of US adults (44 million people) can be classified as obese. Obesity is equally prevalent in men and women. These numbers have increased by 74% since 1991.

Medically speaking, obesity is a disease defined by an imbalance between energy intake and output with the accumulation of large amounts of body fat. Adult people of 20 years and older are generally classified as too heavy or obese if the body weight is respectively 25% or 30% above the hypothetical weight. The latter is derived from the body mass index (BMI). The BMI is calculated by dividing weight in kilograms by height in metres squared ($BMI = w/h^2$).

For example:

A 1.60 m tall body weighing 100 kg
100 : 2.56 (1.60×1.60) = BMI 39.1
A 1.85 m tall body weighing 80 kg
80 : 3.42 (1.85×1.85) = BMI 23.4
(A BMI of <18.5 is considered underweight, while a BMI >25 is considered overweight, a BMI >30 obese, and a BMI >35 super-obese.)

There are, of course, genetic roots to obesity. But the sedentary lifestyle and chronic overeating by the Internet generation makes it easy to become inactive. On top of this, consumption of food is a measure of good life. With all those factors, it is obvious that more serious health problems are yet to come and, in fact, the rate of weight increase in the UK and some other Western European countries is comparable to the USA, with a time lag of about 10–15 years.

Although obesity has reached epidemic proportions, politically speaking this major public health issue is still on the back burner. The prevalence of obesity increases with age in both men and women, possibly due to the fact that resting metabolic rates decline with age and because of the influence of lessened physical activity, such as active sports. Additionally there are indications that educational achievement is associated with body weight: well-educated people are more able to prevent excessive weight gain, perhaps because they have a greater understanding of the benefits of diet and exercise. Also, an individual's response to stress may be important. It is also true that people who adhere to a vegetarian diet usually have a lower body weight than those who don't.

However it arises, medical professionals agree that obesity is difficult to treat. Only about 5% of those who go on weight loss programmes maintain that loss after the first year. It is tougher to maintain weight loss than to initiate weight loss. It is important to note that weight loss is not the same as weight maintenance. It will be absolutely critical to address the issues of obesity. For example, one in four Americans is obese and more than 60% of the population is overweight. It is safe to say that any diet that limits foods to about

1500 calories per day produces short-term weight loss. However, long-term weight maintenance might also be influenced by psychological and physical issues such as mood swings, and dietary counsel. Extended human diet studies have been conclusive in the sense that a moderate fat intake of no more than 30% of calories, limiting protein intake to about 20% and consuming more complex carbohydrates such as fruits, vegetables and grains is an ideal balance.

Apparently, low fat products have not positively influenced the body weight of people in general. On the contrary, the average body weight of people in Western society is increasing. The problem is that fewer people eat because they actually experience symptoms of hunger. Increasingly, people eat because they respond to time of day, social environment and impulses, such as smell, observation or just thoughts. Although obesity has reached epidemic levels, medical funding on a per patient basis is extremely limited compared to other health conditions, such as heart disease, cancer, diabetes and HIV.

It is clear that national governments need to become much more proactive on the matters of health and diet effectiveness. Continuing contradictions and confusion are not helping people who want to be in charge and try to stick to a balanced and nutritionally sound diet.

Environmental Issues

It is true that in many big cities the air quality is also part of the equation. High ozone levels have a negative impact on outdoor physical activities such as brisk walking and running. It is obvious that some degenerative diseases such as cardiovascular disease and cancer find their origin in dietary and nutritional flaws. Certainly, physical exercise conditions the heart, maintains a healthy body weight and increases energy levels, while improving sleep. At the same time, there is a darker side to strenuous exercise and working in environmentally questionable conditions, because it increases oxygen requirements, which can sometimes trigger a chain reaction, risking rheumatoid arthritis, cancer and cataracts.

Like cigarette smoke, heavy smog and air pollution, oxygen can promote the growth of potentially harmful molecules called free radicals. Free radicals are missing an electron and pillage or scavenge electrons from proteins and other genetic material and protective cell structures. Free radicals thus can cause oxidative stress, setting off possible chain reactions leading to genetic destruction and ultimately causing tumour growth. It is therefore of extreme importance to ascertain that the daily diet contains sufficient potent antioxidatives that have been linked to protection against major diseases like cancer and heart disease.

Innovations or Back to Basics?

When developing a new food it no longer suffices to understand plain demographics. Marketers must be aware of lifestyle, attitudes and household composition of targeted consumers. How can these often conflicting objectives be reconciled?

- How to deliver delicious great-tasting but more nutritious, less highly processed foods?
- How to tackle obesity and other degenerative diseases?
- How to use food as a strategy to lower costs of a health care plan?
- How to reduce the environmental burden and dependence on animal-derived foods?

Major innovations will be needed to address these challenges. It will require much broader viewpoints and cross-multitude interactions than the narrow tunnel vision of shareholder value-driven objectives of most stock market listed companies.

Affordable Food is a Basic Human Right

Major sociological and economical changes will affect the quality of our lives and the direction of the food industry in the next few decades. New foods and beverages are being introduced at record rates and most products try to offer something unique to a demanding customer. These demands range from quality and uniqueness all the way down to quantity and value. The world population will continue to grow at unprecedented levels from 6.3 billion in 2003, to 7 billion in 2010 and 8 billion in 2025. Of the latter figure, 5 billion will be global, affluent and urban-based consumers.

The issues of rapid growth of population and shortage of fresh water supply are further clouded by the number of countries that have a greying society and are confronted with a decline in birth rate, which ultimately can lead to progression of current poverty levels. These demographic trends will no doubt influence domestic and international policies, including figuring out how to support ageing populations with managed healthcare systems and two-tiered food programmes ranging from affordable nutrition for people living in the economically depressed countries and the development of functional foods for more affluent societies. If these issues are not addressed, it will have devastating effects and might destabilize world society as a whole.

Taste Expectations

Lifestyle foods such as meat-free or meat-analogue meals embrace a broad spectrum of consumer foods. Lifestyle foods are a part of a food system that will deliver psychologically driven wellness together with nutritious foods for improved health and longevity. Or in other words, not just a product or single ingredient alone, but rather a system of health through foods that deliver personal wellbeing.

Compared to traditional foods, lifestyle foods remain a niche market, albeit at a strongly growing rate. Additionally, it can be expected that hidden nutritional assets, such as lycopene in tomatoes or soy isoflavones, will be leveraged and re-marketed as an intrinsic health benefit.

Eating and diet habits change over time as a result of socio-economic factors. Already, it is evident that the dogmatic attitude of some American franchised fast food companies can not be sustained. For a plethora of reasons, consumers have demanded change and forced the fast food companies to loosen the strict formulae guidelines and adapt to local or regional flavours and economic preferences. A decade from now, the food service sector will be largely unrecognizable from how it is portrayed today. Innovation, convenience, flavour preferences, affordability, entertainment, healthy choices and made-to-order convenience will drive significant changes.

On the other hand, the food service industry has come to realize that health doesn't sell – at least not for now. Most fast food customers don't necessarily want to know what's in food. They just want to enjoy it without the burden of guilt. Yet, as demographic changes occur, nutrition will become a bigger issue over time.

Active interests in health and nutritional issues have slowed most likely as a reaction to many years of nutritional 'terrorism'. The food service sector may lead in culinary trends, but its nutritional correctness lags that of the retail sector. This is largely attributed to the absence of nutritional labelling on food service products, but definitely is also influenced by the mindset of consumers, who seem to have a double standard when it comes to purchasing food in a grocery store and when eating out.

For example, everybody will *say* they want to eat healthily, though when decision time comes the food chosen often doesn't match the intentions.

Change at large corporations doesn't come easy. For example, with great reluctance McDonald's US-based senior management approved in 1993 a store test in the

Philippines to evaluate a new formula concept for hamburgers. A patented technology using soy protein granules allowed the combination of 50% beef and 50% meat analogue ingredients. Despite the early scepticism of many, the dedication of a creative team delivered research triumphs, making an old-fashioned burger taste, look, smell and appear like the traditional burger sandwiches. Looking back, the visionaries of the early 1990s probably were ahead of their time. McDonald's Philippines can be highly commended for their dedication and commitment to delivering great tasting, nutritious foods at affordable prices. Ever since 1993 these right-size formulated affordable foods have become a permanent feature on the menu for the enjoyment of a great many customers. At the start of the 21st century, hundreds of millions of formulated meat patties are being sold through branded fast food companies. This example clearly shows that affordable quality and tasty nutrition can actually become a reality.

Another example is the rather sudden switch the global fast food companies made in menu offerings. After a few threats of litigation from obese people and the revolutionary epidemic of overweight and obese customers, finally the message is being received at the ivory towers of fast food management. It now seems as if a serious initiative is being taken to offer special menus for people following low fat, low calorie or low carbohydrate diets. These meals appeal more to an increasingly health-conscious public.

Fast food experts credit these product innovations to quantum leaps in health research projects in which soy protein has been the main driver. In the meantime, more spin-off menu meat and poultry products have been introduced throughout the sector, allowing a larger part of the population to afford the luxury of eating out and enjoying good food created by Mother Nature.

Fat or Fad?

Despite the enormous offerings of calorie-restricted food and meat products, the typical American diet still derives some 60% of its energy from fat and sugar. Fat-rich diets are usually low in complex or less-refined carbohydrates and fibre. There is no doubt that most consumers have emotional preferences for fat-rich foods. Over many generations the need for fat as a source of concentrated energy and as a way to stave off hunger has changed into a psychological desire for fat to fulfil sensory pleasures, such as mouthfeel, texture, bite, flavour and aroma. In processed meat foods, the presence of fat also contributes to juiciness and tenderness. Calorie-dense (fast) food encourages over-eating, ultimately resulting in weight gain because it is out of step with human evolution. In principle, humans are designed for conditions in which food is relatively scarce and low in energy. Most modern (fast) foods are overprocessed and are typically high in energy. The result is that people consciously or unconsciously over-eat without feeling particularly full. Particularly with foods which contain animal proteins, satiation point is reached later than with foods that contain proteins of vegetable origin.

It is believed that if the percentage of body fat increases, the preference for fat-rich food increases accordingly, although there is little similarity in the craving for fat between men and women. Men usually prefer calories that are combinations of fat and protein, or fat and salt. The most popular choices for men are pizza, sausage, hamburger and french fries. Women, on the other hand, generally prefer foods with hidden calorie combinations of sugar and fat such as ice cream, chocolate, cookies, cake and doughnuts. Consequently, consumer cravings for fat may be both biologically and behaviourally driven.

There is little doubt that calorie-controlled food and meat products are here to stay. However, consumers' rather schizophrenic behavioural purchasing decisions tend to provide a cloudy picture. There are clear trends for calorie-controlled foods, yet this is offset by a strong resurgence of high-fat foods. It is as if the consumer wants to be rewarded for healthy eating. The more people resolve to dieting, the more they will eat rich, tasty food to compensate. With all that healthy eating, exercising and sacrificing, there has to be a reward, too. Perhaps the brain's neurotransmitters are the ultimate decisionmakers in behavioural purchasing and subsequent diet patterns. As a result, actually very little change can be seen, if any at all. A slow increase in the average body weight and increasing amount of body fat percentage is something that needs to be deciphered before we really understand the psyche of the consumer.

Then again, for those consumers who actively try to reduce their fat intake, quite often the fat-free foods are replaced by high-calorie foods made with refined flour and sugar. Though these foods provide a 'feel-good' sensation, triglycerides, another measure of heart disease risk, increase significantly.

Close analysis of nutrient intake over a great many years has clearly indicated that economic prosperity increases fat and sugar consumption at the expense of complex carbohydrates, fibre and vegetable proteins. This is clearly illustrated by countries that have adopted, or are in the process of adopting, Western diets, such as Japan, Singapore, and cosmopolitan areas in countries such as Thailand, China, the Philippines and South America. This shift in diet can have positive and negative side effects. Increased fat and sugar content and decreased consumption of soy protein, coupled with the unfortunate loss of a plethora of phytochemicals such as genistein and isoflavones or phyto-oestrogens, can contribute to the development of chronic diseases such as coronary heart disease, obesity and cancer.

On the positive side, a balanced controlled diet of vegetable protein and animal protein, the latter preferably not linked with high-cholesterol-containing animal fats, is believed to be responsible for the rapid growth of elderly populations and the increased height and body size of the younger generation in affluent cosmopolitan areas. This evolution started in Western Europe and North America in the early part of the Industrial Revolution and continued to the post-war generation. It is expected that informed consumers will rapidly pick up the overwhelming and convincing scientific evidence that rather dramatic changes in the diet will be necessary to promote longevity.

This is especially true for vegetable-based foods that deliver not only high-quality protein and complex carbohydrates, but also contain phytochemical compounds. Soybeans in particular are the richest source of plant phyto-oestrogens or isoflavones that may help to prevent hormone-dependent cancers and other degenerative diseases.

Interpretation

A key point regarding these emerging scientific data is the overriding question of how to communicate these messages to end users. Much has been written recently about a new wave of health food and meat products in the pipeline waiting to be launched. Quite often, however, government regulations regarding health claims hold back a more rapid introduction to the marketplace. However, it is highly unlikely that these so-called functional foods will substitute for the elementary guidelines to control calorie intake and obtain regular exercise. In terms of ideal body weight, there are simply no long-lasting shortcuts or quick fixes. The most important goal is to prevent society becoming split into two main groups, namely, people who care about personal health, well-being and longevity, and those who tend to enjoy what some describe as compulsive eating.

It will be difficult to ask food and meat processors to be the referee in this matter. Meat and food processors simply need to manufacture and market what the consumer tells them they want and will pay for. However, it is safe to assume that the complexity of the diet will continue to boost the introduction of new food and meat products at an ever-increasing pace, and will diversify to specific demographic categories for fragmented consumer interest groups. Hence, it will be fascinating to see if the staple foods of today's marketplace are going to survive in an unchanged form 10 years from now.

Processed meat products will need to anticipate these changes. Sure, a sausage will always be a sausage, but the conceptual positioning and the perceived image will zero in on targeted customers who are, in extremes, either prepared to pay for feeling good about themselves or who insist on the availability of quality foods at the lowest possible prices. Prepared meals for the microwave generation and, more importantly, take-away cooked meals will change traditional home cooking forever. Some of these changes will be a slow evolution and dependent on economic and social demographics. Others will be more dramatic and may well revolutionize the way food is marketed and enjoyed.

Affluent Change

The percentage of US households made up of married couples with children dropped from 45% in 1970 to 25% in 2000. No doubt the face of the family has changed with increasing numbers delaying childbirth and baby boomers becoming empty nesters. Hectic lifestyles are the norm for large segments of society, such as working women who try to juggle the impossible task of being successful as a professional, a mother, a wife and a lover all at the same time. This development, together with a growing number of single households, has led to discerning consumers who need greater flexibility in meal opportunities that can be indulgent yet healthy.

The future will focus less on families and redirect increasingly to the life-stage consumer segments. Marketing to children is one of the sub-categories. Instinctively, children know how to influence the decision-making process of parents using negotiating skills and tactics to elicit good behaviour.

The reduction of family size and the increased influence of outside communication such as television and the Internet have made children into more equal family members earlier in their life. Translated to food and fun, this means that 'entertainment' has become an essential part of the value that restaurants need to provide to stay ahead of the pack. A recent development is fast–casual dining at franchised chain restaurants, which is the fastest growing segment, but this has occurred at the expense of independent restaurants. However, the pendulum of change is in full swing. Newer restaurant styles are now designed to deliver a dining experience at a more appealing fast–casual value, including home-style meals to solve the 5 o'clock dilemma for an increasing number of people with busy households or 'won't cook, don't cook' generations. The challenge is to provide a freshly prepared, great tasting and nutritious meal at a reasonable price for a large group of consumers that are too worn out to fix a meal that requires time and effort. These fast–casual restaurants with an upscale look and appearance probably try to integrate a centre-of-the-plate serving, such as a functional non-meat protein-enhanced pre-cooked meat portion or a pre-cooked meat analogue, together with freshly prepared contemporary food selections featuring some classics and ethnic culinary foods with provocative bold seasonings from around the world.

'Globesity'

Calculations of a person's caloric needs must take into account activity levels. There has been a shift in the recommendation for the minimum amount of physical activity. As recently as 1996, the United States Surgeon General suggested at least 30 min of moderate activity on most days. New guidelines in 2003 recommend that adults and children exercise for at least 1 hour a day doing moderately intense physical activities such as swimming, cycling or simply brisk walking. The reality, however, is that these well-meant recommendations are impractical, based on the notion that at least 50% of the US population is now totally sedentary. Should health promoters be practical and reach for what is possible or dogmatic and preach the unattainable goals of 1 hour's daily exercise?

The reason why alarming numbers of people are overweight or obese is simple: *They eat too much!*

The socio-economic and cultural reasons are more difficult to explain and require input from many experts. The level of overweight and obesity demands urgent action on many levels in order to prevent further increases in the prevalence of diseases. Whereas obesity is slightly more common in women than men, the percentage of people who are classed as overweight is higher among men. Lower educational status, more television and computer viewing coupled with lower physical activity are each strongly associated with overweight and obesity. It is obvious that the latter confirms that sedentary lifestyles have become the single biggest roadblock for furthering the quality of life of society as a whole. Also people who are obese often are depressed and this is particularly true for women with a poor body image.

Just as the medical profession is winning the war against vexing age-old diseases, a new enemy is rapidly emerging in the 21st century. In the USA alone, about 300,000 deaths per year are associated with overweight and obesity. The World Health Organization (WHO) has blamed processed food for the sharp rise in obesity levels and other chronic diseases around the globe. Body weights of Americans are at an all-time high and it is estimated that some 120 million people fall into this category. On a worldwide basis, the numbers are even more staggering, with more than 1.7 billion people classified as overweight (=25% of the world population), of whom 312 million are obese, up from 200 million in 1995. According to the latest data (2003) from WHO, the global profile of disease is changing. Cardiovascular disease, cancer, obesity, diabetes, gall bladder disease, osteoporosis and respiratory disease now account for approximately 60% of the almost 57 million global deaths annually. Overweight and obese people also have a major negative impact on the economy. These fat people cost more in health care than heavy smokers and drinkers. In the USA alone a staggering US$115 billion is the economic setback for medical claims, lost productivity and future earnings due to premature death.

The rates of obesity-related diabetes, cancers and heart disease put many of the 300 million obese people worldwide at increased risk. Obesity is poised to become a global health disaster and it will be extremely difficult to bring it under control. There is a complicated interaction of protein-peptides, hormones and genetics involved in controlling appetite and hunger. There are, of course, radical methods to control overeating. For example, a medical procedure called bariatric surgery, also known as stomach stapling, is an option to reduce a patient's stomach significantly. However, these procedures can result in serious side effects like blood clots and internal bleeding.

Both the medical profession and nutritional experts agree that prevention is the most favoured option to battle this disease. Probably the greatest contribution to mankind of vegetable protein and soy protein in particular is that these environmentally safe and sound foods are uniquely able to pack premium protein quality into foods that contain low to medium calorie contribution for long-lasting weight management. Soy proteins simulate satiety much more rapidly than most animal protein formulated foods, which often also contain higher levels of fat.

As people everywhere get bigger and heavier, the social impact is also enormous. For starters, American girls today shop for clothes that are roughly two sizes larger than when their mother was at that age. Seats in airplanes, stadiums and furniture also need adaptation. 'Globesity' has arrived and will negatively impact all walks of society at unprecedented levels. The business implications are phenomenal and not only are food companies addressing these concerns, but pharmaceutical companies are intensively researching for miracle slimming drugs, while cosmetic surgeons work overtime to satisfy the need for liposuction.

Ten per cent of children between the

ages of 2 and 5 years are already overweight, not to mention obese teenagers topping 15% in 2003. This major surge comes with changing habits: only a small percentage of children walk to school, they exercise much less and love to eat junk food at school and at home to satisfy their sweet teeth.

Juveniles as young as 5 years show signs of heart disease, and chances are that this generation will be the first to live shorter lives than their parents. For some children, gaining weight can turn into a medical crisis.

Type 2 diabetes, an obesity-associated disease once known as adult-onset diabetes, now strikes children too. It is obvious that American adults, 64% of whom are overweight or obese, are not necessarily a role model for children or a good influence on eating habits and activity levels.

Type 2 diabetes is a chronic disease in which the body does not properly produce or use the hormone insulin. Insulin helps transport glucose from the blood into the cells, where it is used as the body's primary fuel. Overweight people face real health problems, such as higher risk of type 2 diabetes, heart disease and cancer, but also suffer lack of mobility and an inability to use all body functions to full satisfaction.

Not just excessive fat consumption, but also refined carbohydrates are to blame. Unlike whole grains which break down slowly in the digestive tract, refined carbohydrates surge into the bloodstream as glucose. Herein lies a main danger, because if the glucose is not immediately used as 'fuel' for activities, the body needs to react quickly to produce insulin to move the glucose out of the blood and deposit it in fat and muscle cells for storage. A rapid increase in blood sugar stimulates a large release of insulin, the hormone that directs glucose to the muscle. High levels of glucose and insulin can have negative effects on cardiovascular health. It has been determined that overweight or obese people who are inactive can become resistant to insulin's effects and therefore require more of the insulin hormone to regulate the adverse metabolic responses to carbohydrates. An occasional indulgence in food abundance does no harm, but for sedentary people who have a habit of overeating the wrong foods, insulin production won't be sufficient and can thus trigger 'adult onset diabetes' or diabetes mellitus type 2, fostering many ailments of which heart disease is the most important.

Lack of activity as well as over-nutrition is the real culprit in the obesity problem. Physical exercise helps to control insulin levels, while ingesting certain food combinations, such as fat and sugar or starches, elicits a massive release of insulin, allowing the body to become an ideal storage place for fat. Research indicates that a moderate but high-quality protein level in food intake is critical to stabilize blood sugar, which is the underlying problem in diabetes.

Among the most worrisome symptoms are changes in blood chemistry that can trigger future health problems. For example, elevated blood-sugar levels, a precursor of type 2 diabetes – formerly known as adult onset diabetes – is now soaring in the under 20-year-old population in Western countries. As a result, complications like eye damage, which usually takes years to develop, are suddenly common in the younger age groups also. (See Jenkins and Kendall, 2003.)

Not only has society an obligation to feed the hungry, but what about the staggering medical health bills of obesity? It seems as if obesity and all the linked illnesses hit the poor hardest of all. Especially in the USA, high-calorie-dense 'junk food' is cheap enough to afford on a low income and subsequently for many 'eating to death' has replaced 'eating to live'.

Super-size

Of course consumers themselves are responsible for their food choices. But in all fairness some finger-pointing to the American way of living is justified. After all, American fast food companies, in their unrelenting drive to generate sales and profits through a global empire of restaurants, have introduced super-sized and value-sized food portions. Marketing campaigns funded by almost unlimited advertising budgets directed at certain target groups to Americanize world food habits definitely share some of the blame for making people eat more than is needed. Increasing the size of the serving portions helps to spur sales, and subsequently profits from food generally rise when manufacturers increase serving size. Research clearly shows people eat more when they're given larger portions. Each restaurant and food company has an incentive to get more food on to the plates. There is no question that consumers suffer from portion distortion!

The trend toward super-sizing began in the mid 1970s, but increased sharply in the mid 1980s. From there on, the trend only continued and perhaps that is why the developed countries are now faced with two generations that clearly show a linear line between food-size and waist-size.

Super-sizing is not just happening with fries, burgers, pizza and soda pop. Equally responsible are the colossal sizes of bagels, muffins, chocolate chip cookies and croissants.

Super-sizing food portions and lack of daily physical exercise is therefore rapidly becoming a global epidemic. More and more countries, even some that were struggling to prevent hunger a few decades ago, are now wrestling with the dangers of excessive nutrition. The USA is a bad role model, as a combined 37% of its adolescents and children are carrying excessive fat deposits. Europe, the Middle East, Asia and sub-Saharan Africa are not far behind.

People who are obese as children have an increased risk of becoming obese adults. The surge in overweight and obesity will set the stage for a global explosion of illnesses that will not only drain economies, but also will severely affect the quality of life of a great many millions of ageing people.

Americans are not just getting fatter; they are ballooning to extreme obese proportions at an alarming rate. The number of extremely obese adults – those who are at least 45 kg overweight, equalling a BMI of 40 – has quadrupled since the 1980s to about 4 million. For the USA, that works out at about 1 in every 50 adults.

According to US government figures, in 1984, 46% of the American population was overweight and 14% were obese. By 1994, the figures were 56% and 23%, respectively. By 2002, they had reached 65% and 31%.

Americans, in particular, are proud to be able to purchase super-size portions and are known to eat everything they are served without actually realizing that the serving sizes are double or triple. Research published recently shows that, contrasted with standard servings in 1982, today's hamburgers are 112% larger, bagels are 195% larger, steaks are 224% larger and muffins 333% larger. Not to mention that a serving of pasta has increased by 480% and a chocolate chip cookie has grown by a staggering 700%. Common sense indicates that there must be a connection between serving sizes and waist sizes.

For franchised fast food restaurants it is relatively cheap to offer super-sized food portions. Food costs are only marginally higher; therefore the marketing blitz to draw higher numbers of customers on super-value promotions obviously justifies the load of the extra but hidden calories. On the other hand, it is also true that any food can theoretically be part of a balanced diet if the portions are tiny enough. Once inside the restaurant or drive-through lane, customers are enticed not to make intelligent and sensible decisions.

Although many countries have national health guidelines for reducing obesity, very few countries actually have a plan to implement these guidelines. In a way, schizophrenic behaviour occurs, because people who want to eat right have to behave abnormally. For example, most people don't actually pay close attention to what constitutes a serving. 'A serving is what is being served', is a rather logical conclusion.

No longer is obesity only an adult problem. In the USA at present, one out of four children is overweight. There is a significant health crisis of obesity among children, and one of the primary contributing factors to the national epidemic of obesity is the fact that the dietary choices made by and for children are significantly devoid of essential micronutrients. Children who principally consume foods and beverages high in sugars and fats are usually lacking vitamins, minerals and fibre. In reality these affluent children in the USA are as prone to the many illnesses associated with micronutrient deficiencies as those children in Third World countries. To attack this severe health problem it is necessary to find a way to reach parents first.

The way food is promoted to targeted children has a distinct effect on their eating pattern. It is highly likely that a link exists between promotional advertising and children's eating habits. The real culprits are pre-sugared breakfast cereals, confectionary, savoury snacks and soft drinks. The influence of television and the Internet reinforces multi-faceted communication combining high-sugar and high-fat types of food with point-of-consumption activities. Usually these advertised diets contrast sharply with the recommendations of public health advisers and guidelines.

Overweight and obese children are not only risking their health, they also feel targeted at school and in other social settings. Parents feel embarrassed as well, as it is hard to feel proud of their offspring. Since the 1990s the number of overweight children has grown rapidly. Even more worrisome are the strong indications that overweight children are more likely to stay overweight or obese as adults. It looks like a script for a science fiction movie: obese parents and undernourished children living together in a high-tech house in a nice suburban community with empty streets. After all, television and computer screens and unsupervised snacking are the only exercise most children are accustomed to, while both parents are busy with their careers.

Legislation and Litigation

But let's not be too harsh on the American lifestyle and food culture. Overweight and obesity is quickly becoming a global battle. For example, in Germany every third child under the age of 12 and every fourth teenager is overweight. Even in the well-known Mediterranean diet culture of wine and olive oil, waist sizes are slowly but surely expanding to unprecedented levels.

Fast food companies are struggling to keep consumers loyal and happy as they look to higher-quality healthier food. Most of these companies are 'sandwiched' between their great tasting traditional menu offerings and the not-so-great-tasting healthy modern foods.

Perhaps it is not a question of blame, but it is true that American food companies share much of the responsibility for exporting typical American foods to nearly every part of the world, with perhaps Africa as the only exception. Clearly American food and beverage companies in their unrelenting push to increase shareholder profits decided long ago to develop international markets for these unhealthy foods full of unneeded calories. Proliferation of American choices of salty, fatty and sugary foods have clearly undermined the generally healthier eating traditions of other countries.

There has been a long-standing notion that food companies were recession-proof. Not any longer! The companies with the most to lose generally market foods and beverages with an overload of fat, salt and sugar. Consumer litigation will force American companies to adjust product portfolio in order to meet consumer demands for healthier foods. Well known brand companies are currently working double duty to reposition R&D projects and are facing an incredibly difficult task to satisfy both government food regulators and at the same time meet consumer demand for healthy yet tasty foods.

Still change is about to happen and recently global fast food chains have selectively launched the first products aimed at people watching their waistline – low-fat chicken sandwiches and salads on menus can now be seen as part of a well orchestrated makeover. Dieters also will be able to order (fast) food meals that substitute salads for french fries, bottled water for soft drinks and 'bunless' hamburgers and chicken patties. For example, to reduce carbohydrate intake, 'bunless' hamburgers are wrapped in lettuce.

Is there an answer to the obvious paradox of whether corporations can successfully satisfy shareholder value and sell smaller, healthier and tasty food portions at the same time?

Early indications are that clearly the threat of law suits has triggered more food companies into action to change rather than they proactively sought healthier solutions. It is expected that large multinational food companies which have much to lose will start to trim portion sizes. But even so, the bottom line is that major change can be expected in the years ahead. Perhaps these discussions will be more intense than the public's debate on GM foods.

Another important variable in the availability and positioning of healthy foods is government regulations. The EU has a tradition of strong regulations and has proposed a directive that would make it much tougher for companies to make health claims on foods and beverages. In comparison, the USA Food and Drug Administration most recently made it easier for food and beverage companies to make health and nutrition claims. These inherent differences will undoubtedly influence marketing dynamics and as a result consumers on both sides of the pond will need to be educated accordingly. In that sense, it seems as if the world is getting larger, instead of smaller.

Instead of becoming part of the problem, the food industry should take positive steps to become part of the solution. The food and meat industry should therefore implement proactive strategies, if only to avoid potentially onerous government intervention and/or reduce the risk of legal liability and damage to its public image.

Complexity

For some food companies it's time to get some innovative collective thinking in place because it is clear that American fast food imperialism not only has generated at least two generations of over-sized and overweight people, but equally important, we now are confronted with a society suffering from degenerative conditions such as heart disease, high cholesterol and high blood pressure, stroke, bone and joint weakening, osteoporosis and, not least, mental anxiety and depression.

On the other hand, fast progress in technology-driven lifestyles has fast forwarded the attitudes and behaviour of people, yet slowed down physical activities to dangerously low levels. Human genes are programmed to be physically active, and the abundance of foods with large amounts of hidden calories has created an imbalance between caloric intake and calorie-burning activities.

How long will it take before the evils of the couch-potato syndrome make way for sensible weight management? How can massive numbers of people be motivated to react and fit exercise into their daily lives? Based on current knowledge there is no quick-fix solution in sight. The complexity of the issues includes social infrastructure, changing food habits, sedentary behaviour and above all decreasing motivation for physical activities. For example, the popularity of some diets, such as the low-carbohydrate slimming methods, illustrates that people are very willing to try easy and tasty ways to lose excess weight, even though some of these diets spark much medical debate about their long-term effects.

Perhaps the time has come for food companies in general and franchised fast food restaurants in particular to give serious thought to the earlier suggestions to install a Nutritional Advisory Board. After all, the past has proved that somehow, someone in the future is going to pay the price for super-sizing the customers' body.

Downsizing Food Intake

Increasingly, people eat because they respond to time of day, social environment and impulses, such as smell, observation or just thoughts. Although obesity has reached epidemic levels, medical funding on a per patient basis is extremely limited compared to other health conditions, such as heart disease, cancer, diabetes and HIV. The future of healthcare costs to combat obesity-related diseases is beyond comprehension. But perhaps even more important is the overriding issue of how to find communication ideology and consumer platforms to discuss these issues? So far the food industry and the scientific health professionals have only contradicted each other with, as a logical consequence, consumers being inundated with results touting glory or doom for practically every single known food. Healthy food does not necessarily translate to elimination of a key ingredient such as fat. Consumers like to indulge in pure pleasure; they have come to expect it and it has resulted in concerned consumers shifting to weight management with more emphasis on positive nutrition rather than on negative nutrition.

For example, soy protein is now extensively being used beyond the typical use in meat emulsions and water binders in processed whole muscle meats such as roast beef. Now a great many high-protein/high-fibre cereals together with ready-to-eat food bars and ready-to-drink smoothies deliver health benefits. Recent research shows that through a combination of weight loss and physical activity, the risk of adult onset diabetes can be reduced dramatically. Lean and high-quality protein, including meat, dairy and soy protein can play an important role in a healthful lifestyle that prevents or manages degenerative diseases.

Being Fit

There is a growing belief that being overweight, even obese, isn't as unhealthy as being sedentary. Recent research at the renowned Cooper Institute for Aerobics in Dallas, Texas, showed that unfit lean people, as measured by performance on a treadmill, were nearly twice as likely to die as the fit, including the obese fit. This indicates that a more effective treatment might be a healthy diet with lots of fresh fruit and vegetables and exercise, though not purely for the purpose of weight loss. The latter draws attention to a larger problem, which is the obsession of modern society with appearance. Most people work out not to get fit but to get thin and when that fails to happen they quit the daily routine (Table 6.1). Obviously there is a major challenge for health care professionals: getting people to focus on feeling better rather than looking thinner. Needless to say, it will take a great many years to dispel the myth that thin equals fit, and fat unfit. However, just to be sure, the healthiest option is to be fit and trim.

The most dangerous fat lies around the organs, deep within the belly. Obese sedentary women in particular tend to have more

Table 6.1. Counting calories. Studies show that exercise can promote good long-term health no matter how much you weigh. A brisk half-hour walk a day is enough to get the benefits. Combined with a healthy diet, it also helps to stave off obesity. How many calories does your workout burn?

Activity	Calories per hour
Sitting	80
Weightlifting	215
Volleyball	215
Golf	250
Lawnmowing	325
Walking	325
Kayaking	360
Dancing	395
Waterskiing	430
Hiking	430
Aerobics	505
Racquetball	505
Tennis	505
In-line skating	505
Skiing	575
Hockey	575
Martial arts	720
Bicycling	720
Running	720
Swimming	790

intra-abdominal fat and thus are at higher risk of heart disease, stroke, high blood pressure and diabetes, as well as cancer, including uterine, breast and colon cancer. Exercise significantly lowers the amount of body fat, including lowering the amount of intra-abdominal fat deposits. A recommended level of exercise is 45 min a day, 5 days a week. People who store their fat around the stomach are at higher health risk for chronic conditions than people who store fat in their buttocks and thighs. (See Burke, 2002.)

Nutrigenomics

Government, healthcare professionals and the entire chain of food processors must unite and develop a plan that uniquely incorporates health cuisines and physical activity. They should be proactive over health and diet guidelines rather than just compile statistics and react only on signal trends accompanied with the occasional warnings. Continuing contradictions and confusion are not helping people who want to be in charge and try to stick to a balanced and nutritionally sound diet. In the past, dietary guidelines were directed at the whole population and based on the recommendations for the majority of consumers. However, it is clear that in developed countries where affluent consumers already 'enjoy' an abundance of food choices, individually customized food selections are needed in the search for health, well-being and longevity.

Functional niche foods of today will most probably transform into normal food options addressing the needs and wants of people who are prepared to spend extra on foods in order to remain energetic, mentally sharp, not to mention delay the onset of age-related diseases such as osteoporosis, cancer and heart disease and boost the immune system. On the horizon, food or pharmaceutical companies eventually will exploit nutrigenomics to develop functional foods tailored to meet the needs of individual people with specific genetic traits. Nutrigenomics is the understanding of how dietary chemicals affect individual health by interacting with their individual genetic make-up, altering the expression or the structure of the genes. Eventually genetic manipulation could become a common form of treatment. If one thing is certain, the end of the seismic effect on the slimming business is nowhere in sight.

Most people know that the secret of a long and healthy life is to avoid an excess of calories and to eat plenty of fresh vegetables and fruit. It is expected that sometime before 2010 nutigenomics will offer people personalized and effective dietary advice to prevent or even cure non-communicable diseases such as cancer, Alzheimer's, heart disease and osteoporosis. Human bodies react to what they eat, but not all bodies react in the same manner. People eat many different kinds of foods and many of these foods contain hundreds of compounds in addition to the basic protein, carbohydrate, fat and vitamins. Much research still lies ahead and scientists need to identify the important plant micronutrients and figure out how much people need to consume.

At first glance, nutrigenomics and meat products do not have much in common. However, that might change when personalized healthcare is implemented and specific metabolic signatures or profiles predict the interaction of the human body with different nutritive and non-nutritive components present in processed meat and lifestyle foods, such as meat analogues. In this sense, it is reasonably certain that the soy protein ingredients used in meat products will be preferred for more than just technological and organoleptical reasons.

Lifestyle Dimensions and Blurred Demarcations

Although it started a few decades ago as a fragmentation of movements, vegetarianism will ultimately lose its position as a niche market segment and slowly but surely integrate into mainstream diets. Vegetarianism has been instrumental in providing people of all walks of life with a realization of its value to both the environment and health. The contributions of the vegetarian movement have evolved to a greater awareness of both socio-economic and health-driven issues. Now that this awareness has penetrated a large part of the population, it can be anticipated that vegetarianism will lose its strict definition and slowly move into a mass market positioning. Eventually, 'vegetarian' will become part of the catch-all segment 'lifestyle foods'.

The last few years have signalled that vegetarianism is on the wane, but fortunately the decline is overshadowed by the growing number of meat reducers or lifestyle food consumers. Rapid growth of vegetarianism in the early 1990s is levelling off, and instead a significant demographic movement is actively reducing meat intake, especially the fashionable and psychologically driven lifestyle food consumers such as young professionals and young urbanites. Consumers in the first decade of the 21st century are much more individualistic and want their purchases, including food selections, to reflect a different set of personal values. For food marketers it is important to monitor these changes to stay ahead of the curve. While it is true that vegetarianism is on the decline, actively reducing meat consumption is definitely in vogue. To a certain degree, demographic trends are influencing the way in which food will develop. Demographic changes, albeit subtle, change faster than marketers like to acknowledge. For example, the numbers of the youth market are dwindling, while at the other end of the scale aspirational consumers over the age of 50 are skyrocketing.

However, wait a minute: marketers should not abandon the influence of the new generation either. Youngsters definitely look at food differently. It is important to realize that the younger generation growing up with moderation of (red) meat intake will have no problems embracing genetic modifications or the addition of certain natural components in foods to meet goals such as environmental, mental and physical well-being as well as dealing with a rapid growth of intolerance to substances such as wheat gluten and many other forms of food-inflicted allergies. Today's children are growing up faster than any previous generation and their interactive mindset demands instant gratification. Increasingly, these young consumers turn to brand-names for security and affirmation. Foods, including a growing selection of pre-packaged performance and fun foods, therefore need to meet the demands of quality, trust, honesty and safety.

Meat consumption is certainly influenced by the attention generated by vegetarianism, which has affected people's purchasing decisions. For example, there is a trend toward reducing the meat portions or opting for meat-free meal days a few times a week. For nearly all trends, meat-free alternatives will evolve to a point whereby ultimately the distinction between meats and meat-free will be blurred in both the organoleptical sense and in the perception of the consumer. In the next decade, it is likely that the traditional demarcations between certain processed meats and meat analogues will fade.

Despite the trend towards smaller meat portions, indulgence is here to stay, and many consumers will have no problem whatsoever in continuing to make their choice of restaurant on the serving size of the sizzling steak, not the quantity of the vegetable serving.

New Diet Proposals

The new diet proposals by the USA Department of Agriculture (USDA) reflect the fact that for the first time consideration is given to people's age, gender, weight and the amount of exercise. More than 60% of adults and 13% of children are overweight, according to the USA Federal Center for Disease Control and Prevention. More than 50% of the US population and overweight people don't get enough exercise and the urgent message needs to go out to the public that they have to eat less. The bottom line is that a behavioural change is required and it will come as a shock to most people when they realize how few calories they are entitled to in their daily diet.

For starters, the new dietary recommendations suggest that most women aged 35–70 years should eat 1600–1800 calories a day, and that for men in the same age group the range should be 2000–2200 calories. In the past it was assumed that most people were active and the abovementioned calorie intakes were routinely projected to be about 600 calories higher. The new USA food pyramid proposal has undergone revision, although its basic premise will remain the same and consumers still will be encouraged to limit total fat intake to just 30% of all their calories and saturated fat to less than 10%. The new pyramid makes grain, of which 50% should be whole grains, the largest component in the diet. Fats, oils and sugars should be eaten sparingly, while the consumption of foods high in Omega-3 fats, such as fish, should be encouraged. Also the new dietary proposals include recent nutritional standards for vitamins, minerals, fibre and macronutrients like protein, fat and cholesterol. For example, recommended cholesterol intake should be 300 mg or less and sodium intake should not exceed 2400 mg per day.

The new USA diet proposals replace the 1992 food pyramid and should come into effect by 2004. The new pyramid and its dietary guidelines are much more individualized than in the past. That is a major improvement, though the real issue remains that the majority of people are still largely unaware of how many calories they consume in relation to daily expenditure.

In the first USDA food guide pyramid a lot of emphasis was given to limiting fat consumption. Looking back it can be concluded that the latter was a major oversimplification because it has become clear that not all fats are necessarily bad nor all complex carbohydrates good. The 'fat-is-bad' mantra provoked the idea that carbohydrates are good. Monounsaturated or polyunsaturated fats have a beneficial effect on a positive LDL (bad) to HDL (good) cholesterol ratio in the blood, thus decreasing the risk for development of coronary heart disease. The consumption of trans-unsaturated fatty acids found in many baked goods, fried foods and margarines should be minimized because these transfats increase triglycerides while reducing HDL. Transfats should therefore be avoided because they have no place in a healthy diet.

If anything has been learned from the past 40 years it is that calorie intake has gone up through super-sizing food intake while mini-sizing daily exercise. It will be difficult to make people aware that high calorie intake and a sedentary lifestyle are on a collision course with physical and emotional well being.

Atkins Revolution

The diet pendulum has gone from one extreme to the other. In little less than 10 years the diet story has changed from no fat to no carbohydrates. As usual the food industries are quick on their feet and are now racing to please dieters with food packages that boast the number of 'good carbohydrates', 'bad carbohydrates', not to mention 'net carbohydrates' and 'glycaemic index'.

Dr Robert C. Atkins became a key player in the field of weight loss when he published his bestselling book *Diet Revolution* in 1972. Despite an avalanche of criticism from 'traditional' nutritional and medical experts, Dr Atkins' views not only survived into the 21st century, but grew to become the most successful weight management plan of all time.

Studies show that the followers of the Atkins philosophy can expect to lose 3–9 kg over the first 2 weeks while eating foods that most weight loss diets want to eliminate. The Atkins plan allows people to adhere to their lifestyle while adjusting food intake by minimizing carbohydrate consumption.

Basically, the Atkins diet is 'high protein', 'high fat' and no/low carbohydrates.

By withholding carbohydrates, the body is forced into ketosis (lipolysis), thus switching the metabolism to burning mainly fat for energy. Since not all carbohydrates are created equal, in the Atkins philosophy it is essential to simply eliminate the 'unhealthy' or 'bad' carbohydrates made from white flour, rice and potatoes together with table sugar and replace them with 'healthy' carbohydrates that are present in some fruits, non-starchy vegetables, seeds and nuts. Once the target weight has been reached, a lifetime weight management diet allows a gradual increase in carbohydrates until the Atkins carbohydrate equilibrium is reached.

Although low- or no-fat claims won't fade away anytime soon, it can be expected that the pendulum will swing back and reorient toward a focus on the importance of total calorie intake, as opposed to hammering messages about cutting fat calories. The latter messages have sadly failed, and it is no longer enough to make low- or no-fat claims on labels. On the contrary, many millions of dedicated consumers have made the decision to embrace the Atkins diet. This diet promotes a carefully scripted food intake of high protein and high fat at the expense of carbohydrates. (See Atkins, 2002.)

Despite many years of promoting low fat diets, consumers have had it with empty promises and are now following the 'diet that works'. As a result, an avalanche of 'low carb' foods is being introduced and, for example, diet-conscious shoppers are actively seeking more cookie alternatives in the fast-growing healthy bar category. The low carb diets have made some traditional foods such as bread, pasta and rice an at-risk category almost overnight. There definitely is a migration from those foods that are perceived as unhealthy to those foods that are perceived as healthy. The pendulum in full action. Meanwhile, sales of health-oriented bar snacks and granola bars have jumped as increasing numbers of people change their eating habits in the quest of body weight reduction and improved health. This trend will keep the pressure on big food companies to react quickly by offering perceived healthier foods. Unthinkable only a year ago, even fast food companies are now jumping on the bandwagon and have started to sell the sacred all-American burgers without the bun. Bakeries are rushing to develop low carb bread alternatives that contain wheat glutamine protein. These are unprecedented changes in fast food dogmas and the philosophy of super-sizing carbohydrates through offerings of french fries, refined grain buns and sugar-loaded sodas clearly have backfired. Low carb burgers are now part of a lifestyle that also includes regular exercise and a balanced diet.

For a growing number of people a low carb plan is just what is needed to kick-start their diet to reduce bodyweight in search of increased self-esteem and well-being. It thus can be expected that diet regimens such as the Atkins diet, the South Beach diet and the 40/30/30 diet that include new foods with a low glycaemic index (low GI) will capture market share from the many low fat foods that were state-of-the-art only three years ago. The late Dr Robert C. Atkins coined the term 'net carbohydrates', meaning the measurable impact on blood-sugar levels, such as carbohydrates found in sugar, potatoes and white bread. The glycaemic index is a ranking of how quickly the body converts a carbohydrate to sugar. Slow release carbohydrates or 'good' carbohydrates are fibrous foods such as broccoli, whole grains like barley, oat and bran cereals and fruits such as apples. Soybeans have a very low glycaemic index, meaning they have little effect on glucose levels.

It is clear that the definition of slimming foods has changed also. Under the Atkins philosophy slimming foods are enriched with proteins and these hyperproteinated foods may contain 'healthy' amounts of fat also. As a result, low carb food selections such as promoted by Dr Atkins are based on avoiding hyperinsulinism. This mechanism occurs when excessive insulin is produced after carbohydrates are consumed, which in turn could cause fat storage, diabetes and a craving for more carbohydrates. Proteins are widely used in weight management foods due to their lower calorie values than fat – 4 kcal/g versus 9 kcal/g for fat – and also because protein cannot be deposited in the body in the form of fat. Adhering to such a weight management system is the most direct mechanism for burning fat. When carbohydrates are not available for energy, the body switches to its back-up system for fuel: body fat.

A major step forward in the right direction would be to universally accept a new and innovative approach to the USA food guide pyramid. Authorities, medical health experts and the food industry have come to realize that there is no single nutritional solution for people battling overweight, obesity, diabetes and heart disease. Clearly calorie-counting approaches, as supported by low fat foods, have not been successful for many of the approximately 60% of our population who have been using low-fat diets over the last few decades. Slowly a new thinking has become accepted for the individualization of nutritional approaches and for food guidelines to allow also a controlled-carbohydrate option based on the existing and emerging scientific research that supports the safety and efficacy of controlled-carbohydrate nutrition. A typical controlled-carbohydrate food guide pyramid emphasizes a wide range of protein sources and nutrient-dense carbohydrates, such as most vegetables, certain fruits, nuts, dairy products and whole grains, that have a low impact on blood sugar. The major benefit of this weight management diet is that the average overweight person can follow this lifestyle diet, eat until satisfied and achieve a healthy balance of fats and other nutrients all without having to count portions or calories.

Although the scientific verdict about prolonged use of the Atkins diet is still under debate, the Atkins diet has most certainly challenged the philosophy that low fat diet was considered the best way to control weight. After decades of stressing the need for low fat diets, now the importance of carbohydrate management is at the forefront of consumer's attention. For weight management the 'right' type of carbohydrate is gaining rapid exposure. This is referred to as Glycaemic Index (GI) and it ranks carbohydrates according to their immediate impact on blood glucose levels. The Glycaemic Index is a numerical system of measuring how fast a food or ingredient triggers a rise in circulating blood glucose; the higher the GI, the greater the blood sugar response. Therefore, a low GI food will cause a small rise in blood sugar levels. Studies show low GI foods benefits diabetics' type 2, assist weight control and help reduce the risk of coronary heart disease. A GI-based diet has been of particular interest in Australia and is likely to become more popular in North America and Western Europe. It is clear that a host of new functional ingredients will be introduced to help formulate low GI foods. For R&D departments it will be important how carbohydrates are digested and utilized in the body, thus predicting the technical factors affecting the GI values. Consumers with restricted diets still desire the convenience of processed foods, providing their needs are met. With more people following these alternative diet philosophies, food manufacturers have the opportunity to deliver products with a measured GI value and thus allow consumers to proactively engage in personal diet and weight management. To avoid confusion the food industry needs to reach a decision of how best to communicate a low GI diet to consumers. For a food segment that is about to become mainstream it is of paramount importance to label products accurately enabling consumers to make intelligent purchasing decisions.

Vegetable proteins and soy proteins are of particular interest in special dietetic foods because they are much less likely to be accompanied by fat and cholesterol than animal proteins and thus contribute to balanced food formulations. Soy protein isolate is highly suitable for weight management due to its complete amino acid profile and the presence of naturally occurring isoflavones. (See Holt, 1999.)

What's Next?

Unfortunately, in the next few years, the saga of confusion and disagreement over dietary correctness will continue to influence food purchasing decisions and eating habits. However, there is no reason not to adopt a cuisine that incorporates scientific evidence already known. Science is clearly linking plant-rich diets to the avoidance of modern degenerative diseases, such as obesity, cancer, osteoporosis and heart disease. However, with all the progress that has been made, society still has not found an answer to making people eat less and exercise more. After all, although most people know that they are personally accountable for their weight, it is extremely difficult for them to adopt a healthier lifestyle. It is not so much the awareness of being overweight; rather it is the struggle to do something practical about it. For long-lasting effects it will be essential to take single foods beyond a vague 'low fat' or 'lighter' offering, and develop complete menus so that consumers can make educated and clear choices.

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7
Genetically Modified Organisms (GMOs)

History has shown that people are often sceptical and hostile when confronted with breakthrough technologies, especially when it comes to such an important matter as food. There is no doubt that American companies early on in the introductory stage of genetically modified organisms have raised false and misleading expectations, including making predictions that were too self-beneficial and self-centred. As a logical result the consumer became confused by the extreme complexity of understanding the subject.

Mankind has selected animals, plants and microorganisms for many centuries and as such has enriched the wholesomeness of our current food supply by intentional crossbreeding to improve upon hereditary make-up. Therefore gene-technology is not really something new.

Since the dawn of mankind people have used ingenuity and technology to make life easier and safer. Change throughout the world is accelerating with increasing pace. Change can be divided into classical or agricultural-driven, such as cultivating seeds and domesticating animals, and technology-driven change such as coal and oil energy, steel and computers.

The agricultural civilization preceded the technology-driven era by thousands of years. Ever since the Middle Ages, technology-driven inventions have overpowered the earlier agricultural domination. However, it can be theorized that the technology-driven industry in the classical sense of the word, for example utilizing non-renewable energy sources such as oil and clean water, will ultimately be superseded by a new kind of fundamental technology. This technology will be driven by a clear and concise understanding of living organisms, or in other words, modern biotechnology.

Currently biotechnology is only in the Stone Age. Despite current controversies, agriculture has only scratched the surface of biotechnology.

Biotechnology will enable civilization increasingly to utilize renewable energy sources, such as sunlight, water and soil, to meet consumer needs with products that can be recycled. That will provide a rapidly growing world population with some ecological sustainability. Biotechnology also has the potential, when managed carefully with ethical and economical constraints, to be more efficient, cheaper, cleaner and more flexible. Above all, biotechnology can leave significantly fewer 'fingerprints' in terms of waste control and management.

Our imagination cannot fully comprehend the magnitude of the huge changes ahead that will affect our lives forever. A great many products could be grown instead of manufactured from non-renewable components. For example, biotechnology allows plastics to be 'grown' using the maize plant as a vehicle. Soybeans can be genetically turned into 'coffee' beans, and tropical fruits such as bananas could be used as a vehicle to allow vaccines for epidemics such as hepatitis to reach the poverty-stricken millions in developing countries who are in desperate need of medicines to finally eliminate these degenerative diseases.

Biotechnology typically involves the use of recombinant DNA technology, which is a process of inserting specific genes or combinations of genes from a variety of sources. Modern biotechnology is more precise and predictable than traditional techniques, and it is clear that this technology is only at the early stage of commercialization. However, the truth is most probably that the biotech companies first and foremost targeted industrialized, large-scale farmers to increase profits. However, it is clear that in order to be successful, the next step must provide economical and ecological benefits for the largely neglected countries experiencing water shortages or famine. In the longer term, biotechnologies will probably supercharge and transform farming in both industrialized and developing countries in order to achieve topline growth.

Golden rice, a rice rich in beta-carotene which the body converts to vitamin A, is an example. Millions of children still suffer from blindness, skeletal deformities and anaemia. Other examples of biotechnology are the development of foods without life-threatening allergies such as present in shrimp and groundnuts, the availability of fruits and vegetables with a longer shelf life, not forgetting the development of foods with fewer anti-nutrients and the presence of heart-healthy fats and foods with vaccines delivery systems. More modifications are on the horizon, including the insertion of genes to trigger production of iron in foods, which could be a powerful tool to tackle the problem of anaemia, especially in developing countries.

Likewise, the ability to crossbreed diverse forms of life will have a profound impact on world agriculture. Crops, including soybeans, can be made drought-tolerant, or produce their own pesticides and increase crop yield. These developments will demonstrate a much better ideology, economic and social value in developing countries.

The biggest advantage of biotechnology is the potential of providing greater health and wealth to many tropical areas of the world, especially those in extreme poverty and hunger. The Western world should no longer tolerate the fact that the other half of the planet is devoid of the very basics taken for granted in developed countries. Biotechnology, together with the completion of the human genome project, will become a powerful tool for addressing existing inequalities in wealth, food and health.

However, it is absolutely necessary across all levels of society that consensus be reached. The potential negative side effects of biotechnology need to be avoided or eliminated from the start. This can be accomplished by an honest dialogue between scientists, economists, business leaders, consumers, religious leaders, environmentalists and farmers. Only then can the ‘dark side’ of biotechnology, including the selective use of human genes, be turned into a positive enabling science to bring humanity to a new and unprecedented quality of life.

For the next 10 years, biotechnology first and foremost will prove its value toward increased harvest quantities and qualities, including nutrition. This early development will be followed by using biotechnology to transform the world economy into a mechanism where wealth and health is shared more equally, together with the advancement of biotechnology-generated medical breakthroughs, including stem-cell use.

Honest Communications

People who have a deep-rooted mistrust of biotechnology should be included in the dialogue. Their views and opinions should be taken seriously. Fear of biotechnology can be slowly changed to a positive awareness by demonstrating that through strict control the science will ultimately prove to be a cornerstone for sustainable world food production and health improvement. A universally accepted natural evolution of ‘green’ technology progress will significantly contribute to closing the gap between food excess in some countries and starvation elsewhere.

One of the current drawbacks of crops produced by biotechnology is the intellectual property constraint. Countries in Africa are little more than an afterthought, and American biotech companies obviously sought out more lucrative market potential in Europe, USA, Canada and Japan. This is clearly demonstrated by the many court cases concerning intellectual property rights for inherited genetically modified traits. African food staples like cassava, sorghum and millet received little attention from biotech companies, who rather spent the money on the commercial crops such as soy and maize for the rich countries. Even US universities share some of the blame. Rather than contributing to humanitarian development of GM foods in developing countries, they preferred to sell the intellectual property rights to cash-rich multinationals.

The vast majority of GM research at participating Universities is supported through public funding. As the public withdraws its support for GM foods, so goes science. This looming danger should be avoided. Even the agro-biotech industry now agrees that the present ranges of GM crops should benefit all societies, including farmers, the environment as well as consumers. Often, the food industry fails to clearly communicate to the public the advantages of this new technology. The challenge for regulators, science and multinational food companies is how to clearly communicate with the consumer such advantages as better taste, more nutrition and lower prices.

Of course, there is a risk that a few companies selling GM seeds at significant premiums might increasingly dominate the world's agricultural infrastructure. There is some justification in the fear that farmers and ultimately consumers will become the victims of a new kind of economic imperialism or colonialism by American and European agro-biotech industries.

GM Diversification

In principle, GM foods can be grouped as follows:

- The food itself contains GMO. For example, tomatoes, soy milk.
- The food contains active or live GMOs such as moulds, fungus as protective cultures in dry fermented sausage, or lactobacilli bacteria in yoghurt.
- The food contains inactivated GMO-based ingredients or trace elements such as amino acids, enzymes and vitamins.

It is projected that by 2005 nearly 80% of all enzymes will be genetically engineered. These biotech methods will ultimately replace many chemical processes. These novel food constituents allow the food industry to embark upon a revolutionary journey where designer foods for example can take the place of pharmaceuticals to support cardiovascular health, remove the dangers of allergies, and decrease environmental dependence on climate and fresh water supply.

To move forward it will be essential to focus on specific situations in specific countries and compare all possible options and approaches in agricultural research and economics and compare these results with the potential cost of doing nothing.

GM foods have already become a significant part of the food supply, ranging from cake mixes to veggie burgers and cheese. The consumer doesn't know about the presence of these gene-altered foods or ingredients unless they are motivated to look for specific labelling. This is similar to those people who believe organic foods are better and thus seek these organic-labelled choices. For example, there is a strong paradox in the psychologically driven behavioural attitude in the mind of consumers when it comes to soy protein nutrition. While soy may appeal to the vegetarian and organic consumer, the same consumer – at least in Europe – tends to have a double standard when it relates to biotechnology.

Most people have been slow to respond, but now are beginning to understand that the world has come to a junction. It is essential that a clear decision be made concerning which road to follow regarding GM foods. There should not be a regulatory patchwork but rather a strong consensus from all sectors of society on the issue. Biotechnology should be universally accepted as the application of modern science to biology, while at the same time safeguarding public interest.

Biotechnology is here to stay (Table 7.1); however, it would be smart to engage consumers in a meaningful discussion on this breakthrough technology so as not to cause fear of the unknown. New technologies, especially as they pertain to the genetic make-up of foods, should not be introduced before the consumers are ready to accept it. Anti-biotech environmentalists and activists have alarmed people about GM foods; this has created a backlash that will take years to heal. Environmental activists fuel an anti-science mentality, and cleverly capitalize on the break between traditional plant breeders and molecular biologists. Also, anti-biotech activists are pushing the industry to counter the negative perceptions about biotechnology with positive, scientifically proven responses. It is understandable that people fear the unknown. Regulatory policy, however, should be based on sound science rather than simply satisfying the often-hidden agendas of special-interest activists or extremists whose only motives seem to be to undermine progress.

The public's image of GM foods will be boosted strongly when the consumer clearly sees benefits such as improved taste, improved convenience, improved nutrition and above all disease-fighting capabilities. Subsequently the next phase of GM crops should preferably bring premium foods, biodegradable plastic and above all food-based pharmaceuticals, including the use of genetically modified bacteria for producing human insulin to treat the many millions of

Table 7.1. Biotech timeline.

1800 BC	Yeast is used to make wine, beer and leavened bread. This is the first time people use microorganisms to create new and different foods.
1700s	Naturalists begin to identify many kinds of hybrid plants – the offspring of breeding between two varieties of plants.
1861	Louis Pasteur develops his techniques of pasteurization, and defines the role of microorganisms, establishing the science of microbiology.
1865	From experiments on pea plants in a monastery garden, Austrian botanist and monk Gregor Mendel, the father of modern genetics, concludes that certain unseen particles (later identified as genes/DNA) pass traits from generation to generation.
1922	US farmers first purchase hybrid seed maize created by crossbreeding two maize plants. Hybrid maize accounts for a 600% increase in US maize production between 1930 and 1985.
1944	Researchers determine that DNA, present in the nucleus of every cell, is the substance responsible for transmission of hereditary information.
1970	Norman Borlaug becomes the first plant breeder to win the Nobel Prize for his work on Green Revolution wheat varieties (high yield).
1982	The first commercial application of biotechnology is used to develop human insulin for diabetes treatment.
1983	The first plants are produced using new biotechnology methods.
1990	The first food modified by biotechnology – an enzyme used in cheese making – is approved for use in the United States.
1991	The Food and Drug Administration (FDA) concludes that foods enhanced through biotechnology, as a class, should be regulated in the same fashion as those developed through traditional methods.
1995	The first soybean developed through biotechnology is introduced.
1996	US government fully approves 18 crop applications of biotechnology.
1999	Researchers announce the development of a 'golden rice' that is rich in beta-carotene, a precursor to vitamin A, to help prevent childhood blindness in developing countries.

Source: *DuPont Magazine* No. 3, 2000, p. 5.

people with diabetes. The latter products in particular will have strong potency to quickly change public perception into a major positive one.

GM Legislation

Biosafety protocols to regulate trade in GMOs are being put into place to demonstrate to the international community that the concerns of consumers about health and safety are being taken seriously. Legislation to regulate the use of GMOs is already in place in some countries. Still, there are no binding international agreements covering liability in the event of accidents leading to environmental or human health damage. It is obvious that countries with a vested interest in the success of GMOs would rather accept differing national legislation than agree to a universal restriction protocol. Only recently the EU published a threshold below which mandatory labelling would not be required. (See Bennet, 2003.)

New rules on the labelling of genetically modified food will have come into effect throughout the European Union from April 2004. Under the new European Commission regulation on GM food and feed, all ingredients that contain or consist of GMOs, or contain ingredients produced from GMOs, will need to be labelled as such. A threshold of 0.9% will apply for the accidental presence of GM material, below which labelling of food or feed is not required. There will also be a 0.5% threshold for the presence of GM material that has not been approved for use in the EU, provided it has a favourable safety assessment from the EU scientific committees. This latter threshold will apply for 3 years. The regulations will not apply to food produced using GM processing aids, such as some cheeses, or products from animals fed GM animal feed. Risk assessment of GM foods will be centralized through the European Food Safety Authority. Authorization, if granted, will be for 10 years, after which companies will have to apply for it to be renewed.

The Future Has Arrived

Sustainable growth is the ultimate goal of biotechnology. Based on today's knowledge and anticipating tomorrow's need, biotechnology is emerging as a critical enabling technology achieving this ambitious objective. Sustainable growth can only succeed if it creates social and shareholder value while reducing its environmental footprint in terms of investments and performance standards. It is likely that environmental impact will become a key element in future business decisions.

The environmental footprint is determined by the amount of non-renewable raw materials and energy that are consumed to manufacture a product and the quantity of waste and emissions generated in the process. In the past, for a company to grow, the footprint inevitably had to get larger. Now and even more so in the future, 'green companies' want to grow while reducing their dependency on non-renewable energy.

The bottom line is that the true criteria for consumers remain great taste, value, convenience and nutrition – not genetics. The market moves from one lifecycle to the other. Responding to opportunities as they emerge will be critical for successful business and bio-solutions will be an essential strategy capturing expanding global markets.

The main advantages of biotechnology can be summed up as follows:

- Improved agricultural sustainability, e.g. reduce pesticides and reduce phosphorus emissions.
- Improved nutritional food quantity and quality.
- Improved feed quantity and quality.
- Reduced harvest and manufacturing costs.
- Development of higher-performing raw materials including functional ingredients.

Despite ongoing discussions and controversy at many levels of society, since the first crops produced in 1994, agricultural biotechnology has seen unprecedented growth both in terms of quantity and quality in the history of agriculture. Already in 1996, a joint report from the WHO and the FAO of the United Nations concluded that 'biotechnology provides new and powerful tools for research and for accelerating the development of new and better foods'. The same expert consultation also concluded that it is extremely important to research and implement distinct strategies including safety assessment criteria to ensure long-term wholesomeness of the entire food chain. Safety issues should be the same for biotech crops and traditionally bred plants.

It is estimated that in 2002 about 52 million hectares of GM crops were harvested worldwide. By far the most popular GM crop is the herbicide-tolerant soybean (33 million ha) but also gaining rapid popularity are cotton, canola or rapeseed, maize, papaya and potatoes. The USA, Argentina, Canada and China are most advanced, while Brazil announced that they would start GM crops in 2003. These crops have engineered agronomic traits to increase yield, improve quality and reduce the need for chemical use for virus resistance, pest protection or herbicide tolerance. Also GM crops conserve the use of fresh water sources and improve the quality of soil which, of course, can enhance biodiversity. The world market for GM soy is growing rapidly and the danger looms that the EU is left behind, which ultimately may affect their competitive position.

Despite the successes of biotechnology, much needs to be done by both biotechnology companies and government agencies to implement strict protocols to avoid placing consumers and the environment at risk. Ecological risks must be intensively researched because once GM microorganisms foreign to our biotope are released, they cannot be recaptured. The current ongoing debates about the safety of the food system have already resulted in new regulatory protocols in both the USA and the EU. Nevertheless, it is expected that many new agricultural GM crops such as coffee, apples, peppers, strawberries and tomatoes will become available that offer specific advantages to consumers. These GM crops might contain, for example, heart-healthy oil to reduce cholesterol and increased amounts of antioxidants and phytochemicals such as vitamin E and carotenoids. Another major benefit will be the removal of allergenic proteins from plants, which subsequently will improve both the nutritional suitability and quality of life specifically.

Gene technology has certainly gained substantial ground in modern food production. As a matter of fact, it is estimated that in the developed world, about 70% of all processed foods contain some GM-related components, ingredients or additives. This is especially true when it comes to the use of enzyme and fermentation technologies that have been developed on the basis of gene science. In the end, consumers need to make well-informed decisions about the implementation of agricultural biotechnology. Clearly, GM benefits should go together with the assurance of absolutely no risk to mankind.

Looking back at the last few years it can be concluded that most food processors and supermarkets have panicked and have yielded to irrationalism and sensationalism from provocateurs and the media, instead of looking at the behaviour of the true decisionmakers, the consumer. Despite an avalanche of inadequate information about GM technology and an overdose of irrational disinformation from green groups that have used scare tactics, there are signs that the general public will decide for GM foods. Rather than listening to what people say on the GM issue, the purchasing behaviour of consumers, once they are in the supermarket, will ultimately decide its success or failure. Much like the GM tomato purée successfully sold in the UK in 1999, GM soy foods will be seen by the public as real added value, less expensive and above all superior or preferred in taste and flavour.

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8
Functional Non-meat Protein Properties

Functional non-meat protein ingredients can be of animal or vegetable origin, and both can be used in processed meat products. For most of the 20th century, milk protein – especially sodium caseinate – was the protein of choice as the ideal fat–water emulsifier in finely comminuted meat products. Milk protein's performance in retorted or canned meat products such as frankfurter sausage made this protein hard to replace.

However, during the last decade of the 20th century, the processing capabilities and flavour improvements of soy proteins have led to considerable erosion of milk protein's market domination. Improved soy protein functionality, including gel strength and emulsification, and removal of 'beany' soy flavour notes have slowly encroached on usage of milk protein. In all fairness it should be stated, however, that a significant part of soy protein's success can also be attributed to the price increases of milk protein in recent years.

The functional properties of proteins are very important, since their performance can either be beneficial or detrimental within the food systems in which they are used. Protein functionality should not be confused with the physical properties. In processed muscle foods, the main properties of a protein ingredient include speed of hydration, its fat- and water-holding capacity, and its capability to aggregate with other solubilized ingredients in a protein network or matrix during thermal processing. Every protein is a unique molecule that can be modified to create certain product characteristics. There are a number of variables that can affect the performance of the protein ingredient under certain conditions.

Emulsion Stability

Another key word that comes to mind when discussing protein performance is gelation. It is believed that gelation is a two-step heat treatment process.

The first step involves dissociation of the protein molecule, followed by the second step in which aggregation forms a gel network or matrix. In principle, heat-induced gels can be divided into two types:

- Thermoset, or irreversible.
- Thermoplastic (thixotropic), or reversible.

The properties of protein ingredients at surfaces or interfaces require attention. Nearly all food products that contain immiscible substances, such as water and oil, need proteins to maintain product integrity. Functional proteins, such as soy protein and blood or plasma proteins have a certain molecular structure that provides an affinity for substances on either side of the interface. The result is an emulsion.

Emulsification is the process by which two normally immiscible liquids are intimately mixed, one liquid being dispersed as small droplets or globules within the other. In food emulsions, the two liquids involved are normally water and oil. The water phase may be a solution of salt, sugars and other water-loving or hydrophilic ingredients. The oil phase may contain fats, oils and other fat-loving or lipophilic food ingredients. Soy proteins are both emulsifying and stabilizing agents.

In a stable meat emulsion, fine fat droplets are therefore dispersed in an aqueous medium containing soluble proteins, other soluble muscle constituents, segments of muscle fibres and connective tissue fibres. In such an emulsion, each fat droplet is 'coated' with a thin layer of soluble protein which has been released into the aqueous medium from the muscle fibres. This meat emulsion or meat matrix can be used as a continuous phase to make frankfurter-style sausage, or it may be used as a phase to support the presence of other (show)-meat (visual pieces of meat) and or fat particles or other inclusions such as cheese or vegetables.

Emulsification is required in many food systems to create characteristic physical and sensory properties. All emulsifiers have an electrically charged, or polar, end and a non-charged, or non-polar, end. The polar end is hydrophilic, the non-polar end is lipophilic. The result in a water–oil mixture is that the emulsifier dissolves part of itself in water and the other part in oil.

Energy is required in the form of high-speed rotating blades to reduce the fat or oil into small particles, preventing coalescence and allowing adsorption of the protein ingredient and subsequent formation of a stable emulsion. There are two types of emulsions, and it just depends on which phase becomes dispersed in the other. In an oil-in-water emulsion, the oil is dispersed in the form of droplets throughout the water or continuous phase. In a water-in-oil system, the water is dispersed within the oil. Most emulsions are oil-in-water (O/W). In some cases, such as low-calorie spreads and sauces, a 'double' emulsion is created in which an O/W emulsion is distributed within a W/O emulsion.

Soy Protein

In general, soy protein isolate is a very hydrophobic (lipophilic) protein. In most cases it is necessary to have sufficient water available to allow the protein to fully hydrate. Once the hydrated soy protein associates with liberated fat or oil from within the cell walls, the protein–fat bonding becomes so strong that dissociation or separation is difficult to achieve. In this respect, it should be noted that the temperature of the fat droplets would influence the hydrophobic properties of the added soy protein. For example, when the fat droplets are cold, the association mechanism is significantly less active compared with higher temperature fat or oil droplets.

In principle, there are three main fractions in functional soy protein:

- Fully soluble protein.
- Soluble aggregate.
- Insoluble fraction.

These protein fractions can partly transform from a soluble state into soluble aggregations into insoluble fractions depending on changing viscosity temperature, salt levels and the influence of phosphate. These variables all translate into a number of organoleptical parameters. For example, research has concluded that preferred product textures are obtained when most of the soy protein is truly solubilized. This is especially important in meat systems with low amounts of skeletal meat and the presence of mechanically deboned meat and organ meats.

On the other hand, when functional soy protein is solubilized, the resulting gel might interfere with protein–protein and protein–fat interactions. This could influence the characteristics of an emulsified meat product with a relatively high amount of skeletal meat that has been subjected to optimum extraction of the salt-soluble myofibrillar protein. This does not necessarily mean that a poor quality meat emulsion is obtained – on the contrary. But it is important to select a soy protein isolate ingredient with specific properties to fully achieve the desired organoleptical properties.

For premium emulsified meat products, a low gelling type of soy protein is recommended, in particular one that demonstrates higher re-aggregations with the other fractions of the meat emulsion. Low-gelling functional soy protein ingredients are usually ideally suited for dry addition to either a bowlchopper or mixer/blender and thus contribute to significantly improved process optimization.

There is a direct correlation between a low gelling protein and pH. The solubility of functional soy protein is pH-influenced. Lean meat has a pH of approximately 6.0, which improves rapid dispersibility but reduces protein solubility. Increasing levels of soy protein have a tendency to increase pH, creating a positive effect on water-holding capacity and emulsification in general, but negative consequences for texture, shelf life, flavour and colour. A somewhat paler colour is actually logical because at increasing inclusion levels of soy protein less myoglobin protein is generally available to provide the typical cured meat colour.

Recent breakthroughs in protein chemistry and processing technology have made available new and innovative functional soy protein ingredients, the third generation of protein ingredients developed since the early 1960s. These highly functional proteins cover a wide area of applications and range from ultra-low gelling to high-gelling characteristics. These designer proteins allow greater processing tolerances, ease of addition, and substantial replacement of the lean meat fraction, if needed.

Third-generation protein ingredients provide a leading edge, giving muscle-food processors greater flexibility in product optimization. All functional soy protein ingredients currently used have been denatured. Because of these modern protein-recovering technologies, a multitude of interesting protein manipulations or modifications can be achieved to obtain specific functional characteristics. For example, the addition of transglutaminase has a correlation with gel strength, whereas viscosity can be regulated by hydrolysation activities within the protein structure. Soy protein processing temperatures have an influence on gel strength, i.e. low processing temperatures increase gel strengths. A high percentage of the soluble fraction of functional soy protein gives increased emulsification and elasticity of the meat batter.

More recent are the high-sucrose and low-stachyose soybeans. Biotechnology has produced these new soybean varieties, which have a significantly reduced content of stachyose and raffinose. Major flavour improvements result. When these bioengineered soybeans are used for manufacturing functional soy protein ingredients, improved taste and better digestibility result, allowing higher inclusion levels, if necessary. In general, soy carbohydrates do not taste poor by themselves. Rather, it is the typical processing method used that triggers taste deterioration, which is caused by lipid oxidation, among other factors.

Most functional soy protein ingredients are used to accomplish one or more of the following processing and product technology objectives:

- Bind or immobilize fat and water.
- Improve sensory or organoleptic parameters.
- Improve shelf life.
- Regulate viscosity.
- Modify gel structure.

Organoleptic properties encompass variables such as texture, fibrosity, juiciness, taste, flavour and colour. From a sensory point of view, taste and colour are the most important considerations, followed by texture and mouthfeel. During manufacturing of soy protein isolate, unwanted flavours are removed, although it is possible to change the flavour profile to accommodate specific requirements.

Flavour and taste design continue to be important for future soy protein research, because a small percentage of the flavour ingredient can carry through to the finished product both in a positive and negative sense. When these new generation functional soy protein ingredients are added to emulsified meat products, traditional cured colour and meat flavours can generally be maintained at inclusion levels of up to 4%.

In nearly all cases the hydration properties of protein ingredients are of great importance. Without sufficient water, a protein simply will not perform. The terms hydration, dispersibility and solubility are often used interchangeably. The main difference is the size of the protein when disassociated in water.

The speed of the protein 'wetability', or protein hydration, often determines the processing performance. Since salt, or sodium chloride, is always used in processed muscle foods, it is important to consider the influence of salt on protein properties and performance. The solubility of soy protein isolate can be increased at its iso-electric point when salt is present. However, the solubility of soy protein decreases when salt is added on either side of the iso-electric point. (See Katsaras and Peetz, 1994.)

Consequently, to optimize the effect of the protein ingredient it is usually preferred to hydrate the soy protein without the presence of salt. Salt usually can be added after the protein has been fully hydrated. Although the functional properties of salt and soy protein remain a key consideration, the new generation of functional soy protein ingredients has addressed the need of many processed meat manufacturers for greater processing tolerances. One key problem solved is the need for dry addition, where most of the dry ingredients are added all at the same time; newer protein ingredients are particularly salt-tolerant and allow the elimination of pre-hydration under certain conditions. Certain types of functional soy proteins set up very quickly in emulsified meat systems. These characteristics should be closely considered when designing the process flow and line set up. (See Ambrosiadis, 1994.)

Functional soy protein ingredients are generally used to accomplish one or more of the following objectives:

- Improve quality whilst maintaining costs.
- Reduce costs whilst maintaining quality.
- Formulate against new end-product specifications.

In many countries there are constraints that may affect the wider inclusion level of soy protein. Regulatory hurdles: use of specific meat sources; minimum meat content; maximum use of soy protein; maximum percentage of fat; maximum moisture; maximum collagen.

More Variables

There are many different soy protein ingredients commercially available, and it can be a very time-consuming and difficult exercise to determine which specific soy protein delivers most performance and most value. In short, soy protein isolate (SPI) contains 86% protein (on an as is basis), therefore 1 part of SPI + 3 parts of water gives 21.5% protein. Or, in other words, the equivalent protein content to fat-free lean meat. Soy protein concentrate contains 70% protein (on an as is basis), therefore 1 part of soy concentrate + 2.3 parts of water gives 21.5% protein. Subsequently, to maintain protein and fat contents in the final emulsified meat, fat-free meat should therefore be replaced on a 1:3 basis when hydrated with SPI or 1:2.3 when hydrated with functional soy protein concentrate.

Apart from differences in protein properties in relation to meat replacement, water-holding capacity and fat emulsification, key processing variables also need to be taken into consideration. For example, high-energy equipment (bowlchoppers) together with staged additions of ingredients tends to favour soy protein isolate. Lower-energy equipment (colloid mills or mixer/emulsifiers) tends to favour soy protein concentrate, especially when a limited amount of formulation water and/or salt is added early on in the processing cycle.

In other words, it can be generalized that meat-reducing or grinding equipment determines the performance of functional soy ingredients. Not the other way around!

Functional powdered soy proteins are designed to perform like salt-soluble meat protein. Soy protein has a relatively high pH value compared to meat protein, while the molecular structure and gelation properties are different from those of meat protein. At increasing levels of functional soy protein, starting at 5.0% and more in emulsified products, some antagonistic effects might surface. These are specifically related to colour, flavour and texture.

- Colour can be adjusted or corrected by selecting one or more of the following additives:
  Liquid or dried blood.
  Angkak (fermented rice colour).
  Erythrosine.
  Carmine (cochineal).
  Beetroot colour.
  Sandalwood colour.
  Red 2G.
- Texture reduction most probably is caused by an increase of pH in the meat emulsion. At increasing levels of lean meat replacement by soy protein at a 1:1 ratio, hardness and chewiness of the product decreases. To offset these negatives, it is recommended that 0.1–0.2% of acid sodium pyrophosphate (SAPP) should be added, while reduction of fat and/or starch can also be a viable solution.
- Flavour can be harmonized or balanced by adjusting one or more of the following additives:
  Addition of MSG.
  Addition of garlic.
  Addition of liquid smoke.
  Increase salt level.
  Increase seasoning level.

Since there are so many protein ingredients available it is difficult to discuss specific suitability parameters. Yet, in general terms it can be stated that high-gelling soy proteins are preferred for low-protein-content sausage, whereas low-viscosity soy proteins usually have superior results for high-meat content sausages.

Pre-emulsions

Pre-emulsions are made from fat, water and functional protein. Pre-emulsions are especially suitable when beef or mutton fat is used. The protein:fat:water ratio is typically 1:5:5. However, many more protein:fat:water ratios are possible.

When soy protein pre-emulsions are made, it is recommended to begin by chopping the water and soy protein into a smooth gel (Fig. 8.1). Once a viscous gel has been obtained, the fat is added to the chopper, changing the knives' speed to fast. After some 4 min chopping, the fat/water emulsion is complete. Typically, 10% to as much as 20% of a pre-made emulsion is added to a base meat emulsion.

The term food emulsions, including premade fat-water emulsions, should not be confused with meat emulsions or meat batters. Meat emulsions are a complex combination of a number of ingredients, phases and structures and will be discussed separately.

From the viewpoint of product stability, pre-emulsions are generally the preferred method incorporating animal fat sources that are difficult to stabilize such as beef fat or pork leaf fat. This is especially true for products that have a high fat content and need to withstand high thermal processing temperatures.

Pre-emulsions are labour-intensive and require additional manufacturing steps, including provision of adequate cooling or freezing capacity. However, for a number of specific products and in geographical areas with a shortage of animal fat, pre-emulsions remain an option (Fig. 8.2). Generally speaking, heat-stable emulsions should be able to withstand a core temperature of 120°C without any visible fat or gel separation.

Of course, for sausage or spread products that are pasteurized, the required temperature is not as critical. Stable pre-emulsions nearly always give better final results than unstable pre-emulsions or when the non-meat protein is added in a dry powder form. A standard pre-emulsion is made from 1 part functional soy protein, 5 parts fat and 5 parts water.

The chopping sequence is as follows:

- Add 5 parts water to a bowlchopper.
- Add 1 part of soy protein isolate and

(a) (b)

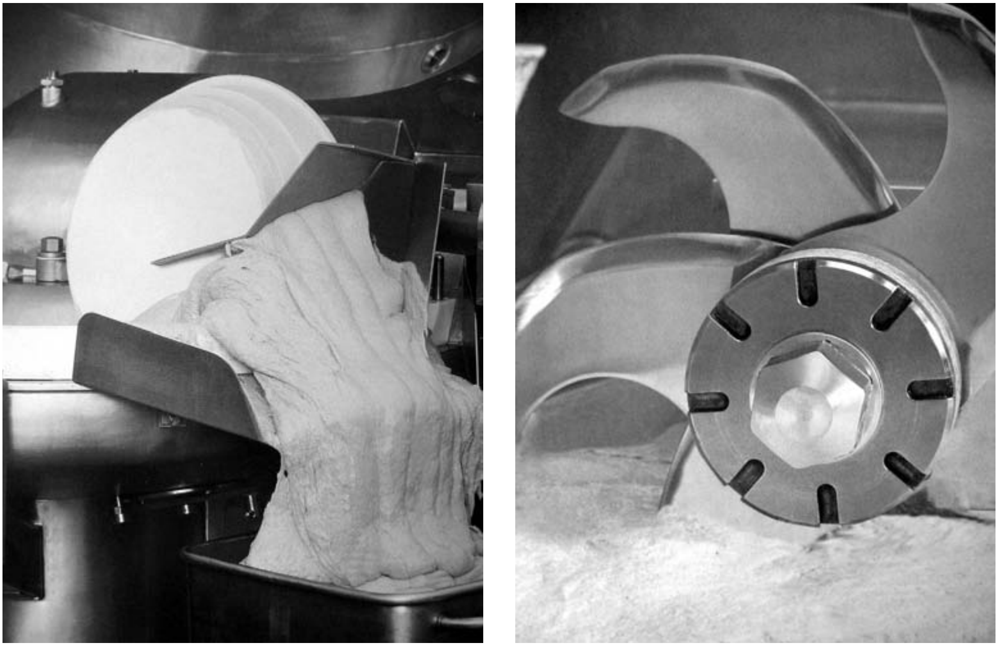

Fig. 8.1. Emulsion preparation in a bowlchopper.

chop at low speed until the protein powder is well dispersed. Continue to chop until a smooth and shiny gel has been formed.

- Add 5 parts fat. Change to fast chopping speed and continue for 3–5 min. The chopping time depends on temperature of water, friction of chopper knives, type of soy protein and the type of fatty tissue.
- Add 2% sodium chloride (salt) during the final minute of chopping. The salt acts as a preservative and will balance the final product. Also, the emulsion will firm up under the influence of salt, and

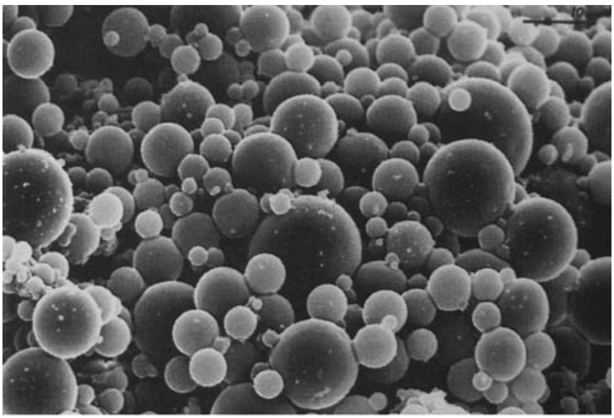

Fig. 8.2. Fat globules surrounded by soy protein film (Scanning Electron Micrograph, magnification 1000 x). Source: Meat Research Institute, Kulmbach, Germany.

that will improve handling during the processing flow.

Fill the emulsion in container-trays in layers of approximately 20 cm. This will ensure rapid cooling. These emulsions need to be kept under refrigeration at <4°C, and can be stored up to 72 h.

It is also possible to withhold some water during the early chopping process. For example, 1 part of soy protein can be emulsified with 5 parts fat and 4 parts hot water. Upon completion of the emulsification, 1 part ice is added to the chopper. This will reduce the temperature somewhat, which can be beneficial in ensuring rapid cooling.

Generally, an ice-cooled emulsion is less firm, but this property can be an advantage. For example, smoother emulsion consistency distributes more rapidly when a mixer/blender is used for final product preparation. When maximum stability is not necessary, i.e. reaching a core temperature of 120°C, it is entirely possible to use warm water or even regular tap water for emulsion preparation. The resulting emulsions can be used for pasteurized products that are cooked to a core temperature of, for example, 80°C.

The chopping sequence is similar to that of the hot water emulsion method, although it is clear that this method is not suitable for animal fat that is difficult to stabilize. For example, pork leaf fat (flare fat) and beef suet need hot emulsification temperatures, or if this is not possible the protein: fat: water ratio needs to be adjusted to 1:5:4.

On the other hand, when pork skin (rind) is used, it is possible to pre-blanch the skin for about 20 min at 80°C. This will soften the collagen tissue and thus reduce the stress when used in a pre-emulsion. Pork skin needs to be added into the chopper prior to the addition of fat and chopped to a fine particle size. The presence of pork skin allows an increase in the pre-emulsion ratio to, for example, 1 part of soy protein isolate, 8 parts of pork skin, 5 parts of fat and 6 parts of water.

The heat stability in fat–water emulsions made with functional soy protein is slightly less than with milk protein (sodium caseinate). For maximum stability in retorted meat products (at 120°C), soy protein isolate should be used at a 1:4:4 ratio of protein:fat:water.

For taste, flavour and stability considerations, it is usually not recommended to use pork leaf fat (flare fat) and beef suet for products that need maximum stability, such as canned frankfurters or liver spreads. However, for pasteurized products pre-emulsions made with vegetable protein using leaf fat or beef suet can be made using hot or warm water to assure optimum protein performance.

Liquid Soy Protein

There are markets that have access to a soy protein manufacturing plant. Large meat processing companies that are located in the vicinity of a soy protein plant can achieve considerable savings by substituting soy protein isolate for liquid soy protein concentrate. Meat formulations where soy protein isolate is taken out should be replaced by liquid soy concentrate on a solid-for-solid basis. Liquid soy concentrate usually has a solid content of 12–14% equalling approximately 7.0% protein on an as is basis.

Obviously most of these savings are obtained by eliminating the expensive spray drying process. However, it should be taken into consideration that liquid soy protein concentrate needs to be stored refrigerated and therefore needs capital investment for buffer silos as well. Liquid soy protein concentrate is an ideal vehicle for dispersing other functional ingredients such as other protein and starch sources. The use of high-moisture protein ingredients in the meat and food industry is relatively new for the soy industry. However, the dairy industry has already successfully implemented similar systems in the 1980s.

Functional Meat Protein Ingredients

Traditionally animal protein sources were used as processing aids in meat products.

These animal protein ingredients included milk protein, collagen protein and blood or plasma protein. Steep cost increases have largely made the use of milk proteins obsolete in most emulsified and coarse ground meat products. (See Admundson, 1986.)

Collagen and animal blood sources continue to serve as a raw material for manufacturing functional ingredients that can be used as stabilizers and binders in processed meats. Blood protein or plasma protein is very compatible with meat in terms of flavour and emulsion enhancement. Blood protein has typically 70% protein and thus can be compared with soy protein concentrate.

Like functional soy protein, blood protein has excellent solubility and possesses a good ability to form strong and elastic irreversible gels at increasing temperatures. The latter makes blood protein an ideal emulsifier for canned meat products that need to withstand retorting temperatures.

Some processed meat products can benefit from co-application of blood protein together with soy protein ingredients in a complex meat emulsion system. Generally speaking, blood proteins should then be used to (pre)-emulsify part of the fat and water, while functional soy protein should be used to support and enhance the gel formation and textural performance.

Soy protein isolate and soy protein concentrate can be seen as cost-beneficial functional ingredients. Besides improving protein digestibility and bioavailability, these ingredients improve texture, water binding, gel formation and fat immobilization. Moreover functional soy protein reduces syneresis, improves texture while increasing processing yields.

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9
Emulsified Meats

Sausages such as bratwurst and hot dogs combine convenience, great flavours and entertainment quality. These features are perhaps the secret of the great success story of sausages through history. Especially now that many varieties are fully cooked and microwavable, a solid platform has been created for further growth of this important segment of the food industry. Actually, frankfurters, hot dogs and bratwurst are going ‘beyond the bun’. Much more than in other countries, the US market has taken the lead in micro-segmentation and specialty sausage in recent years, for example, apple-sage chicken sausage or chipotle-chorizo sausage. Apart from the typical snack food, hot dogs have been transformed to a centre-of-the-plate meal, resulting in the typical American-style hot dog now being available in Xtra premium sizes with many different spice and flavour profiles. However, to be fair, supersizing of hot dogs cannot be credited to the USA. Germany for many centuries has had specialty sausage foods that uniquely served the purpose of centre-of-the-plate meals in combination with sauerkraut and potatoes. At the time, such a meal was typically meant for working-class people.

In most countries sausage consumption follows a distinct seasonal pattern. Hot dogs and frankfurters are eaten year round, but in the USA and Canada there is a definite consumption peak during baseball and barbecue season in summer months. The latter is also true for fresh sausages, which are most popular during the outdoor grilling season. Dinner sausage, such as smoked ring sausage and bratwurst, peaks in October when people get in the mood for typical autumn and winter foods.

From a global perspective, the processed meat industry is confronted with an enormous complexity of formulas and processing variables. This is true for both industrialized and developing countries, where finely comminuted or emulsified meat products are produced with percentages of lean meat ranging from 5% to 50%. These situations often call for an overhaul of the traditional thinking that was once true for meat emulsions based on yesterday’s values. A new challenge now arises for the meat processor and the manufacturer of the functional ingredients to work closely together to develop a total system approach to obtain cost-efficient, quality products that meet or exceed consumers’ expectations. In this respect it is noteworthy to catch the trend that in some developed markets animal by-products are being eliminated and replaced by ‘clean-and-green’ soy protein ingredients to improve nutritional and quality profile.

Definition

A raw meat emulsion can be described as a dispersion. Under thermal processing, this dispersion changes from a fluid to a solid in which the fat is entrapped in the gel structure. The degree of fat comminution and its distribution in the matrix play important roles in the end product. The size of the fat particles determines the degree of coalescing that may cause fat or jelly separation. Usually fat has a stabilizing effect on the gel network during thermal processing. Fat acts as 'filler' within the gel to reduce the amount of shrinkage within the meat batter structure. The finer the comminution and dispersion of fat, the stronger the formation of the meat emulsion, provided sufficient solubilized protein remains available for aggregation. As a practical side note, however, it can be observed that peeling problems may arise with skinless sausage if too much fat is tied up within the meat emulsion. The presence of pork skin (rind) and other types of collagen-rich meat, or when too much starch has been added, also influences the latter effect. (See Schut, 1976.)

All meat products share in common the attributes of the lean meat fraction that binds all the product components into a cohesive structure. The mechanism of binding in processed meat systems is complex. Many of the properties are still not fully understood. A number of factors affect binding, namely, the amount of protein extraction, mechanical treatment, presence and concentration of salt and other functional ingredients (including non-meat protein), temperature, pH and method of cooking. Classification of different protein groups is purely academic, but is useful in gaining a thorough understanding of the variables that determine the finished qualities of an emulsified meat product. (See Barbut, 1995.)

Chemical Composition of Meat

Lean meat (Table 9.1) consists of about 20% protein, 2.5% fat and 3% soluble substances such as carbohydrates, vitamins and minerals. The remainder is water. Of the total meat protein, about 50% is myofibrillar protein, which contains approximately 35% myosin and 15% actin. The remaining meat protein is made up of sarcoplasmic proteins and connective tissue, or stromal proteins.

Technologically speaking, the myofibrillar protein fractions are most important for achieving binding, emulsification and gelling. The sarcoplasmic protein fractions are in solution in the intracellular fluid, also called sarcoplasma. These proteins are soluble at low ionic strength.

Their main functional contribution is to provide the typical cured meat colour. Sarcoplasmic proteins are denatured by heat and at low pH. In their native state, these proteins are highly soluble, although they have a low viscosity and gel strength and contribute minimally to water-holding capacity, texture and emulsification.

Myofibrillar proteins are an integral

Table 9.1. Meat analysis.

	%
Water	75.0
Protein	19.0
Myofibrillar: salt-soluble	(11.5)
Myosin, actin, tropomyosin, troponin, M proteins, actinins	
Sarcoplasmic: water-soluble	(5.5)
Glyceraldehyde, aldolase, myoglobin, haemoglobin	
Connective tissue: insoluble	(2.0)
Collagen, elastin, reticulin, mitochondria	
Lipids (fats)	2.5
Carbohydrates	1.2
Glycogen, glucose, lactic acid	
Miscellaneous	2.3
Vitamins, inorganic (minerals), nitrogenous	

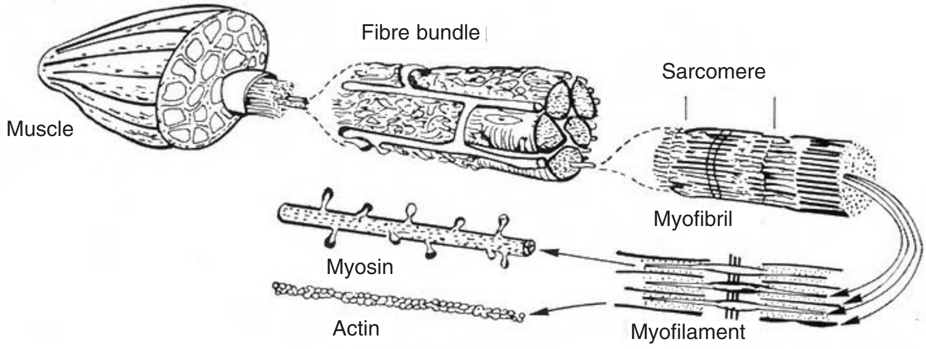

Fig. 9.1. Muscle bundles and structure.

part of the filaments in the muscle tissue (Fig. 9.1). The filaments consist of thick filaments, or myosin, and thin filaments, or actin. In live animals, muscles shorten or relax by increasing or decreasing the amount of overlap between the myosin and actin. This same mechanism affects the degree of water-holding in meat. If the thick myosin filaments shorten, the H-zones between the longitudinal sections of the myofibril are compressed, and water is expelled. Each thin actin filament terminates at the Z-line, whereas the thick myosin filaments terminate at the M-line that cross-bridges and interconnects the actin and myosin.

Protein Extraction

The solubility and water-holding capacity of the myofibrillar proteins is minimal at pH 4.5–5.5. Increasing the pH of meat from pH 5.5 to 6.5 increases the amount of extracted salt-soluble protein.

Freezing reduces the amount of total protein and the salt-soluble protein that can be extracted from the muscle (Fig. 9.2).

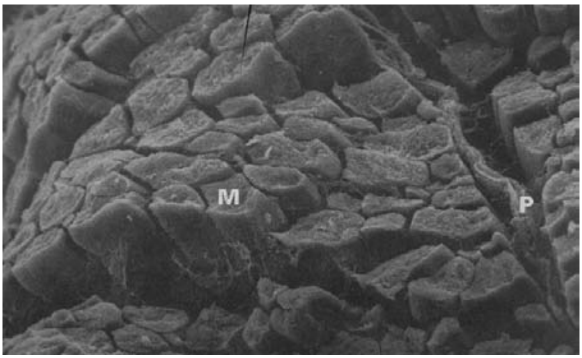

Fig. 9.2. Scanning electron microscope photograph of muscle cells (M) with perimysium (P), part of the connective tissue. Scource: Meat Research Institute, Kulmbach, Germany.

Also, it is noteworthy that polyphosphate, in the presence of salt, increases the amount of extractable protein, compared with salt alone. When protein extraction is done properly, the myofibrillar protein forms a strong, elastic gel.

Connective tissue, or stromal protein, includes collagen (the main fraction surrounding the muscle), epimysium (the fibre bundles), perimysium and the single fibres (endomysium). Elastin, cell membranes and mitochondria are the other connective tissue protein fractions. These proteins shrink to about one-third in length when heated to 60°C and convert to gelatine when heated to over 70°C. The presence of connective tissue protein in meat products is important for ensuring textural properties, although too high an inclusion level should be avoided, since it will stress borderline formulations.

As long as the meat membranes remain intact, the escape of moisture or purge is difficult. All the water present is bound in some varying degree by protein. However, not all the water is bound with equal strength.

An overview of the different 'types' of water in meat tissue:

- Protein-bound water: these water molecules are so tightly bound that even at temperatures of –50°C no ice crystals can be formed.
- Filament-bound water: this water is immobilized within the actin and myosin filaments.
- Fibril-bound water: this water is immobilized between the filaments of the fibrils, and is believed to be bound as a result of pH.
- Free water: this water is present in the sarcoplasmic area and is very loosely bound.
- Extracellular water: this is all the remaining water situated outside cellular membranes and is held in narrow capillaries. In post-rigor meat, up to 15% of water is in extracellular form.

Influences

The percentage of pork carcasses with quality defects such as pale soft exudative (PSE) meat has been estimated to be as high as 30%. These meat variables, such as PSE and dark firm dry (DFD) conditions further complicate the degree to which water is bound in the meat. Both PSE and DFD meat have irregularities in pH and thus significant differences in water-holding capacity, protein solubilization, protein swelling, colour and flavour. It is not only the pH itself, but also the speed of the pH decline that determines the condition of the meat. The colour of PSE meat is much lighter than normal meat, which is in turn lighter than DFD meat. This phenomenon is not due to the lack of myoglobin, but rather because of the 'open' meat structure and its watery appearance. This causes a change in the way light reflects as it bounces back at different angles. However, the advantage of lower pH meat is higher salt absorption and faster conversion from nitrite (NO_2) to nitric oxide (NO), establishing an improved cured colour with the myoglobin.

Normally nitric oxide combines with myoglobin, forming nitroso-myoglobin, which changes into di-nitrosyl-myoglobin in uncooked meats. That changes into di-nitroso-haemochromes when the product is cooked. Despite the readiness of PSE meat to take up salt and the rapid conversion of nitrite into nitric oxide, its water-holding capacity remains low.

Pork, and to a lesser extent turkey, are affected by discrepancies in pH (Fig. 9.3). Contrary to PSE, DFD meat has a pH level that remains above 6.2. This high pH is caused by an incomplete breakdown of muscle glycogen and it will be obvious that these quality defects adversely affect the processing characteristics. The high pH is responsible for a superior water-holding capacity, though unlike PSE meat, DFD meat has a lower absorption of salt and cure (nitrite), and reduced conversion of nitrite to nitric oxide reacting with the myoglobin due to strong swelling of meat fibres. DFD meat thus forms a less stable cured colour and often has an accelerated microbial condition promoting spoilage and reducing shelf life. In PSE meat, a breakdown of sugar into acid normally occurs, caused by bacteria. In DFD meat, spoilage or putrefac-

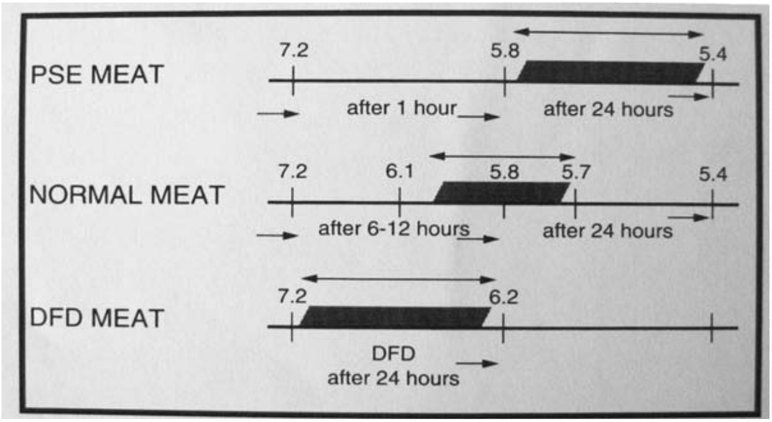

Fig. 9.3. pH ranges of PSE, normal and DFD meat.

tive bacteria create protein breakdown that causes development of an undesirable base flavour.

Between slaughter and onset of rigor mortis, muscle meat passes through a series of biochemical changes, and anaerobic conditions cause the natural presence of adenosine triphosphate or ATP to undergo gradual disintegration (Fig. 9.4). After slaughter, ATP in muscle is gradually depleted and the actin and myosin transformed into actomyosin. The degree of myofibrillar protein extraction from muscle is influenced by the development of rigor mortis, or a shortening and stiffening of muscle fibres. For example, in pre-rigor or hot deboned meat, an abundance of ATP separates the myofibrillar protein myosin and actin. In the loosely bound cross-links between these thick and thin filaments, substantial amounts of water can be stored, and under the influence of salt the myofibrils release salt-soluble proteins and become swollen. After rigor mortis sets in, which for beef is within 4 h, and for pork within 1 h of slaughtering, pH drops and ATP is gradually depleted. Consequently, the muscles contract and become firm and tough. The spaces also become smaller, and thus the water-holding capacity is reduced. Optimal extraction of the myofibrillar proteins depends on the concentration of salt

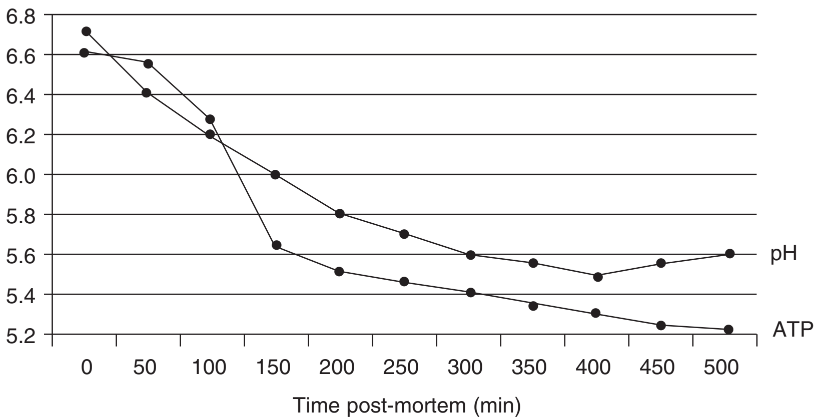

Fig. 9.4. Correlation between ATP and pH in post-mortem muscle tissue.

and phosphate, the temperature, the pH, the degree of comminution and mechanical action, and the quality of the lean meat. Salt has the tendency to reduce pH, whereas alkaline polyphosphates tend to increase pH. Salt improves emulsification, because of the increasing amount of protein extracted with smaller meat pieces at a given time/temperature. By altering the ionic and pH environment during heating, a coherent three-dimensional protein matrix or structure is formed.

Meat Emulsions

Emulsified products, such as frankfurters, hot dogs and bologna, are made from meat that is entirely or partly disrupted in the presence of water, salt and other processing aids, such as phosphates, citrates, carbohydrates, non-meat proteins and seasonings. The resulting product can be best described as a multi-phase system containing a solution of water and dissolved ingredients, water with suspended particles, gel, the emulsion itself and even entrapped air or foam.

The term 'meat emulsion' (Table 9.2) is often mixed with the terms 'meat batter', 'meat matrix', 'meat comminute' and even 'meat dough'. Meat emulsions are distinguished from classical emulsions because the continuous phase of the meat emulsion is a colloidal matrix of protein and salt, rather than a simple liquid. The structural integrity of this matrix is critical to the stability of the meat emulsion. Quite a number of viewpoints exist among meat scientists, but for order's sake this book will refer to emulsified meat as products in which discrete particles of meat cannot be distinguished, although for appearance, visible pieces of meat or fat may be embedded in the emulsion.

Table 9.2. Typical emulsified meat product (%).

Protein	9–14.0
Fat	15–30.0
Salt	1.0–3.0
Phosphate	0.0–0.5
Sodium nitrite	0.01–0.03
Sodium ascorbate*	0.03–0.05
Starch	0.0–10.0
Sugar	0.0–4.0
Seasoning	Varying
Water	By difference

*Or sodium erythorbate.

Influence of Compositional Ingredients

The environment in which meat processors operate is changing so rapidly that it is almost impossible for researchers to keep up with the speed and the implementation of new compositional meat product ingredients. Research usually changes one parameter at a time in order to establish its effect.

The introduction of new processing technologies, alternative meat sources – including calorie-restricted meat products – has changed conceptual thinking dramatically in the last few years. These changes have had a significant impact on the composition of the sausage emulsions. For example, changes such as fat reduction or even the elimination of fat, salt reduction and lean meat replacement all impact on traditional eating properties.

With consumers, there is an obvious gap between their expressed desires and their ultimate choices, because historically they don't always make rational purchasing decisions: consumers refuse to sacrifice taste for perceived health claims. Many of the current meat emulsion technologies can be used or adapted for the development of consumer-friendly meat products. However, a new perspective is necessary to understand the changed role of meat proteins and innovative functional ingredients in today's emulsified processed meat products. These changes in formulations can greatly influence emulsion stability in relation to its behavioural characteristics and cross-functional interactions.

The main properties of the functional non-meat proteins in emulsified meat products are promotion of swelling, gelation and emulsification. It is important to have a thorough understanding of these fundamental properties, including the build-up of structural associations of intramolecular and aggregation bonds.

Three main interactions that occur in meat emulsions are:

- Protein–water interactions.
- Protein–protein interactions.
- Protein–fat interactions.

Protein–water interactions determine the characteristics of water uptake, swelling and solubilization. Protein–protein interactions generally control the degree of aggregation and meat matrix development, while the interfacial interactions mainly describe surface tension and emulsification properties. Additionally, there are formulae in which a complex of ingredients and additives are used, such as polysaccharides, to improve upon certain properties, including higher moisture retention, or to manipulate or mimic certain eating sensations.

Technologically speaking, the protein–water interactions can be considered of most interest to meat processors. The capacity of meat (Fig. 9.5) to bind added water continues to amaze researchers. Salt (NaCl) together with sufficient amounts of water, triggers swelling and solubilization of the meat protein. Salt increases the surface tension of the water, thus it is very important to ascertain that an optimum ionic strength is obtained when solubilizing the salt-soluble myofibrillar protein. During thermal processing, solubilized protein surrounds the liberated fat. Together with the swollen myofibrillar protein fragments, the solubilized protein forms a network that prevents the coalescing of fat and also arranges the fixation or structural enforcement of all supporting compositional ingredients, such as connective tissue, collagen fibres and functional non-meat proteins. Salt also offers an inexpensive way of potentiating flavours, and as an added bonus it provides the benefit of decreasing water activity of the product. Therefore salt assists the preservative system by creating a less hospitable environment for bacterial growth.

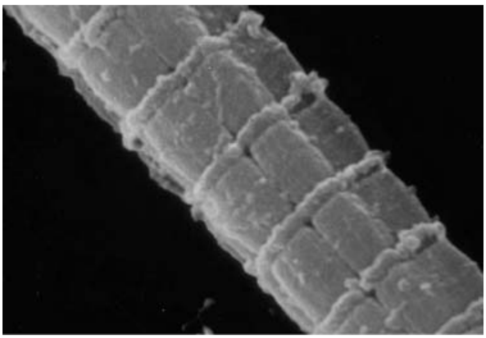

Fig. 9.5. Scanning electron microscope photograph, showing bundle of untreated myofibrils. Source: Meat Research Institute, Kulmbach, Germany.

Gel formation is probably the most important functional property of meat protein, the key being the behavioural characteristics of the contractile protein actomyosin. Ideally, during comminution, all muscle cells are opened up to solubilize in the presence of sufficient water, salt and phosphate. Phosphate usually speeds up the extraction of protein, and the total amount of protein extracted.

The percentage of extracted salt-soluble protein increases according to the intensity of comminution, although almost equally important is the influence of pH, temperature, salt and phosphate. To maximize the extraction of salt-soluble protein, cryogenic cooling may be used during chopping or blending. At a constant temperature, protein extraction is a function of time. Added processing time will boost protein availability and/or allow reduction of salt or phosphate, while maintaining sufficient fat stabilization and textural formation.

Meat proteins also have the capacity to form a stable oil/water (O/W) emulsion. Salt-soluble proteins have superior emulsification properties compared with water-soluble proteins. It is believed that the salt-soluble protein is preferentially adsorbed at the fat/water interface. In its native state, myosin protein has less affinity to bind water (shows a higher surface hydrophobic capacity). After the dissocia-

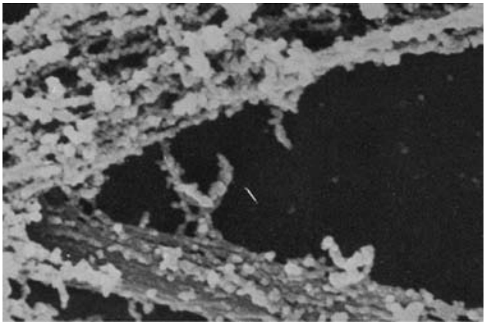

Fig. 9.6. Scanning electron microscope photograph, showing early stage effect of salt and phosphate-treated myofibril. Source: Meat Research Institute, Kulmbach, Germany.

tion of actomyosin in the presence of phosphate, the actin protein remains in the water phase, whereas the myosin is directed towards the liberated fat droplets. Fat emulsification usually leads to the same result; however it is achieved in a different manner. When the salt-soluble proteins are interfacially adsorbed to fat globules, they lose the ability to gel and to form a three-dimensional matrix. (See Gordon and Barbut, 1990.)

Phosphates are mainly used for their buffering capacity to stabilize pH. Their main function is to serve in chelating polyvalent cations, such as magnesium and calcium, and heavy metals, such as iron and copper. This capability allows better water binding and the scavenging of free radicals that cause oxidative rancidity. Because of their negative surface charge, phosphates assist in the stabilization of dispersions, emulsions and suspensions.

Polyphosphates, especially diphosphates, have unique properties to solubilize actomyosin in the presence of salt (Fig. 9.6). Sodium tripolyphosphate (STPP) (Table 9.3) is most often used in processed meat products, though in many cases combination blends of phosphates give improved results. For example, the addition of sodium pyrophosphate to meat products will accelerate development of a cured 'red' meat colour in emulsified meat products. This feature can be important for meat products with a reduced amount of lean meat or when limits on smokehouse capacity require higher processing temperatures to increase throughput. Phosphates also have the tendency to lower meat batter viscosity which is often beneficial as process temperatures are less inclined to increase. The latter helps to avoid premature emulsion breakdown.

In finely comminuted meat batters the presence of phosphates supports heat stability as well as the ability to bind water, thereby increasing yield levels. Typically, levels of phosphate addition to meat batters range from 0.1% to 0.4%.

From the above, it can be noted that water-holding capacity is greatly influenced by pH. At the iso-electric point (IP), the water-holding capacity of meat is at a minimum. Actually, the IP can also be defined as the pH at which protein has the lowest active electrical charge. Changes on both sides of the IP will cause an unbalanced electric charge which increases water-holding capacity. Ionization causes electrostatic repulsion against positive-charged protein side chains, which subsequently allows more space for water-holding.

More Variables

Before protein–protein interactions in meat emulsions can occur, it is necessary to destroy the crosslinking of actomyosin (Fig. 9.7). Phosphate is ideally suited for dissociating crosslinking, and for restoring some of the pre-rigor properties of meat protein. The presence of phosphate in meat emulsions improves batter stability, yield and texture. In the raw emulsion, phosphate also reduces viscosity, which allows a significantly higher filling speed for both

Table 9.3. pH effect of phosphates.

Phosphate	% pH solution
Tetrasodium pyrophosphate	10.5
Sodium tripolyphosphate	9.8
Sodium hexametaphosphate	7.0
Sodium acid pyrophosphate	4.2

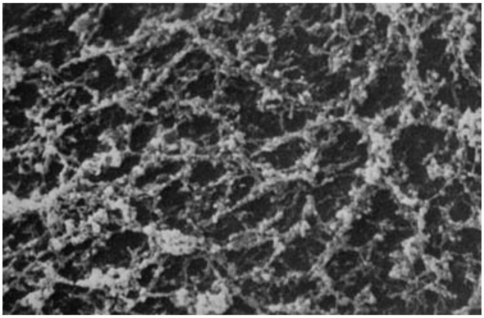

Fig. 9.7. Scanning electron microscope photographs of salt soluble myofibrillar protein formed into a granular, threadlike network. Source: Meat Research Institute, Kulmbach, Germany.

traditional filling lines and for coextrusion processing.

It is common knowledge that during the blending or chopping process of a meat batter or meat emulsion, temperature rises due to friction by the movement of the mixer arm or fast rotating chopper knives. The latter is also influenced by the particular design of the chopper knives. The presence of starches and high-viscosity non-meat protein ingredients can cause stiffening of the meat batter. Certain ingredients also take up large amounts of free water, which has a further detrimental effect on optimum blending and chopping performance. Selecting ingredients that maintain low viscosity in the early part of the comminution process and the addition of phosphate directly on to the lean meat portion, if possible with a portion of the salt, will help to offset some of the viscosity increase. This enables prolonged blending or chopping, thus optimizing protein solubilization and reducing fat particles to very small globule sizes (Fig. 9.8). (See Jones and Mandigo, 1982.)

Mechanically deboned meat (MDM) generally has a pH of 6.5 or higher. Therefore, the addition of a small amount of sodium acid pyrophosphate (SAPP) can bring advantages in improving chewiness of MDM-formulated emulsified sausage. The addition of small amounts of SAPP is also beneficial for sausage formulas that have high inclusion levels of functional soy protein. However, a slight disadvantage of SAPP inclusion might be a greater tendency for purge development compared to sodium tripolyphosphate.

The Role of Fat Globules

The melting points of various types of fat can substantially influence the degree of dispersion and subsequently the adsorption of protein at the fat/water interface. In a raw meat emulsion in which sufficient extracted salt-soluble protein is present, the proteins direct their hydrophilic or water-loving regions toward the oil/water interface (Fig. 9.9). For calorie-reduced sausages, a relatively large part of the

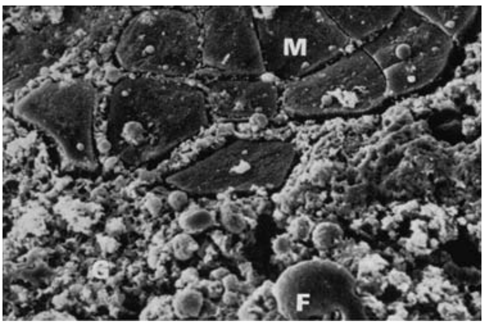

Fig. 9.8. Scanning electron microscope photograph: M = meat fibre, F = fat globule in a course emulsion matrix. Source: Meat Research Institute, Kulmbach, Germany.

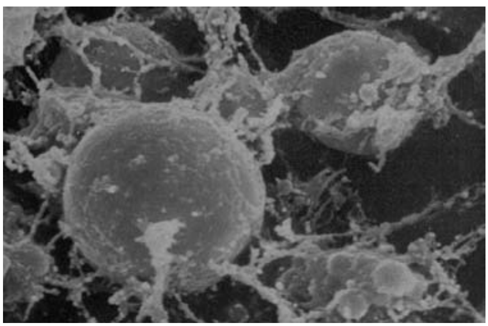

Fig. 9.9. Scanning electron microscope photograph showing oil globules preferentially bound by solubilized protein network. Source: Meat Research Institute, Kulmbach, Germany.

hydrophobic or water-hating regions of protein molecules are not utilized. This phenomenon causes protein molecules to change absorption and adsorption patterns and can result in significantly reduced water-holding capacity, or purge. The previously mentioned variables in meat protein and the reduction of fat and/or the relative reduction of salt in the emulsion can cause product irregularities. It seems that the presence of sufficient fat plays an important role. In general, increasing amounts of fat – up to approximately 30% – lowers the shrinkage of the protein structure. Subsequently yield improvement will be obtained.

It is obvious that the unfolding or denaturation of proteins and the subsequent aggregation or re-association of the solubilized meat fragments is a key to obtaining an optimum gel network. In this process, ingredients, additives and processing variables can be responsible for altered visco-elastic characteristics. For example, certain types of gums exhibit a diluting or anti-gelling effect, resulting in a less dynamic crosslinking and aggregation. It is also possible that the conformational stability, that is the protein/gum interaction, does not change the crosslinking itself, but will negatively impact the rheological properties of the gelling suspension.

Gelwork interference is a common problem in sausage production. Many research studies and empirical processing experience have shown that a high viscosity in a raw meat emulsion does not necessarily translate into strong elasticity once the product has gone through thermal processing. Elasticity, which is an important parameter in developing meat-like texture, is generally formed once the temperature of the meat emulsion reaches 43°C for protein/protein interactions. These temperatures are usually higher for protein/gum interactions and start at 60°C. The temperature depends on the type of the gum, if indeed an improved texture can be obtained.

The same scenario is basically true for protein/protein interactions when functional non-meat proteins are used. For standard meat products with a relatively high lean meat and fat content, the availability of extractable salt soluble protein is generally sufficient to ensure both emulsification and gelation (Fig. 9.10). However, if meat sources of lower functional quality are used, such as mechanically deboned meat, organ meat or trimmings, or if the formulation calls for increased water or reduced salt, the availability of extracted salt-soluble protein is insufficient to achieve both emulsification and gelation (Fig. 9.11). In these cases functional non-meat protein ingredients are usually added to 'fortify' the meat emulsion.

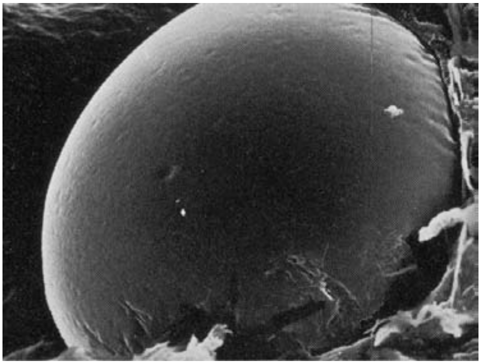

Fig. 9.10. Scanning electron microscope photograph of a single fat globule surrounded by a continuous layer of protein. Source: Meat Research Institute, Kulmbach, Germany.

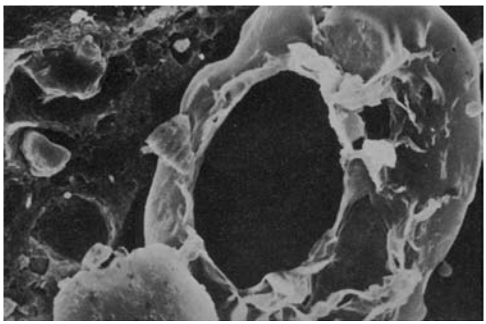

Fig. 9.11. Scanning electron microscope photograph of a ruptured coated fat globule, possibly caused by fat expansion during thermalization, with fat coalescing as a result. Source: Meat Research Institute, Kulmbach, Germany.

Table 9.4. Relevant factors in water and fat management in processed meats.

Proteins	Gums	Starch	Other
Soy protein isolate	Methylcellulose	Potato	Fibres (e.g. inulin)
Soy protein concentrate	Guar	Corn	Wheat gluten
Total milk protein	Carrageenan	Rice	Transglutaminase
Sodium caseinate	Alginate	Tapioca	
Whey protein concentrate	Konjac flour	Wheat	
Blood (albumen) protein			

The criteria for selecting the most appropriate functional non-meat protein depends on formulation variables, processing equipment, the protein's contribution to the nutritional profile and cost efficiency (Table 9.4). In principle, non-meat protein ingredients can be divided into animal and vegetable origin. Some animal protein products such as sodium caseinate, a milk derivative, and blood (albumen) have demonstrated a positive influence on high-fat stabilization, especially when retorted. However, throughout the world the inclusion level of fat in processed meats has gradually declined, and also there is a marked increase in the use of meat of lower skeletal quality. Blood (plasma) protein and milk protein products have a significantly higher price profile. Together, these variables have reduced the need for these types of animal protein ingredients.

Changing Paradigms

Two of the most significant concerns for today's consumer are nutrition and safety. At the same time, consumers are putting top priority on taste, value and convenience. Taste and flavour remain the most valuable assets meat processors have to offer to ensure repeat purchases, but that is where complications arise.

In the 'bad old days', high-fat meat products translated into high quality. The classic European-style sausage, such as Braunschweiger, Mettwurst and many others, had a fat content of at least 50%. Even today, the world's best-selling pork breakfast sausage at fast food restaurants has a fat content well over 30% – or, to put it differently, well over 80% of the calories come from fat. Slowly, the notion is sinking in that over-consumption of animal fat and transfats can lead to serious health problems. That is one of the main reasons that the current generation has been instrumental in shifting from the consumption of 'red' meats to lower saturated fat foods, such as poultry and aqua foods. Beef fat contains about 54% saturated fatty acids – similar to lamb and mutton fat – compared with about 45% for pork fat. These numbers are significantly higher than chicken fat, which contains only 32% saturated fatty acids. But what is the wisdom here? The Atkins diet has prompted renewed debate about fat as a potential health hazard. The jury is still out, which makes market positioning of formulated food and meat products very difficult.

For example, only a few years ago the rather sudden change in consumer demand for low fat and fat-free meat and poultry products caught food legislators off-guard. The rather strict legislative guidelines were relaxed to allow meat processors to address the need for calorie-restricted processed meat and poultry products. However, most recently this low fat category of formulated foods has come up against the popularization of carbohydrate-controlled foods, including formulated meat products.

Low-fat Emulsion Processing

It seems so simple to create low fat spin-off versions of existing products, but in reality this isn't so easy. Merely formulating with leaner cuts of meat creates three main problems: it changes the manufacturing variables; it significantly changes flavour, texture and juiciness; and it substantially increases costs. Fat can be seen as the lubricant for improved eating characteristics. Reduced fat levels usually translate into a drier, more rubbery texture. Spices and seasonings react differently when fat is reduced or eliminated. There are a number of functional ingredients, additives and even fillers that partly can compensate for the lack of fat. Basically, these ingredients can be categorized as to whether they improve water-holding capacity or whether they mimic fat. (See Shand, 1997.)

It is only logical that if fat levels decrease, water content must increase. Meat protein remains the most important binder of its own juices and added water. Lean skeletal muscle meat has a high water-holding capacity, compared with fatty and/or organ meat sources. Alkaline phosphates and sodium chloride are the main additives to support the extraction of salt-soluble meat protein. These additives expose the hydrophilic areas of the meat proteins. The latter is a function of pH, which has its lowest water-holding capacity and solubility at pH 4.5 > 5.5.

Functional soy protein ingredients are able to bind with water and fat and withstand heat processing while maintaining texture and allowing sufficient moisture release upon eating. The solubilized portion of the myofibrillar protein forms a very strong, elastic gel. Functional soy concentrates and soy protein isolates especially support the aggregation of the complex protein network and yield management (Fig. 9.12). Besides these functional non-meat protein ingredients, there are a few polysaccharide gums, such as carrageenan and konjac flour, that have found their way into products with low amounts of lean meat. These additives are mainly used to bind water and to decrease purge released after thermal processing.

Pre-Emulsion Variables

The use of pre-made emulsions in comminuted meat batters or meat emulsions continues to be popular in a number of countries. Often pork skin (rind) (pork rinds), beef collagen or diaphragm meats are utilized in these pre-emulsions. Soy protein isolate and, to a somewhat lesser extent, soy protein concentrate is uniquely able to stabilize fat and water emulsions. Pork skin (rind) and other similar meat by-products can be considered a collagen protein and these proteins play a major role in the texture of meat products. They also contribute to flavour and texture, while providing cost-savings for the meat processor.

There are a number of typical processing variables, however, that need close attention in order to achieve optimum results:

- Cold-made pork skin (rind) emulsions outperform hot-made pork skin (rind) emulsions.

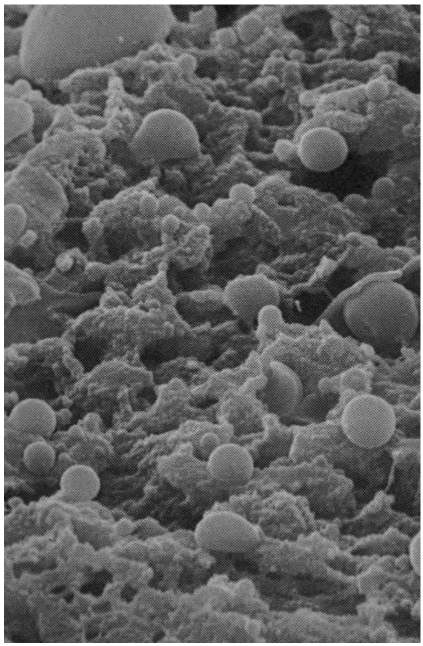

Fig. 9.12. Scanning electron microscope photograph showing sausage matrix with 30% fat, stabilized with soy protein isolate. Source: Meat Research Institute, Kulmbach, Germany.

- Meat emulsions that contain pork skin (rind) emulsions will have improved texture and yield when cooked at a higher temperature.
- Comminuted meat emulsions will have improved texture and higher yield when chopped to a finer particle size, or when ground through finer plate sizes, i.e. 1.4 mm.
- Dry addition of soy protein ingredients to the meat batter will improve cooked meat colour compared to products which contain a pre-made emulsion.
- Generally speaking, the use of pre-emulsions removes a significant amount of free water from the processing system. Thus greater viscosities are created, leading to temperature increases and frequently also a lighter product colour.
- Because of gelling, pre-emulsions usually set quickly, and therefore these pre-emulsions should be used as quickly as possible in the final emulsion matrix.
- See Combi Emulsion, p. 189.

Solutions for Low Fat Formulas

For coarse-ground sausage, visible fat can be replaced by a combination of modified starch and konjac flour. Acetylating the konjac flour with an alkali presets the starch-containing gel, which is heat stable, and chopped or ground in small pieces of fat analogue.

Coarse, lean meat can be simulated using a patented structuring technology that granulates certain types of soy protein isolate and water. The granules can be manufactured in a number of patented processes utilizing a chopper, mixer/grinder or an innovative in-line granulating system that simulates meat analogue particles in a matter of a few minutes. The granules can be coloured using, for example, extracts of paprika or sandalwood, if desired, to match the cured and cooked meat colour. The resulting soy protein granules (Fig. 9.13) can be immediately cooled and in-line blended with the other components.

Both the fat analogue and the meat analogue particles, when mixed with a certain portion of ground muscle meat, can mimic the traditional eating quality of coarse-ground meat and poultry products. These protein granules are also successfully used in emulsified meat products to improve texture, or as 'show' meat to replace the more expensive lean chunk or particle meat.

New micro-cutting equipment now allows emulsion size reduction while maintaining a vacuum. Often a micro-cut process is needed following the traditional chopping process or when a mixer/blender set-up is used. Micro-cutting reduces the emulsion to a very fine particle size. If this action is done while maintaining a vacuum, colour stability and product density are improved while air entrapment is avoided, thus minimizing the possible creation of gel pockets.

There is a wide selection of modified food starches and other carbohydrates that can contribute to a good all-round stabilizing matrix in an emulsified meat product. Starches, maltodextrines, milk solids such as sweet whey powder and even maize syrup solids are often used to complement the functionality of soy protein ingredients. Starches and maltodextrines are relatively inexpensive and can optimize water immobilization beyond the appropriate inclusion level of soy protein additions. Milk solids, such as sweet dairy whey or hydrolysed milk protein, have the beneficial effect of globular micro-partic-

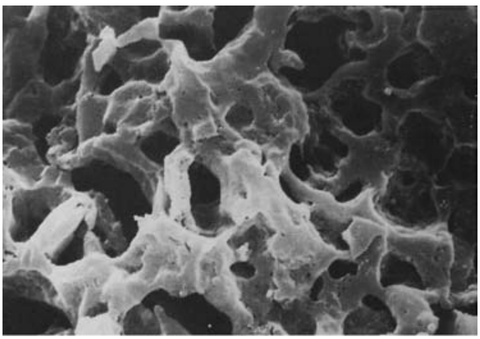

Fig. 9.13. Soy protein gel with compact structures (Scanning Electron Micrograph, magnification 5000 x). Source: Meat Research Institute, Kulmbach, Germany.

ulation, which simulates the presence of fat. To further enhance the juiciness and succulence of the finished product, it is recommended to formulate low- or no-fat emulsified sausages with 1–2% added gelatine. High-gelling soy protein isolate is ideally suited to preventing adverse reactions with these supporting functional ingredients.

Fat-free Technology

Technology to address consumer demands is changing at an ever-increasing pace. It was only a few years ago that USA meat processing companies revolutionized consumers' perceptions with the introduction of the 97% fat-free hot dogs and sliceable deli meats, such as bologna. Although early consumer acceptance was hindered somewhat by poor-quality texture, mouthfeel and flavour, this did not stop further research to decrease the fat content even further.

One might question why it is so important to eliminate even the last 3% fat from a sausage. Well, frankly, extensive consumer research revealed that many consumers still had a problem putting the 3% fats in the right perspective. Three per cent fat still contributes to the 30% fat calories within the total diet, something that is considered the upper limit by the guidelines of the American Heart Association. To avoid confusion, fat-free hot dogs and fat-free sliceable luncheon meats were introduced (Table 9.5). This introduction has initially generated very favourable consumer response, which in turn prompted quite a number of meat processors to quickly reposition similar fat-free products of their own. However, it is true that low-fat or high-end consumers are divided into different categories. A few years after the introduction of fat-free meat products, the initial market growth came to a halt and has declined ever since.

It remains a mysterious phenomenon why in the USA low fat hamburgers have failed to gain consumer acceptance, whereas low- or no-fat hot dogs and other similar luncheon meats have been able to capture the limelight of consumers' attention. However, it should be noted that the rather sudden surge of low carb foods has resulted in a significant decline in low fat

Table 9.5. Calorie calculations per 100 g of product.

	g/100 g	kcal/100 g	% of calories
Hot dog 30% fat			
Protein	11	44	14
Carbohydrates	2	8	2
Fat	30	270	84
Total calories		322	
Hot dog 10% fat			
Protein	12	48	32
Carbohydrates	3	12	8
Fat	10	90	60
Total calories		150	
Hot dog 3% fat			
Protein	13	52	55
Carbohydrates	4	16	17
Fat	3	27	28
Total calories		95	
Hot dog 0% fat			
Protein	13	52	76
Carbohydrates	4	16	24
Fat	0	0	0
Total calories		68	

and fat-free meat products. There is no doubt that meat companies will eventually reposition the low fat meat products, and it is even possible that this category might disappear altogether. For many consumers, high fat is back in vogue.

The manufacturing of fat-free meat products requires a rather significant departure from traditional meat batters and/or meat emulsions. Basically, the formula of a fat-free emulsified meat product contains about 45–55% premium quality lean skeletal meat, the remainder being water, flavourings, salt, seasoning and, most importantly, a combination of functional non-meat ingredients such as hydrolysed proteins, functional non-meat protein ingredients, hydrocolloids and modified food starches. Reduced-fat and reduced-salt meat products create a number of challenges for the meat processor. Lowering sodium chloride will actually increase the available water. Fat-reduced meat products also have a higher available water content. However, free moisture is a major cause of microbial growth. Very often it will be necessary to add some formula and processing hurdles to prevent or delay microbial spoilage. Vacuum blending and packing as well as post-process pasteurization to eliminate surface contamination are methods that are recommended. Technologically speaking, it is necessary to immobilize the rather high amount of added water and meat juices in such a manner that a harmonious three-dimensional integrated network is formed with a multitude of characteristics, formed by texture-providing meat proteins and functional non-meat ingredients. It is also necessary to satisfy the stringent organoleptic demands of consumers in terms of fat mimicking, juice release and flavour contribution. These need to be strikingly similar to the original full-fat product. The latter is the key to the ultimate success or failure of calorie-restricted processed meat products.

Emulsion Analogue

Much has been written about the rather schizophrenic and erratic consumer behaviour patterns as they relate to food purchasing decisions. Consumers try to ease their mind with rational thinking based on emotional motives. In other words, consumers want the good things in life, such as great-tasting flavour, without the guilt and the calories. It is expected that the market for processed meat products will move into two extremes, namely full-fat processed meats and reduced-fat meat products. It remains to be seen if the niche market for fat-free hot dogs and sliceable luncheon meats will be sustainable long term. Probably not!

It was not many years ago that the main debate about meat emulsions was focused on the amount of fat that could be stabilized or immobilized in the final product. Even in low fat products, one still can speak technologically about an emulsion where the size of the fat droplets and their distribution in the meat matrix are of importance for variables such as succulence, bite, texture and yield. However, with fat-free hot dogs, sausages and deli meats, the word ‘meat emulsion’ no longer seems correct. For fat-free products, it is perhaps necessary to agree on a different descriptive name, such as ‘protein–colloid mixture’ or ‘emulsion analogue’ (Fig. 9.14).

The fact is that the traditionally important role of fat needs to be replaced by an analogue performance of functional ingredients. Preferably, these functional ingredients should have a nutritional profile similar to lean meat, and above all, the ability to mimic the textural properties of emulsified, coarse or fragmented meat products. (See McMindes, 1991.)

It is doubtful that a single non-meat protein source will have all the required characteristics. It is more likely that it will have to be teamed up with functional ingredients offering synergistic behavioural values, such as a combination of bland-tasting soy protein isolate of varying gel strengths and maltodextrine, and possibly dairy derivatives and modified food starches. In terms of processing temperatures for calorie-restricted products to obtain meat batter stability, it is suggested to reduce these to between 6°C and 12°C, as otherwise premature meat denaturation might follow.

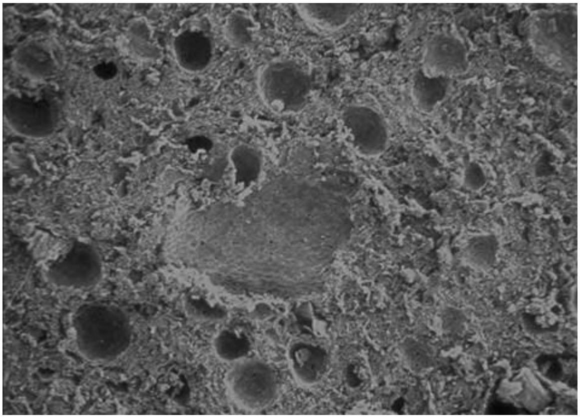

Fig. 9.14. Scanning electron microscope photograph of a fat-free sausage analogue matrix. Source: The Solae Company, St Louis, Missouri, USA.

Temperature Considerations

Temperature control plays a significant role in maintaining the desired colour of a processed and cooked meat product. Lower storage and display temperatures greatly benefit a stable colour. To optimize colour formation and stability, additives such as salt, phosphate, nitrite and cure accelerators like ascorbate and erythorbate preferably need to be added prior to fat addition to the chopper or blender. It should be pointed out that these essential additives are given sufficient time to react with the lean meat portion of the formulae. Pre-curing lean meats generally also results in improved colour formation and stability.

Chilling efficiency and the speed of chilling emulsified sausages such as hot dogs is important. Even if the sausages have been cooked sufficiently to destroy vegetative pathogens such as salmonellae, some spores will survive. It is also possible that the emulsified sausages will acquire surface contamination during the various manufacturing steps, including air movement, showering and in-plant handling prior to packaging.

After cooking, sausages are usually blast-chilled before being moved into holding coolers. In case of manufacturing downtime or other mishaps, chilling might be compromised, resulting in microbial growth. The specific identity of the microbial hazard depends mostly on the type of environment. Recontamination of chilled emulsified sausages must be avoided, and ideally the process of peeling, collecting, packaging and moving the product into distribution needs to be accomplished within 1 hour.

Ideal finished product temperature after packaging should be <4°C, which is well below the lower limit for the growth of spore formers (10°C). The presence of sodium chloride (salt) and sodium nitrite will retard the growth of surviving pathogens. Holding times between chilling and packaging need to be kept to a minimum, not only to safeguard microbial standards but also to avoid excessive weight loss of moisture, resulting in lower net-weight packages. Additionally, hot-dog-style sausages have the tendency to experience peeling difficulties when kept too long in the holding rooms.

Rework is processed meat that fails to meet the strict QA specifications and therefore is prohibited from sale. This material is often unavoidable in meat processing. Still, every attempt should be made to reduce rework to a minimum. Rework can cause quality flaws due to microbial spoilage, rancidity and colour abnormalities. It is suggested to allow a maximum amount of 5% to be reused or reprocessed in each new batch. Reworked product should be less than 7 days old and kept at a temperature of <4°C.

Interactive Co-extrusion Progress

The world of sausage processing is about to see major innovations in co-extrusion technology. The new generation of co-extrusion technology has eliminated many of the first generation drawbacks and product flaws, such as primary and secondary skin imprints and prolonged processing times. Also, yield and energy processing efficiencies have improved significantly. Ingenious improvements in equipment design have allowed major technology advances in cosmetic appeal for both the traditional ring or horseshoe-shaped, natural curve-shaped frankfurter and the hot dog-type Vienna sausage. Even the Old World classics, such as British bangers, fresh sausage and semi-dry fermented salami sticks, now are successfully produced on innovative co-extrusion equipment. Another major progress in co-extrusion technology is the successful manufacturing system of closed-end casings. This patented process (Townsend Engineering Co., Des Moines, Iowa, USA/Oss, The Netherlands) produces exquisite particle definition, whereas bite can rival natural casing organoleptical properties such as casing snap or knack.

Both meat emulsion and collagen gel are extruded simultaneously – hence the word co-extrusion – and the rope of wet collagen-covered sausage is subsequently carried on a conveyor belt into a brine slide for rapid de-watering. Upon leaving the brine treatment, the strength of the sausage rope should be sufficient to allow clear crimping and cutting into the desired links or looping on to smoke sticks for further (traditional) thermal processing.

Co-extrusion can best be compared with the spinning of a traditional or natural collagen casing into which the meat batter is simultaneously filled inside. In the past and still today much of the engineering know-how originates in The Netherlands. The new generation of co-extrusion equipment is based on a rather long collagen hardening time in a slide filled with, for example, a di-potassium phosphate brine solution. A relatively short passage through a drying/cross-linking section to improve overall handling capabilities follows the initial collagen hardening.

Vegetable-based skin material (mainly alginates) can now also be successfully applied, which makes the equipment an option for the manufacturing of meat-free hot dogs. The use of vegetable-based casings allows labelling such as ‘Kosher’ and ‘Halal’, whereas 100% beef-free products can successfully be made when pork collagen is used for casing formation.

Collagen gel and vegetable-based gels have many potential bridges for chemically interacting with the extruded meat emulsion. Co-extrusion processing variables, such as length of brine bath, brine concentration and temperature, amount of liquid smoke and the speed of the conveyor belt, can influence the degree of water removal from the extruded collagen gel. Apart from delivering the sensory attributes consumers look for in smoked sausages, the direct injection of liquid smoke into the collagen gel is a very effective method for improving cross-linking or skin hardening in the preliminary stages of processing.

It appears that variables such as temperature and airflow have a significant impact on the final co-extruded product characteristics. The switch from conventional smoked sausage processing to advanced co-extrusion technology requires high-calibre total project management capabilities from the engineering or equipment company. This includes professional assistance from the early stages of conception through to final manufacturing start-up, including training and control of processing variables. On-line modem links can now be used for advice and assistance, greatly improving process efficiency, including eliminating operation errors causing down-time.

The most recent fine-tuning of the co-extrusion process now allows double-stream extrusion. The simulation of a true curved frankfurter sausage in varying diameters and lengths, together with true round edges, will no doubt further raise interest in the technology among meat processors. Also, improved collagen systems now allow in-line injection of for example liquid hickory smoke, while optimizing texture and bite. However, possibly the most significant equipment improvement is the extended brine bath that virtually eliminates primary skin imprints. The latter is further improved when high osmotic salts are used in the brine bath (Fig. 9.15).

Metering of the meat and collagen dosing controls the weight of the extruded sausages. The process operator can set these parameters, allowing accuracy of the individual links in dimension and weight. The control of the same dimensions and weights for different meat emulsion viscosities can be a function of the menus stored in the PLC. All basic settings for each sausage type are fixed in a certain menu, and the operator is able to fine-tune the collagen dosing, the meat dosing, brine bath speed and crimper speed to optimize overall process efficiency. Efficiency also involves some recipe variables, such as emulsion temperature, ambient temperature, meat source and the influence of functional non-meat ingredients, such as added vegetable proteins used to reinforce the emulsion stability. Subsequently, a wide range of sausage products can be successfully produced from as short as 20 mm to as long as 800 mm, with diameters from as small as 8 mm to as big as 40 mm or larger.

A few words need to be said about the importance of adapting the meat emulsion for the co-extrusion processing systems. In order to obtain optimum cosmetic appeal, it is recommended to use soy protein supplementation to increase the viscosity of the raw meat emulsion or meat batter. Together with an in-line liquid smoke dosage, which can be added to the collagen dough at point of extrusion, the specific formula ingredients will need to 'stiffen' the meat dough so that a minimal amount of sausage deformation results immediately after extrusion.

Building in process tolerance with functional soy proteins and selected food starches helps to ensure proper, consistent nozzle flow and viscosity. Apart from the typical meat emulsion variables and the use of soy protein ingredients, it can be mentioned that perhaps the single most important advantage of a viscosity regulating

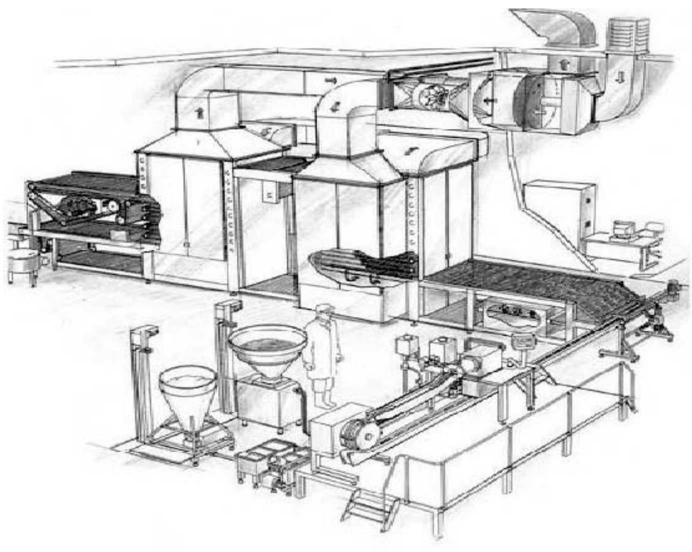

Fig. 9.15. Drawing of an integrated co-extrusion sausage line. Courtesy of Townsend Engineering Co., Iowa.

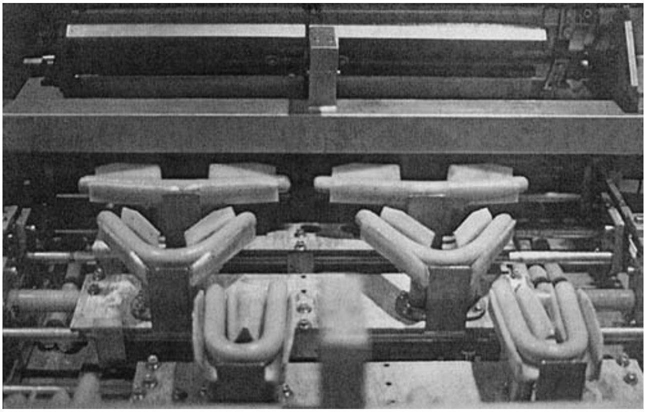

Fig. 9.16. Display of co-extruded sausages.

non-meat protein is its ability to maintain the directional integrity of the sausage. This ability is often called 'form memory', and its strong directional hold will contribute to greatly improved machinability and the overall cosmetic appearance of the end product.

The type of collagen gel used also influences the cosmetic appeal. Collagen translates to bite and textural characteristics, and knack and snap properties. In recent years the production of collagen gel has seen increased competition, which has led to greater pricing efficiency and selection criteria. Co-extrusion allows drastic efficiency improvements, including huge savings compared with pre-manufactured casings.

Now that leading American meat processors have opted for these innovative processing systems, it is likely that the final worldwide breakthrough of co-extrusion technology, including the operation of true automated processing technology involving very little physical labour, has finally arrived at the start of the third millennium. These recent process improvements, including significantly faster manufacturing times, uniquely allow integration of highly efficient operation systems, while providing ample opportunities to adapt formulae that are environmentally safe, economical, with improved shelf life, healthy and tasty.

Co-extrusion clearly has come of age. The new technology advancements now uniquely allow simulation of traditional products, together with the opportunity to develop innovative products where flavour, colour and aroma can be truly customized and integrated with the meat matrix by finding the right and delicate balance of desirable product characteristics (Fig. 9.16).

Meat processing technology should never stop longing for better and more efficient methods. Creative solutions driven by spirited entrepreneurial individuals will remain the cornerstone of the ultimate co-extrusion system. The recent equipment improvements are truly a new beginning for an old dream to come true: perfecting sausage automation while improving the bottom line.

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Formulation Examples: Emulsified Meat Products

Wiener Franks (Canada)

Ingredient	%	%
Pork picnics	12.00	12.00
Pork jowls (no skin)	20.00	20.00
Pork fat	8.00	8.00
Beef heart	10.50	12.00
Pork skin (rinds) emulsion[a]	8.00	8.00
Beef connective tissue (1 mm)	8.00	8.00
Water	22.00	20.00
Salt	2.15	2.15
Curing salt (6.25% $NaNO_2$)	0.20	0.20
Sodium ascorbate[b]	0.05	0.05
Dextrose	1.00	1.00
Maize syrup solids	1.00	1.00
Soy protein isolate[c]	2.00	
Soy protein concentrate[c]		2.50
Potato starch	4.50	4.50
Seasoning	0.60	0.60
Total	100.00	100.00

[a]Skin emulsion: 10 parts of blanched pork skin (rinds); 1 part soy protein; 10 parts water; (2% added salt near end of chopping).
[b]Alternative: sodium erythorbate.
[c]High-gelling SPI or FSPC. (Note: the choice between SPI and FSPC is discussed in Chapter 2.)

Smoked sausage (USA)

Ingredient	%	%
Pork picnics	44.00	48.00
Beef meat 50CL	20.00	20.00
Turkey (mechanically deboned)	14.00	10.00
Water	15.00	15.00
Salt	1.80	1.80
Curing salt	0.20	0.20
Sodium ascorbate[a]	0.05	0.05
Maize syrup solids	1.50	1.50
Soy protein isolate[b]	1.50	
Soy protein concentrate[b]		1.50
Non-fat dry milk	1.50	1.50
White pepper	0.25	0.25
Marjoram	0.10	0.10
Nutmeg	0.10	0.10
Total	100.00	100.00

[a]Alternative: sodium erythorbate.
[b]High-gelling SPI or FSPC.

Procedure:

1. Grind fat meat to 8 mm and grind lean meat to 5 mm plate settings.
2. Add lean meat into mixer with salt, curing salt, and mix for 30 s.

3. Add water/ice and mix until 3 min have elapsed.
4. Keep temperature below 4°C.
5. Add soy protein and other dry ingredients, and mix until all free water has been absorbed.
6. Hold meat mixture in cooler overnight and final grind to 3 mm prior to stuffing or co-extrusion.
7. Smoke and cook schedule to a core temperature of 72°C.
8. Shower with cold water or brine.
9. Blast chill to 4°C.
10. Packaging and post-pasteurization.

Variety meat smoked sausage (USA)

Ingredient	%	%
Beef tripe (flaked/ground)	16.00	16.00
Beef head meat (flaked/ground)	16.00	10.00
Beef meat 80CL (pre-cured)	10.00	10.00
Beef heart emulsion[a]	10.00	10.00
Beef tongue	10.00	16.00
Pork meat 50CL (pre-cured)	10.00	10.00
Chicken (mechanically deboned)	10.00	10.00
Water	10.00	10.00
Salt	2.30	2.30
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Sodium ascorbate[b]	0.05	0.05
Maize syrup	2.30	2.30
Soy protein isolate[c]	2.30	
Soy protein concentrate[c]		2.30
Seasoning	0.90	0.90
Total	100.00	100.00

[a]Beef heart emulsion: (frozen) beef heart 75%; water 18%; soy protein 6%; salt + cure 1%; chop to 5°C.
[b]Alternative: sodium erythorbate.
[c]Use high gelling SPI or FSPC.

Procedure:
1. Pre-cure beef meat 80CL with salt and water. For example: 88% 16 mm ground beef + 7% water and 5% salt. Blend for 15 min and leave overnight to cure.
2. Pre-cure pork 50CL.
3. Add pre-cured pork in blender with water and soy protein. Mix for 5 min.
4. Add flaked ground beef tripe, head meat, tongue, seasoning and blend for 5 min.
5. Add chicken (mechanically deboned), pre-cured beef and heart emulsion; blend for 3 min.
6. Stuff in ring-shape natural pork casings 30/32 calibre or edible collagen casing and smoke-cook to 72°C IT. Shower with cold water and chill to 4°C.

Beef and pork Polish sausage

Ingredient	%	%
Beef meat 90CL	40.00	45.00
Beef navels 50CL	7.25	7.00
Pork trimmings 50CL	20.00	15.00
Water	25.00	25.00

Salt	2.00	2.00
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Phosphate	0.30	0.30
Soy protein isolate[a]	1.50	
Soy protein concentrate[a]		1.75
Maize syrup solids	1.50	1.50
Dextrose	0.75	0.75
Sodium ascorbate[b]	0.05	0.05
Mustard powder	0.75	0.75
Seasoning	0.75	0.75
Total	100.00	100.00

[a]Suggest high gelling SPI or FSPC.
[b]Alternative: sodium erythorbate.

Procedure:

1. Grind all meat through a 3 mm plate setting.
2. Add ground meat to blender, add (curing) salt + phosphate and mix for 30 s.
3. Add half the water/ice and mix for 3 min.
4. Add soy protein and mix for 3 min.
5. Add balance of water and mix for 2 min.
6. Add other ingredients and mix until a strong coherent meat matrix has been achieved.
7. Stuff or co-extrude in 30/32 mm cal. horseshoe-size shape.
8. Smoke and cook schedule to 72°C IT.
9. Shower with cold water or brine.
10. Blast chill to approximately 4°C.
11. Packaging and post-pasteurization.

Salchichas (Argentina)

Ingredient	%	%
Beef meat 90CL	32.00	28.00
Beef meat 75CL	4.00	4.00
Beef hearts	4.00	4.00
Pork trimmings 35CL	20.00	24.00
Water	26.00	26.00
Salt	2.20	2.20
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Sodium ascorbate[a]	0.05	0.05
Phosphate	0.30	0.30
Soy protein isolate[b]	3.00	
Soy protein concentrate[b]		3.00
Sweet dairy whey	1.00	1.00
Wheat starch	4.00	4.00
Dextrose	0.50	0.50
Oleoresin[c]	0.10	0.10
MSG	0.06	0.06
Sodium lactate	2.60	2.60
Liquid smoke	0.02	0.02
Carmine (3% carmine acid)	0.02	0.02
Total	100.00	100.00

[a]Alternative: sodium erythorbate.
[b]Use high gelling SPI or FSPC.
[c]Oleoresin blend of coriander, paprika, pepper, cardamom and garlic.

Procedure:

1. Mixer/emulsifier. Plate settings 1.2 mm.
2. Temperature out of emulsifier 22°C.
3. Stuff into cellulose casings.
4. Smoke and cook schedule to a core temperature of 72°C.
5. Shower with water or brine.
6. Chill to a temperature of approximately 4°C.
7. Packaging and post-pasteurization.

Vienesa (Chile)

Ingredient	%	%
Beef meat 85CL	20.00	20.00
Pork trimmings	20.00	20.00
Chicken (mechanically deboned)	20.00	20.00
Water	31.00	31.00
Salt	1.80	1.80
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Sodium ascorbate[a]	0.05	0.05
Phosphate	0.30	0.30
Soy protein isolate[b]	4.00	
Soy protein concentrate[b]		4.50
Sucrose	0.30	0.30
Sweet dairy whey	2.00	1.50
MSG	0.10	0.10
Oleoresin[c]	0.28	0.28
Liquid smoke	0.02	0.02
Total	100.00	100.00

[a]Alternative: sodium erythorbate.
[b]Use high gelling SPI or FSPC.
[c]Oleoresin blend of white pepper, onion, garlic, paprika, coriander.

Procedure:

1. Mixer/emulsifier. Plate settings 1.4 mm.
2. Temperature out of emulsifier 10°C.
3. Stuff into cellulose casings.
4. Smoke and cook schedule to a core temperature of 72°C.
5. Shower with cold water or brine.
6. Blast chill to approximately 4°C.
7. Packaging and post-pasteurization.

Smoked ring sausage (The Netherlands)

Ingredient	%	%
Pork shoulder meat	32.60	27.60
Pork jowls	13.20	18.20
Pork fat emulsion[a]	18.20	18.20
Water	30.40	30.40
Salt	1.90	1.90
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Sodium ascorbate	0.05	0.05
Phosphate	0.20	0.20
Encapsulated lactic acid[b]	0.40	0.40

Dextrose	0.40	0.40
Soy protein isolate[c]	2.00	
Soy protein concentrate[c]		2.00
Pepper	0.20	0.20
Mace	0.15	0.15
Coriander	0.10	0.10
Monosodium glutamate	0.05	0.05
Total	100.00	100.00

[a]Pork fat emulsion: pork fat 45%; water 45%; soy protein 8%; salt 2%.
[b]Encapsulated lactic acid to regulate desired pH level (slightly acid).
[c]Use high gelling SPI or FSPC.

Procedure:

1. Grind meat to 8 mm.
2. Chop meat, (curing) salt, phosphate for 20 s.
3. Add half the water/ice and chop to 3°C.
4. Add soy protein isolate and balance of water and chop to 5°C.
5. Add pork jowl and pork emulsion and chop to 10°C.
6. Add all remaining ingredients (not encapsulated lactic acid) and chop to 12°C.
7. Change to mixing speed and add encapsulated lactic acid.
8. Co-extrude or stuff into edible collagen casings, 34/36 cal. and shape into ring size.
9. Smoke and cook to a core temperature of 72°C, followed by cold water or brine shower.
10. Blast chill to 4°C.
11. Packaging and post-pasteurization.

Frankfurter sausage (USA)

	%		
Ingredient	30% fat	20% fat	10% fat
Beef trimmings 90CL	18.00	21.00	29.60
Beef trimmings 50CL	14.70		
Turkey trimmings 85CL		15.00	
Pork trimmings 75CL	15.50		20.60
Pork trimmings 50CL	23.80	26.10	
Water/ice	21.20	30.00	36.15
Soy protein isolate[a]	1.20	2.00	3.20
Salt	2.00	2.00	2.00
Phosphate		0.30	0.40
Nitrite[b]	0.01	0.01	0.01
Dextrose	1.00	1.00	1.00
Maize syrup solids	2.00	2.00	2.00
Sodium lactate			3.30
Sodium ascorbate	0.04	0.04	0.04
Oleoresin blend	0.01	0.01	0.01
Garlic powder	0.01	0.01	0.01
Onion powder	0.01	0.01	0.01
Seasoning	0.52	0.52	0.52
Food starch			1.15
Total	100.00	100.00	100.00

[a]Suggest low gelling SPI.
[b]140 ppm or substitute with appropriate amount of curing salt.

Fat-free hot dog (USA)

Ingredient	%	%
Pork lean knuckles	36.30	37.45
Soy protein granules[a]	17.15	15.00
Soy protein isolate[b]	2.00	
Soy protein concentrate[b]		3.00
Water/ice	33.90	33.90
Salt	2.00	2.00
Phosphate	0.40	0.40
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Maize syrup solids	2.00	2.00
Dextrose	1.00	1.00
Flavour and seasonings	0.30	0.30
Modified potato starch	1.50	1.50
Sodium lactate	3.30	3.30
Total	100.00	100.00

[a]Use soy protein isolate.
[b]Use high gelling SPI or FSPC.

Procedure:

1. Prepare isolated soy granule[a] in chopper, mixer/grinder.
2. Pre-grind meats 8 mm.
3. Add meat, salt, phosphate, curing agents and half of the water to the mixer.
4. Mix for 2 min and add soy protein isolate.[b]
5. Add isolated soy granules[a] and remaining ingredients.
6. Apply vacuum and mix 5 min.
7. Emulsify through 1.2–3.0 mm plates.
8. Stuff into desired cellulose casing.
9. Smoke and cook schedule to a core temperature of 72°C.
10. Shower with cold water or brine.
11. Blast chill to a temperature of 4°C.
12. Packaging and post-pasteurization.

Food service frankfurter (UK)

Ingredient	%	%	%
Pork meat 85CL	8.00	9.00	10.00
Pork head meat 75CL	22.00	22.00	20.00
Beef fat	8.00	8.00	8.00
Bacon trimmings	16.00	14.00	8.00
Chicken (mechanically deboned)	16.00	16.00	16.00
Water	16.00	16.00	22.00
Salt	2.20	2.20	2.20
Soy protein isolate[a]	2.00		2.00
Soy protein concentrate[a]		3.00	
Textured soy protein concentrate[b]			2.00
Curing salt (6.25% $NaNO_2$)	0.15	0.15	0.15
Phosphate	0.30	0.30	0.30
Potato starch	8.10	8.10	8.10
Sugar (sucrose)	0.50	0.50	0.50
White pepper	0.10	0.10	0.10
Ginger	0.20	0.20	0.20

Mace	0.20	0.20	0.20
Coriander	0.15	0.15	0.15
Smoke flavour	0.05	0.05	0.05
Sodium ascorbate	0.05	0.05	0.05
Total	100.00	100.00	100.00

[a]Use high gelling SPI or FSPC.
[b]Alternative: TSF.

Procedure:

1. Add pork meat, MDC, bacon trimmings and chop to low speed for a few revolutions.
2. Add (curing) salt, phosphate and chop for 15 s.
3. Add water/ice and chop to 3°C at high speed.
4. Add soy protein and chop to 6°C.
5. Add beef fat and chop to 10°C.
6. Add all other ingredients and chop to 14°C.
7. Pass through micro emulsifier < 18°C.
8. Fill into desired casing and thermal process to a core temperature of 72°C.
9. Shower with cold water or brine.
10. Blast chill to 4°C.
11. Packaging and post-pasteurization.

Canned Vienna sausage

Ingredient	%	%
Pork meat 65CL	12.00	12.00
Pork (mechanically deboned)	10.00	10.00
Beef 65CL	10.00	10.00
Pork jowls 30CL	18.00	18.00
Pork skin (rinds) emulsion[a]	18.00	18.00
Water/ice	18.60	18.00
Salt	3.50	3.50
Curing salt (6.25% $NaNO_2$)	0.20	0.20
Phosphate	0.30	0.30
Sodium ascorbate	0.05	0.05
Potato starch	5.70	6.00
Soy protein isolate[b]	3.00	
Soy protein concentrate		3.30
White pepper	0.10	0.10
Mace	0.20	0.20
Coriander	0.15	0.15
Smoke flavour	0.10	0.10
Onion powder	0.10	0.10
Total	100.00	100.00

[a]Skin emulsion: blanched pork skin (rinds) 47%; water 47%; soy protein 4.2%; salt 1.8%.
[b]Low viscosity SPI or FSPC.

Procedure:

1. Pre-blend all pre-ground meat, skin emulsion, half the water/ice, salt and phosphate for 3 min.
2. Add soy protein and balance of water and blend for 3 min.
3. Add all remaining ingredients and blend for 3 min.
4. Pass the meat mix through a multi-plate setting at 1.6 mm.
5. Fill in cellulose 18 mm casings.

6. Smoke and cook schedule to a core temperature of 68°C.
7. Chill with cold water or brine.
8. Fill into cans filled with brine and leave about 1 cm head room.
9. Sterilization.

Vienna hot dog (South Africa)

Ingredient	%	%
Turkey (mechanically deboned)	27.00	27.00
Pork back fat	7.00	7.00
Pork skin (rind) emulsion[a]	7.00	7.00
Pork fat emulsion[b]	10.80	10.00
Pork liver	1.00	1.00
Water	35.00	35.00
Salt	1.80	1.80
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Sodium ascorbate[c]	0.05	0.05
Phosphate	0.40	0.40
Tapioca starch	3.00	3.30
Soy protein isolate[d]	6.00	
Soy protein concentrate[d]		6.50
Guar gum	0.20	0.20
Pork flavour	0.10	0.10
Seasoning	0.50	0.50
Total	100.00	100.00

[a]Pork skin (rinds) emulsion: blanched pork skin (rinds) 47%; water 47%; soy protein isolate 4%; salt 2%.
[b]Pork fat emulsion: pork leaf fat 40%; water 50%; soy protein isolate 8%; salt 2%.
[c]Alternative: sodium erythorbate.
[d]Use high gelling SPI or FSPC.

Low fat frankfurter (Japan)

Ingredient	%	%
Pork meat 90CL	44.00	44.80
Turkey drum meat	11.00	11.00
Water	33.00	32.00
Salt	1.80	1.80
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Phosphate	0.30	0.30
Non-fat dry milk	1.00	1.00
Soy protein isolate[a]	2.00	
Soy protein concentrate[a]		2.20
Maize syrup solids	1.80	1.80
Dextrose	1.80	1.80
Garlic powder	0.01	0.01
Onion powder	0.02	0.02
Mustard powder	0.10	0.10
Seasoning	0.30	0.30
Sodium ascorbate[b]	0.02	0.02

Sodium lactate	2.70	2.70
Total	100.00	100.00

[a]Use high gelling SPI or FSPC.
[b]Alternative: sodium erythorbate.

Procedure:
1. Pre-grind all meat to 5 mm.
2. Add meat, (curing) salt, phosphate and approximately half of the water to a blender and mix for 2 min.
3. Add soy protein and other ingredients and mix until in total 4 min have elapsed.
4. Pass meat matrix through an emulsifier with 1.4 mm plate settings.
5. Fill in 26 mm diameter cellulose casings.
6. Smoke and cook schedule to a core temperature of 72°C.
7. Shower with cold water or brine.
8. Blast chill to 4°C.
9. Packaging and post-pasteurization.

Co-extruded frankfurter (Spain)

Ingredient	%	%
Chicken (mechanically deboned)	28.00	25.00
Beef trimmings 85CL	15.00	18.00
Pork spleen	5.00	5.00
Pork fat	5.00	5.00
Water/ice	33.25	33.25
Salt	1.80	1.80
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Phosphate STPP	0.30	0.30
Phosphate SAPP	0.10	0.10
Soy protein isolate[a]	3.00	
Soy protein concentrate[a]		3.00
Sodium ascorbate[b]	0.05	0.05
Dextrose	0.80	0.80
Seasoning	0.82	0.82
Onion powder	0.02	0.02
Garlic powder	0.01	0.01
Maize starch	1.50	1.50
Wheat starch	1.50	1.50
Potato starch	1.50	1.50
Sodium lactate	2.20	2.20
Total	100.00	100.00

[a]Use high gelling SPI or FSPC.
[b]Alternative: sodium erythorbate.

Procedure:
1. Pre-hydrate soy protein and water in a chopper or mixer to a 1 to 4 ratio.
2. Add all meat, (curing) salt, phosphate and balance of water and chop or mix until a strong binding matrix has been formed.
3. Add all other ingredients, including sodium ascorbate, food starches.
4. When chopped take the meat emulsion to approximately 14°C.
5. When mixed take meat mixture to approximately 10°C and pass through an emulsifier with 1.4 mm plate settings.
6. Thermal processing to a core temperature of 72°C.

7. Shower or chill with water and cool down to 4°C.
8. Packaging and post-pasteurization.

Coarse-ground smoked sausage (Japan)

Ingredient	%	%
Pork shoulder meat	53.00	55.00
Pork meat 70CL	14.00	14.00
Water	26.00	24.00
Salt	1.50	1.50
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Phosphate	0.35	0.35
Soy protein isolate[a]	3.00	
Soy protein concentrate[a]		3.00
Sugar	0.80	0.80
Sodium ascorbate	0.05	0.05
Beef extract	0.15	0.15
Seasoning	0.40	0.40
Lactose	0.40	0.40
MSG	0.20	0.20
Total	100.00	100.00

[a]Suggest low gelling SPI or FSPC.

Procedure:
1. Pre-grind half of the meat through a 5 mm plate, and the remaining half through an 8 mm plate.
2. Add chilled water to the chopper together with all ingredients. Upon completion of the brine, add the ground meat and chop for 3 min at mixing speed setting.
3. Transfer the meat mix to a blender and vacuum mix for 5 min.
4. Keep meat overnight at <6°C.
5. Stuff into natural or collagen casings or co-extrude.
6. Smoke and cook schedule to a core temperature of 72°C.
7. Shower with water or brine.
8. Chill to approximately 4°C.
9. Packaging and post-pasteurization.

Smoked sausage (China)

Ingredient	%	%	%
Pork shoulder meat	25.00	27.00	20.00
Pork trimmings 70CL	16.20	16.20	16.20
Pork fat	17.40	17.40	17.40
Water/ice	28.00	26.00	30.00
Salt	2.00	2.00	2.00
Curing salt (6.25% $NaNO_2$)	0.20	0.20	0.20
Phosphate	0.30	0.30	0.30
Soy protein isolate[a]	3.70		3.70
Soy protein concentrate[a]		3.70	
Textured soy protein concentrate[b]			3.00
Sugar	0.63	0.63	0.63
Dextrose	0.63	0.63	0.63
MSG	0.13	0.13	0.13

Sodium ascorbate[c]	0.20	0.20	0.20
White pepper	0.17	0.17	0.17
Ginger powder	0.06	0.06	0.06
Cardamom	0.02	0.02	0.02
Pimento	0.02	0.02	0.02
Garlic powder	0.02	0.02	0.02
Food starch	5.32	5.32	5.32
Total	100.00	100.00	100.00

[a]Suggest high gelling SPI or FSPC.
[b]Alternative: TSF.
[c]Alternative: sodium erythorbate.
Optional for additional shelf life: encapsulated lactic acid 0.1%; sodium lactate 3.3%.

Procedure:
1. Chop the lean meat with half of the water/ice, (curing) salt and phosphate to a temperature of –2°C.
2. Add balance of water and fat, and chop until 2°C.
3. Add soy protein, seasonings, sugar, and chop to 6°C.
4. Add food starches and chop to 10°C + add hydrated TSPC.
5. Vacuumize and stuff in collagen casing and smoke and cook schedule until a core temperature of 72°C has been reached.
6. Shower or chill with cold water.
7. Packaging and post-pasteurization.

Hot dog (Philippines)

Ingredient	%	%
Beef 85CL	20.00	20.00
Beef fat	9.00	9.00
Pork trimmings 65CL	20.00	18.00
Water/ice	36.00	38.00
Salt	1.50	1.50
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Sodium ascorbate[a]	0.05	0.05
Phosphate	0.30	0.30
Non-fat dry milk	1.00	1.00
Soy protein isolate[b]	2.50	
Soy protein concentrate		3.00
Carrageenan	0.50	0.50
Textured soy protein conc.[c]	2.00	2.00
Wheat flour	5.00	4.50
Seasoning	2.00	2.00
Total	100.00	100.00

[a]Alternative: sodium erythorbate.
[b]Suggest high gelling SPI or FSPC.
[c]Alternative: TSF.

Procedure:
1. Mix pre-ground meats 8 mm, (curing) salts, phosphate, water and dry added soy protein for 12 min.
2. Add pre-ground beef 3 mm and all other ingredients, including hydrated TSPC and blend for an additional 12 min.

3. Stuff in cellulose casings and follow desired smoke and cook cycles.
4. Shower with cold water and blast chill to 4°C.
5. Packaging and if desirable freeze or post-pasteurize.

Frankfurter

Ingredient	%	%
Pork meat 75CL	30.00	30.00
Pork jowls 50CL	12.00	12.00
Pork fat	12.00	12.00
Beef meat 90CL	12.00	12.00
Water/ice	26.00	26.00
Salt	1.60	1.60
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Sodium ascorbate	0.05	0.05
Non-fat dry milk	1.70	1.20
Soy protein isolate[a]	1.50	
Soy protein concentrate[a]		2.00
Pork flavour	0.20	0.20
Dextrose	0.30	0.30
Seasoning	0.50	0.50
Sodium lactate	2.00	2.00
Total	100.00	100.00

[a]Suggest high gelling SPI or FSPC.

Procedure:
1. Chop at low speed lean meats with salt and phosphate for 30 s.
2. Add half of the water/ice and chop to 2°C.
3. Add soy protein, non-fat dry milk powder and balance of water/ice and chop to 4°C.
4. Add pork jowls and pork fat and chop at high speed to 10°C.
5. Add remaining ingredients and chop to 14°C.
6. Fill into 22–24 mm casings.
7. Thermal processing and blast chilling to 4°C.
8. Packaging and post-pasteurization.

Salsicha (Brazil)

Ingredient	%	%
Chicken (mechanically deboned)	18.00	18.00
Turkey (mechanically deboned)	18.00	18.00
Chicken thigh meat	16.00	16.00
Turkey thigh meat	8.00	8.00
Beef trimmings 70CL	8.00	8.00
Pork jowls	8.00	8.00
Pork skin (rinds) emulsion[a]	8.00	8.00
Water	10.00	10.00
Salt	1.50	1.50
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Sodium ascorbate[b]	0.05	0.05
Phosphate	0.30	0.30
Potato starch	1.50	1.00
Soy protein isolate[c]	1.50	
Soy protein concentrate[c]		2.00

Seasoning	1.00	1.00
Total	100.00	100.00

[a]Pork skin (rinds) emulsion: water 40%; blanched pork skin (rind) 54%; soy protein isolate 5%; salt 1%.
[b]Alternative: sodium erythorbate.
[c]Suggest high gelling SPI or FSPC.

Food service salchicha (Mexico)

Ingredient	%	%
Chicken (mechanically deboned)	30.00	35.00
Pork hearts	4.00	4.00
Salivary glands	4.00	
Pork skin (rind) emulsion[a]	8.00	8.00
Beef trimmings 70CL	8.00	10.00
Textured soy protein concentrate	2.00	2.00
Water	30.00	28.00
Salt	1.60	1.60
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Sodium ascorbate	0.05	0.05
Phosphate	0.30	0.30
Soy protein isolate[b]	2.00	
Soy protein concentrate[b]		3.00
Modified potato starch	8.00	6.00
Dextrose	1.00	1.00
Seasoning	0.90	0.90
Total	100.00	100.00

[a]Pork skin (rinds) emulsion: water 40%; blanched pork skin (rind) 55%; soy protein isolate 4%; salt 1%.
[b]Suggest high gelling SPI or FSPC.

Procedure:
1. Add beef trimmings, mechanically deboned chicken, hearts, glands, phosphate, (curing) salt and half the water to chopper and take the temperature to 4°C.
2. Add balance of water and soy protein and take temperature to 8°C.
3. Add skin emulsion and all other ingredients, including starch and hydrated TSPC, and chop to 10°C.
4. Pass through emulsifier.
5. Stuff in cellulose casings and follow appropriate smoke/cook cycle.

Poultry roll (uncured)

Ingredient	%	%
Chicken breast meat	72.40	72.40
Chicken skin (1 mm)	5.00	5.00
Water	15.00	15.00
Salt	0.80	0.80
Phosphate	0.30	0.30
Soy protein isolate[a]	1.60	
Soy protein concentrate[a]		1.60
Sodium lactate	3.30	3.30

Poultry roll (uncured) (*continued*)

Ingredient	%	%
Non-fat dry milk[b]	1.00	1.00
Seasoning	0.60	0.60
Total	100.00	100.00

[a]Suggest high gelling SPI or FSPC.
[b]Alternative: sweet whey powder.

Procedure:
1. Grind chicken breast through kidney plate.
2. Add chicken breast, salt, phosphate and water to blender and mix for 2 min.
3. Add ground skin and mix until 3 min have elapsed.
4. Add soy protein and mix until 6 min have elapsed.
5. Add other ingredients, including sodium lactate, and blend until 10 min have elapsed.
6. Fill into PVDC or moisture-proof seamless fibrous casings and cook to a core temperature of 72°C.
7. Shower with cold water and chill to 4°C.

Turkey white and dark roll (uncured)

Ingredient	%	%
White turkey meat	36.00	36.00
Dark turkey meat	36.00	36.00
Turkey skin	10.00	7.40
Water	10.00	12.00
Salt	1.00	1.00
Phosphate	0.30	0.30
Dextrose	0.60	0.60
Soy protein isolate[a]	1.40	
Soy protein concentrate[a]		2.00
Non-fat dry milk[b]	0.80	0.80
Turkey flavour	0.10	0.10
Seasoning	0.50	0.50
Sodium lactate	3.30	3.30
Total	100.00	100.00

[a]Suggest high gelling SPI or FSPC.
[b]Alternative: sweet dairy whey.
Desinewed drum meat may be included in the dark meat portion. Dark meat may be chunked drumstick or thigh meat or trimmings. White turkey meat can include also scapula meat or breast meat trimmings.

Procedure:
1. Grind turkey skin through a 1 mm plate.
2. Grind turkey meat through a 3 cm plate.
3. Add ground turkey meats, salt, phosphate, water and mix for 2 min.
4. Add soy protein and blend for 2 min.
5. Add ground turkey skin and blend for 2 min.
6. Add all remaining ingredients, including sodium lactate and blend until 10 min blending time has elapsed.
7. Fill into moisture-proof fibrous casings or PVDC casing.
8. Cook to a core temperature of 72°C.
9. Shower with cold water and chill to a temperature of 4°C.

Polony sausage (South Africa)

Ingredient	%	%
Mechanically deboned chicken	22.00	30.00
Meat trimmings 50CL	22.00	22.00
Skin emulsion[a]	33.00	25.00
Water	11.00	11.00
Salt	1.80	1.80
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Soy protein isolate[b]	2.50	
Soy protein concentrate[b]		3.00
Maize starch	2.50	2.00
Potato starch	2.50	2.50
Sodium ascorbate	0.05	0.05
Phosphate	0.30	0.30
Guar gum	0.20	0.20
Seasoning	1.80	1.80
Carmine colour or Angkak	0.20	0.20
Total	100.00	100.00

[a]Pre-made emulsion: pork leaf fat 27%; blanched pork skin (rind) 27%; hot water 20%; soy protein isolate 4%; cold water 20%; salt 2%.
[b]Suggest high gelling SPI or FSPC.

French polony (Zimbabwe)

Ingredient	%	%
Pork 80CL	10.00	10.00
Mechanically deboned chicken	16.00	10.00
Skin emulsion[a]	10.00	15.00
Pork fat	20.00	20.00
Water/ice	30.00	30.00
Salt	1.70	1.70
Curing salt (6.25% $NaNO_2$)	0.20	0.20
Phosphate	0.30	0.30
Tapioca starch	2.50	2.50
Potato starch	2.50	2.50
Soy protein isolate[b]	5.00	
Soy protein concentrate[b]		6.00
Sodium ascorbate[c]	0.05	0.05
Non-fat dry milk[d]	0.90	0.90
Pepper	0.20	0.20
Onion powder	0.10	0.10
Garlic powder	0.05	0.05
Carrageenan	0.20	0.20
Paprika powder	0.20	0.20
Carmine colour	0.10	0.10
Total	100.00	100.00

[a]Skin emulsion: blanched pork skin (rinds) 47%; water 47%; soy protein 4%; salt 2%.
[b]Suggest high gelling SPI or FSPC.
[c]Alternative: sodium erythorbate.
[d]Alternative: sweet dairy whey powder.

Chicken bologna (USA)

Ingredient	%	%
Chicken (mechanically deboned)	90.00	85.00
Chicken skin		5.00
Water	5.80	5.80
Salt	1.50	1.50
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Phosphate	0.30	0.30
Non-fat dry milk[a]	0.60	0.60
Soy protein isolate[b]	1.00	
Soy protein concentrate[b]		1.00
Seasoning	0.60	0.60
Sodium ascorbate[c]	0.05	0.05
Total	100.00	100.00

[a]Alternative: sweet whey powder.
[b]Suggest high gelling SPI or FSPC.
[c]Alternative: sodium erythorbate.

Procedure:
1. Grind chicken skin to 1 mm or chop to fine paste.
2. Add mechanically deboned chicken to chopper or blender together with other ingredients, including soy protein and take temperature to 4°C.
3. Use emulsifier for fine emulsion appearance.
4. Stuff in a PVDC casing or moisture-proof fibrous casings and cook to a core temperature of 72°C.
5. Shower with cold water and chill to 4°C.

Olive loaf (USA)

Ingredient	%	%
Pork trimmings 75CL	40.80	40.80
Beef trimmings (3 mm)	11.70	11.70
Beef fat (3 mm)	5.80	5.80
Water	7.60	7.60
Salt	2.30	2.30
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Phosphate	0.30	0.30
Sodium ascorbate[a]	0.05	0.05
Soy protein isolate[b]	1.50	
Soy protein concentrate[b]		2.10
Non-fat dry milk powder[c]	1.60	1.00
Maize syrup solids	2.90	2.90
Dextrose	4.40	4.40
Sweet red pepper	6.10	6.10
Olives	14.30	14.30
Seasoning	0.50	0.50
Total	100.00	100.00

[a]Alternative: sodium erythorbate.
[b]Suggest high gelling SPI or FSPC.
[c]Alternative: sweet dairy whey powder.

Procedure:
1. Add ground lean meat into blender with (curing) salt, phosphate and mix for 30 s.
2. Add half of the water, soy protein and non-fat dry milk powder and mix for 3 min.
3. Add remaining water and fat, fatty meat, (rework if any) and blend for 3 min.
4. Add all other ingredients and seasoning (not vegetables) and blend for 3 min.
5. Emulsify through colloid mill and return emulsion to blender for final mixing with drained vegetables.

Meat base emulsion

Ingredient	%	%
Pork meat trimmings 70CL	34.00	28.00
Turkey (mechanically deboned)	34.00	28.00
Chicken skin (1 mm)	6.00	6.00
Beef or pork fat emulsion[a]		12.00
Water	20.00	20.00
Salt	1.60	1.60
Curing salt (6.25% $NaNO_2$)	0.20	0.20
Phosphate	0.30	0.30
Sodium ascorbate	0.05	0.05
Soy protein isolate[b]	2.00	
Soy protein concentrate[b]		2.40
Non-fat dry milk	0.40	
White pepper	0.15	0.15
Mace	0.10	0.10
Ginger powder	0.10	0.10
Onion powder	0.10	0.10
Dextrose	1.00	1.00
Total	100.00	100.00

[a]Pre-emulsion: 5 parts of hot water; 1 part of soy protein isolate; 5 parts of beef or pork fat; (2% salt addition during last few revs of chopper).
[b]Suggest high gelling SPI or FSPC.

Procedure:
1. Chop meat, (curing) salt, phosphate at low speed for 30 s.
2. Add water/ice and chop to 3°C.
3. Add pre-made emulsion, all other ingredients and chop to 12°C.
4. Use this base emulsion for a wide range of speciality cooked emulsified or semi-coarse meat products.

Dutch fricandellen (extruded) (The Netherlands)

Ingredient	%
Beef trimmings 70CL	13.00
Beef head meat	10.00
Chicken (mechanically deboned)	10.00
Pork skin (rind) (blanched)	6.00
Pork fat emulsion[a]	10.00
Pork back fat	10.00
Pork jowls	10.00
Water	13.00
Salt	1.60
Curing salt (0.6% $NaNO_2$)	0.15

Dutch fricandellen (extruded) (The Netherlands) (*continued*)

Ingredient	%
Sodium ascorbate	0.05
Soy protein isolate[b]	2.00
Egg white	3.00
Dextrose	1.50
Rusk (bread crumbs)	5.00
Wheat starch	4.00
Onion powder	0.20
Garlic powder	0.05
White pepper	0.10
Chilli pepper	0.05
Coriander (ground)	0.10
Ginger	0.05
Nutmeg	0.05
Monosodium glutamate	0.10
Total	100.00

[a]Pork fat emulsion: pork fat 45%; water 45%; soy protein 8%; salt 2%.
[b]Recommend high gelling SPI.

Procedure:
1. Add all meats, blanched pork skin (rinds), curing salt, phosphate and soy protein to chopper.
2. Chop for 30 s at low speed.
3. Add water/ice and chop at high speed for 2 min.
4. Add pre-made pork fat emulsion, pork jowls, pork back fat and egg white and continue chopping until approximately 12°C.
5. Change to low chopping speed and add all remaining ingredients. If possible, pull vacuum.
6. The meat batter is extruded into 20–25 cm lengths at a diameter of 2.5 cm.
7. Immediately after extrusion, the skinless 'sausages' are cooked in a continuous water-filled tunnel conveyor. Cook to 72°C IT.
8. Freeze.

10
Meat Patties

The hamburger patty, a true American classic created in the early 1900s, has become the world's most loved processed meat product. The original patty was simply ground meat, and the palms of the hands were the forming device. The real breakthrough came when fast food restaurants designed an intriguing sandwich, which became the first finger food. Some people say that the hamburger is America's greatest contribution to the world's gastronomy.

It is generally agreed that the modern version of the hamburger sandwich first appeared at a County Fair in 1892 in Akron, Ohio. The original hamburger patty dates back to medieval times in Russia. During those years, Tartar people living in the Baltic States considered it a luxury to eat ground raw beef patty seasoned with salt, pepper and onions. The crews of German trading ships brought this culinary delicacy back to their home port Hamburg, where the German version moved the product a step closer to how it is known today by broiling the patty just long enough to get a crispy outside while maintaining a rare, red appearance on the inside.

The early German immigrants brought the hamburger to the USA in the early 19th century. In the late 1880s, the British had their own version of a raw hamburger, which became world-renowned during the Victorian era under its name Salisbury steak. The steak was named after a British physician James H. Salisbury, who advised his patients to eat this 'health food' three times a day to cure a number of illnesses, including gout and hardening of arteries. The Americans perfected the hamburger patty, and they can truly claim that they thought of combining the broiled beef patty with a bun. It is widely believed that the first fully formed hamburger, a bun filled with beef and various condiments, made its debut at the St Louis Fair in 1904. A classic was born.

Hamburger patties have since become nothing less than a staple food for many countries. In the last few years a definite change in conceptual thinking, stimulated by the need to satisfy regional preferences, optimization of food costs and food safety concerns, has given new challenges to food designers to address these needs. However paradoxical it may sound, increasingly the dogmatic 100% meat specifications by the world's leading fast food companies are being relaxed to allow the achievement of these objectives, including creation of special flavouring and textural requirements. For many years the fast food industries had a rather dogmatic attitude toward product formulations and were more comfortable with old problems than with new solutions. The fast food operators now have been placed under the consumer's microscope for price/value considerations, nutritional well-being and a growing desire for new flavour combinations.

Optimizing Variables

It seems so simple, yet in reality it is rather complicated to master all the variables of

Fig. 10.1. Drawing of grinding head. Source: Convenience Food Systems (CFS).

processing meat into good-tasting patties. Meat patties are made from all meat sources and are manufactured in many different sizes, weights and shapes. Hamburger patties are the most popular and it is estimated that their consumption represents slightly more than 50% of the world's total beef consumption. Other meat species are also finding their way into further processed patties. Given its wide scope, readers should realize this overview is only a prologue to further processing technologies for meat patties, including nutritional, cultural and cost considerations.

The variables that affect the sensory properties of meat patties are manifold: genetics, age, pH, carcass cuts, grindsize, the presence of non-meat ingredients, the forming system and pressure, freezing and cooking methods. Some of these variables can be controlled; others are subject to frequent change. It is important that all parameters are optimized so that variables in product specifications can be adequately managed. Patty formulations, including the influence of added soy protein ingredients, need to yield a uniform product with consistent shape retention and texture. Formulation and further processing equipment interactions are especially important for uncoated coarse ground products.

Frozen or fresh primal cuts and trimmings of meat are run through an initial grinding plate (Fig. 10.1) and emptied into a ribbon or paddle blender, followed by an analysing step for fat content. Preferably, the grinding equipment should have an automatic sorting device, which helps to achieve major improvements in product quality by continuously pre-sorting the meat being ground, removing gristle, sinews and pieces of bone and ejecting them before the ground meat goes on to the next stage in the line. The specific batch parameters depend on customer specifications. After blending has been completed, the meat mixture is passed through a second or final grind. A rather innovative way to reduce frozen meat to proper size is the automince system, which actually first breaks down the frozen meat block into subsections, followed in-line by a grinding action of the same equipment to the desired particle size, including the removal of bones and connective tissue material. This process can be completed with minimal increase of temperature (Fig. 10.2).

During forming, the raw and ground meat is fed from the supply hopper to the filling mechanism. Product temperature is constantly measured and the supply pressure adjusted to ensure consistent filling. The filling system ensures that product structure, integrity and texture are maintained. Once filled, the formed product moves to the knock-out station where it is placed on the discharge belt. Ideally, belt speed and all other line components are adjustable, allowing optimal integration into the production line (Fig. 10.3). The two most commonly used forming methods for

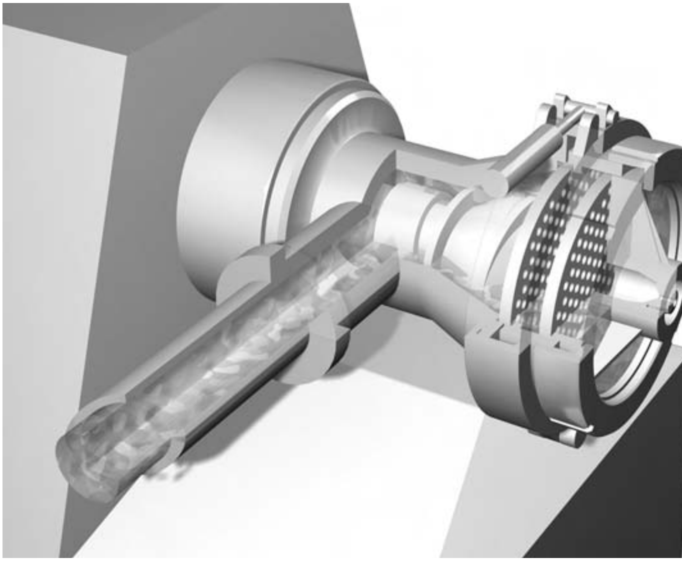

Fig. 10.2. Drawing of a frozen meat block grinder. Source: Convenience Food Systems (CFS).

patties include one that is comprised of a series of vertical columns of meat strands, and another in which a fill system horizontally layers the meat. The density, amount of fat and presence of functional non-meat ingredients will ultimately determine the cooking or grilling speed and exert control over sensory properties. However, in general, it can be observed that a vertical strand filling allows the heat to penetrate more easily and evenly compared with the horizontal fill. Nevertheless, the forming system

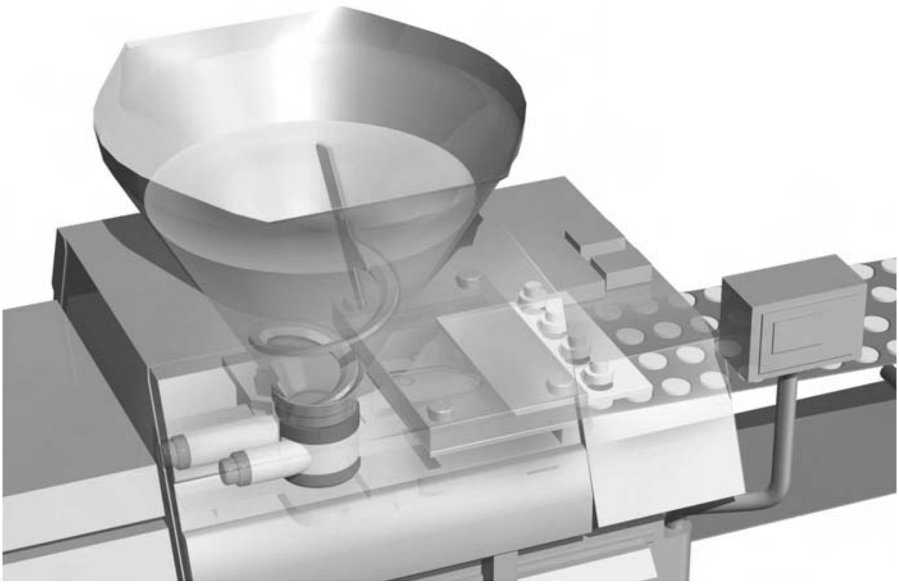

Fig. 10.3. Drawing of a fully automated forming machine. Source: Convenience Food Systems (CFS).

Fig. 10.4. Photo of a high capacity meat forming machine. Source: Convenience Food Systems (CFS).

remains one of the many variables for manipulating desired product characteristics (Fig. 10.4).

Cooking Variables

Since most meat patties are cooked, grilled or fried directly from the frozen state, product safety has become a major issue. From the time carcass meat is chilled and throughout the manufacturing process of the ground patties until cooking or grilling, there are no steps that will kill the pathogens that still may be present in the raw blended, ground and formed meat. Especially in the USA, fast food restaurants are known to overcook hamburger patties, just to be on the safe side and avoid microbial risks. Though consumers appreciate the fully cooked appearance, the same consumers complain bitterly about dry hamburger patties. They want juiciness and flavour, something that has been missing for a number of years, as the speed of restaurant operation has increased without paying much attention to changing sensory parameters. This has become a serious issue for the operators, and it is just a matter of time before formulated meat patties that address consumer needs are introduced.

Overcooking of meat patties on a grill can raise levels of chemicals known as amines, which have been linked to cancer in animals. Amine compounds are formed at high temperatures. Therefore the trick is to cook the meat patties at temperatures that kill bacteria without raising the risk of amine formation. A possible solution is to flip or turn the patties frequently; this will speed up the cooking time while reaching the desired 71°C internal temperature, and also reduce the accumulation of chemicals that may pose some long-term health risks such as cancer.

The degree of readiness, unfortunately, is still mostly based on organoleptic observations rather than on technology and science. There is little doubt that the cooking colour of meat patties is an unreliable indicator to determine the degree of readiness.

Even if the set core temperature has been reached, a patty still might show a pink colour. Pinking can also be caused by nitrogen dioxide when patties are cooked in a gas oven. It is also known that prolonged frozen storage increases the occurrence of pinkness of extra-lean patty formulations.

The reverse is also true and a patty can show a fully cooked appearance (greyish colour) but still carry microbes that cause food-borne diseases. The main risk however, is premature browning. Premature browning occurs when thin-formed patties, such as 10:1 patties (45 g), have a premature transition from myoglobin oxidation to metmyoglobin at temperatures as low as 55°C.

The pH of meat also has specific effects on cooked patty meats. Electrically stimulating meat, especially beef, hastens rigor and subsequently a more rapid drop of pH. Though meat with a pH>6 usually has good binding properties, such meat will retain its native myoglobin colour when heated, and is more prone to microbial spoilage. At this pH, the colour does not always denature at a given temperature, and therefore meat of pH>6 can have a fixation effect on colour attributes. It is known that as animals age, tissue myoglobin increases, which potentially influences the amount of oxidized myoglobin. Also, when steer meat is used, more pink-coloured patties appear (a steer is a male bovine castrated before it sexually matures).

All these variables can give patties the physical appearance of pinkness, while in fact they are fully cooked. It can be hypothesized further that these situations would occur more frequently when a clamshell grill is used, where anaerobic conditions prevail. It also seems plausible that the freezing system that determines the size of ice crystals and the meat formula plays a decisive role in the thermal destruction of microbes during cooking. Freezing meat always has a negative influence on quality, due to mechanical damage of muscle fibres and the reduction in the solubility of myofibrillar proteins (Fig. 10.5).

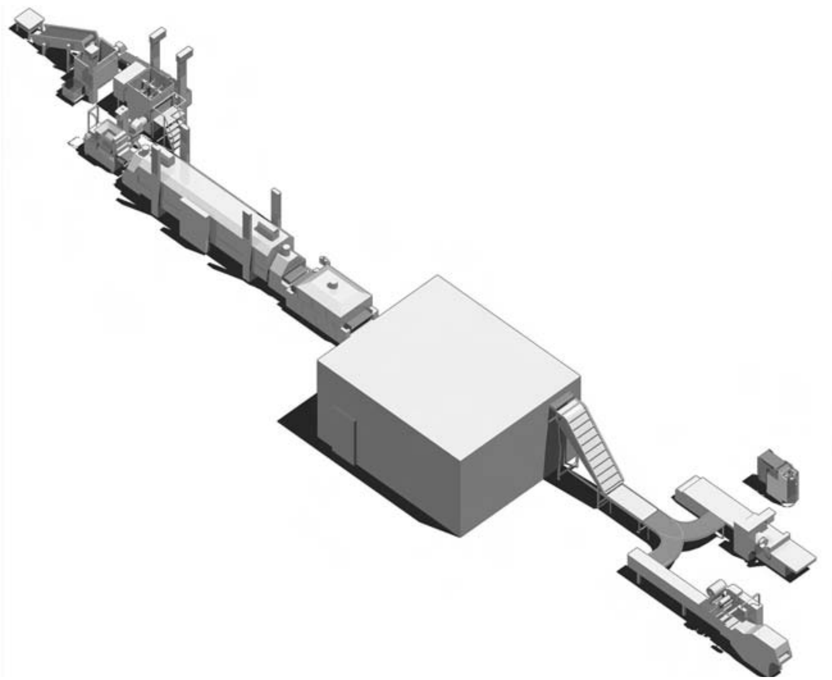

Fig. 10.5. Schematic overview of a fully automated line set-up for fully cooked, frozen burgers. Source: Convenience Food Systems (CFS).

Freezing Impact

Once the meat is standardized for fat content and blended to its desired formula, it is final ground, tempered and formed into the desired shapes and sizes. A fast freezing rate is preferred because smaller ice crystals are formed within the muscle fibre, which also supports minimal water movement from the sarcoplasm to the extracellular spaces. The use of functional soy protein ingredients can actually manipulate variables, especially when the meat patties are made from previously frozen meats that need to be refrozen.

It is well known that freezing meat results in varying degrees of tissue damage caused by ice crystal formation. During cold storage, small ice crystals can recrystallize into larger crystals, causing loss of water-holding capacity and general loss of functionality. A faster drop in temperature during freezing causes less water movement. Myosin fibres in particular can be damaged during slow freezing, leading to formation of larger ice crystals, and because of the resulting meat protein denaturation, a drier and tougher texture.

As a side note, there are contradictory reports on the influence of thawing, but as a general rule it can be stated that quick-frozen meat patties should be fast-thawed, and slow-frozen patties slow-thawed. These empirical observations can be directly translated into the ideal temperature settings and cooking times on a flat grill or oven by calculating the rate at which ice transforms into steam and the rate of the melting of the fat, which influences sensory and safety parameters. For these reasons, small ice crystals, uniformly distributed throughout the ground meat system, together with relatively small fat particles, will promote fast and effective heat transfer during the cooking process.

Individual quick-frozen (IQF) meat products have been successfully used in meat processing for many years. They date back to the 1920s, when fruits and vegetables were frozen at temperatures of –28°C to –40°C. Since the 1960s, cryogenic freezing has become an option, achieving temperatures down to –150°C. Cryogenic systems such as spiral and tunnel freezers and fluidized bed freezing primarily use liquid nitrogen and carbon dioxide. However, mechanical or conventional freezing still plays a major role in IQF processed meat products, especially for large-volume applications. Mechanical or blast freezing systems can not only increase dehydration, but may also drive out taste and aroma. Impingement cryogenic tunnels provide the lowest dehydration rates, while locking and stabilizing meat aromas.

Cryogenic systems have certain advantages and disadvantages when compared to conventional systems. The advantages include:

- increased moisture retention;
- smaller foot print of freezing equipment;
- faster cooling and hence smaller ice crystals;
- faster freezing.

The major disadvantage of cryogenic freezing is the costs associated with the nitrogen and carbon dioxide gases. Also volume throughput can be an obstacle.

Fat Variables

There is little doubt that the percentage of fat is related to the perceived juiciness and mouthfeel. Despite the existing technologies used to reduce the fat content of meat patties to <10%, consumers continue to prefer patties with a fat content ranging from 15% to 25% for beef, and 25% to 40% for pork (Table 10.1). Mutton patties popular in the Middle East usually have a fat content ranging from 10% to as much as 30%, with the fat content determined by the origin of the mutton meat. Mutton patties are nearly always formulated to include the use of (hydrolysed) vegetable protein, spices and seasoning and some water to allow flavour diffusion.

Uncoated chicken patties are traditionally low in fat (<10%), but the lack of fat probably hinders wider acceptance because of the perceived dryness. Problems arise

Table 10.1. Calorie calculations of formulated meat patties.

	g/100 g	kcal/100 g	% of calories
Patty 20% fat			
Protein	18	72	29
Fat	20	180	71
Patty 10% fat			
Protein	19	76	46
Fat	10	90	54

Table 10.2. Melting points of fat.

Poultry	30–38°C
Pork	36–45°C
Beef	41–48°C

when thin meat patties such as the 10:1 weights (45 g each) have high inclusion levels of fat. During cooking or grilling, the unstable fat simply flows out and holes appear. For fat loss to occur in a meat patty, the first requirement is that at some stage during grinding the fatty tissue cells are broken and the fat is released. Following processing, forming and freezing, the fat-releasing processes accelerate at increasing temperatures on the grill, and are especially strong under anaerobic conditions (Table 10.2).

To a large extent, the factors controlling fat loss operate independently of those controlling water losses. There are quite a few variables that influence the degree of fat loss, including type of grinder, sharpness of the plate and knives, temperature of the fat and anatomical origin of the fat. Besides these variables, it can be observed that smaller fat particles usually increase fat losses during cooking. This can often be seen with thin meat patties that have extraordinary weight (fat) loss during thermalization. As the fat content of ground meat decreases, the perception of flavour, juiciness and tenderness decreases proportionally.

Another variable that influences the loss of fat during cooking or grilling is the specific type of fat. In general, it is true that the harder the fat, the greater the cooking loss. Softer fat cells are more pliable and thus better able to avoid damage. Also, the specific temperature influences the degree of fat cell damage. Cold temperatures will usually provide clear, clean cutting, thus reducing the friction that usually decreases fat loss during cooking. Apart from previously discussed attributes, the size of meat particles and method of size reduction also influence the texture of formed ground meat patties. The particle size of ground meat patties usually varies from 3 mm to as small as 1 mm. As a general rule, the lower the specific skeletal quality of the meat, the smaller the grind sizes. By decreasing fat levels, it has been shown advantageous to slightly increase the grind size to about 5 mm.

Consumer Taste Preferences

Designing outstanding meat patties may look easy at first, but in fact changing environmental conditions often challenge the ingenuity of the food formulators. Apart from the previously mentioned issues, variables such as processability, shelf life, cooking tolerance, holding time and, most of all, food costs in relation to nutritional value and consumer acceptance are parameters that will require close monitoring.

With changing environmental conditions, the use of functional non-meat ingredients in formed meat patties has evolved from simply food cost reductions to a technological necessity for accomplishing sensory preferences. Only recently have pertinent product requirements, such as the desire for fully cooked and atmospheric-packed beef patties, prompted innovative researchers to think outside the box and come up with answers on issues that never had been addressed before. Even just a few years ago, reformulating projects often encouraged food technologists to reformulate merely by adding water and a binder. Quite often these reformulations did not address the ethical responsibilities of food marketers to consider nutrition in the widest sense of the word. Now, food designers and the fast food industry increasingly realize their social/ethical responsibilities in maintaining or improving upon nutritional needs. Consumers who buy basic foods deserve optimum quality and quantity of superior protein, together with maintenance of vitamins and minerals. This is especially true for these groups in society such as young adolescent females and other at-risk groups that are often confronted with deficiencies of protein, iron and calcium that can cause health-related problems such as anaemia and osteoporosis. It is important that the new generation of reformulated meat products meets desired nutritional requirements, and these descriptors should be clearly communicated.

The fast food industry is caught between pleasing the consumer by feeding America's 'fat' tooth, or taking out calories and offering healthy sandwich versions. There seems to be a paradox in the rather schizophrenic behaviour of what consumers say they want and what consumers actually like to eat. People, so it seems, like full flavour and indulgence when their mind set is fast food! Rather than scaling down calories and improving upon nutrition, the sandwiches are getting higher, wider and thicker, and are loaded up with high-fat meat, cheese, bacon and mayo. One sandwich typically provides 25% to as much as 33% of the total daily calorie need, and about 50% of the recommended daily intake of dietary fat – not counting the fries and the empty calories of the soft drinks.

Additionally, the American fast food giants are increasingly confronted in foreign countries with issues surrounding their Westernized menu choices. There will come a point at which they have to address the phenomenon that after an initial acceptance by local consumers, regional taste preferences are not necessarily in synch with the beliefs of corporate headquarters.

Despite the hallmark position of US-style hamburgers and chicken patties, the global fast food companies have now realized they have to cater to local markets to sustain a healthy business. Using the strength of a global brand, increasingly non-core products find their way on to the menu, and often these foods outsell the classical core products. Developing dishes that please local tastes is the only logical way to offer affordable, nutritious, tasty foods, while continuing quantitative growth.

With the proliferation of US-dominated fast food choices in mind, it can be reasoned that food formulators and the fast food industry have an ethical and socio-economic responsibility to provide optimum nutrition in their reformulated meat products on the menu. This is especially critical in cases where fast food marketers offer water-added meat and poultry products, including vegetarian alternatives, which unfortunately all too often contain added filler starches to immobilize water.

Functional Ingredients

Technologically speaking, the ease and convenience of utilizing functional soy protein ingredients in both fully automated continuous processing systems and batch-processing systems should be mentioned. These types of vegetable proteins are available in varying gel strengths, enabling processors to fine-tune product characteristics.

The issue of which type of soy protein to select depends largely on the method used to incorporate the functional ingredients into the pre-ground meat mix. In the simplest form, a relatively small inclusion level (1–2%) is added to the pre-ground meat together with the formula water. It is important that the added soy protein be fully hydrated before adding cryogenic additives that will temper the pre-ground meat to allow a proper forming temperature before the meat is finally ground. In more complex coarse ground meat formulations it is often beneficial to combine the use of powdered soy proteins and textured soy proteins. The influence of salt and phosphate, if desired, in conjunction with mixing/blending, can control and correct product density, weight and sensory properties, including texture. The addition of salt promotes the release of salt-soluble myofibrillar proteins, but at the same time its presence increases oxidative activities, often leading to rancidity.

On the other hand, phosphate, which boosts the effects of salt on the salt-soluble protein (SSP) extraction, can be viewed as an anti-oxidant. It is believed those lipid and myoglobin oxidations are closely related. Phosphates inhibit lipid oxidation by acting as chelators of free metals, especially iron, and/or by increasing pH. These two additives can markedly change the sensory characteristics of the meat patty.

As a rule of thumb, the higher the formula's content of meat of lesser skeletal quality, the greater the need for salt and phosphate additions. The percentage and the timing of the added functional ingredients can regulate both the texture and the tightness of the patty. For example, if a tighter texture is needed, salt and phosphate should be added early on during the blending. If a more open texture is required, salt and possibly phosphate should be added towards the end of the blending.

Textured soy proteins are specifically designed for use in ground meat systems and these particulates are available in many sizes, colours and shapes. For maximum replacement of premium lean meat sources, the use of (patented) soy protein granules is still a formidable option. However, increasingly there are processing situations and cost considerations where combinations of textured soy protein together with functional soy protein deliver advantages as well. The combined use of powdered soy protein and hydrated textured soy protein can provide better texture and flavour in a meat patty than either ingredient alone. A good starting point is the addition of 2–3% functional soy protein and 3% textured soy protein concentrate (TSPC) concentrate, equalling 10% on a hydrated basis. Hydrated texturized soy protein concentrate at an inclusion level of 4% can be used as a fat replacement in ground meat patties. This is due to its moisture and fat-binding properties, while its inclusion also increases cooking yield, fat and moisture retention and resistance to directional shrinkage.

When selecting textured soy protein there are product variables to consider:

- Colour: uncoloured (tan); light caramel colour; caramel colour; red/brown colour.
- Sizes: Ranging from 1 to 25 mm. Use a particle size that is larger than the final particle size of the finished meat patty *after* final grind. If no final grind after blending is required, then the textured soy protein needs to match the grind-size of the meat particle.
- Hydration: The ratio of water:extruded protein for TSPC in cold water is 2:1 up to 3:1. The ratio of water:extruded protein for TSPC in hot water is 3:1 up to 4:1. For some applications, such as meat patties, it is recommended to purposely under-hydrate the TSPC or TSF. In these cases, the under-hydrated textured soy protein can absorb the fat and moisture that is released during contact frying of the patty.
- Texture: Calculated on an as is basis, the protein content of TSF is on average 52% and of TSPC 65%. Technologically speaking, in most coarse ground meat applications, TSF and TSPC perform in a very similar manner. The hydration ratios are also very close. However, it is true that TSF will show a stronger soy flavour, which might intensify over prolonged storage. Therefore seasoning adjustments might be necessary.

Textured soy protein concentrate (TSPC) and functional soy protein concentrate or isolate reduce cooking losses and dimensional shrink in meat and poultry patties.

Fig. 10.6. Soy protein formulated beef patties for branded fast food service operators. Source: P.H. Hoogenkamp.

These two types of protein ingredients can provide superior interactions for most coarse ground further-processed meat and meat analogue foods (Fig. 10.6).

Antioxidative Impacts

A related dilemma in this respect is the presence of additives or functional ingredients that can shorten or prolong shelf life. Globalization, leading to longer transport lines and storage times, and the growing need for a 'clean and green' label, has created renewed interest for natural ingredients on the declaration label.

Oxidation promotes rancidity, and thus will shorten shelf life. This is true for both raw frozen patties and semi- or fully cooked patties. The pro-oxidative properties of salt, therefore, limit its inclusion level to <0.8%. These levels are below the threshold for promoting development of rancidity, yet are high enough to contribute to improved meat flavour and texture. Encapsulated salts could serve a useful purpose here.

On the other hand, there are a few natural additives and functional ingredients that have antioxidative properties. Apart from the antioxidative properties of phosphate, an inclusion level of <0.3% is usually quite sufficient. Soy protein isolate can also serve as a functional ingredient for delaying the onset of rancidity. The antioxidative properties or 'scavenging' actions of soy protein isolate in particular have been attributed to polyphenolic acids and isoflavones because of their ability to inhibit free radical reactions.

It has been demonstrated that the addition of 1–2% of these proteins can increase the shelf life by as much as 20% when compared with a control without the soy protein isolate. A similar claim can be made using ground peppers, dried prune paste and lycopene-enriched tomato products added to meat patties. These compounds delay and significantly inhibit the oxidation of both myoglobin and lipids, as well as the growth of psychotropic bacteria. This results in improved meat colour and odour, while also extending shelf life.

Blending, Forming and Freezing

Most meat patties are cooked directly from the frozen stage. It is generally accepted that the greatest freezing damage to meat patties translates into loss of texture and juiciness. Additionally, rancidity oxidation, causing off-flavour development, might influence other organoleptical properties. Soy protein formulated meat patties offer the advantage of minimizing freezing damage. It is important to understand the relationship between processing methodologies like freezing and functional ingredients. Often neglected, freezing can cause many irreversible physical and chemical changes within the meat patty composition. The typical formulated meat patty has at least a dual influx of freezing conditions, though often, if pre-frozen meats are used, the finished patty might be frozen and refrozen as many as three times: carcass freezing; formulation N_2 or CO_2 snow to allow proper forming; and final patty freezing. It is important to be aware of these variables because they can severely impact on quality variables.

Freezer and/or chilling burns occur when solution concentration damages organoleptic parameters due to formation of ice crystals and the subsequent change in concentration of the solution inside the frozen molecules. For example, the presence of salt in formulated meat patties can trigger increasing ionic concentrations that can damage the meat patty and its intermediate binding matrix, damage that is often irreversible. The same is true for freezing dehydration, which causes an osmotic transfer of water from the meat fibre interior to the exterior.

Freezing can also cause mechanical damage to cell membrane structures. As ice crystals continue to grow, they can penetrate into the fat, which can cause stability problems and excessive fat loss when the patty is thawed and cooked on a flat grill. Freezing deterioration can be caused either by chemical or physical changes. The advantages of rapid freezing are less drip loss when the patty is thawed and improved texture and juiciness.

During frozen storage, the number of ice crystals will slowly be reduced and thus the average size of the ice crystal increases. To improve product quality, it is important to aim for the formation of smaller sized ice crystals. Crystal growth due to slow freezing, recrystallization and/or insufficient freezing holding temperatures can inflict serious damage to the organoleptic properties of a meat patty. The presence of non-meat ingredients in formulated meat patties might also promote water or moisture migration. This is especially true if salt and phosphate are added, because that tends to move water toward the surface of the meat patty. This is the reason some meat patty manufacturers glaze or spray a moisture vapour on to the surface of the patty to compensate for freezer loss and to prevent surface drying.

Freezing yields also need to be considered. Airblast freezing in a static tunnel leads to about 4–5% dehydration. In-line spiral freezers have about 2% yield loss, while impingement freezers have the lowest dehydration losses for meat patties at 0.5–1.0%.

The degree of drip loss in meat used for patty formulations is well known. The amount of drip loss is not only influenced by the length and temperature of freezer storage and thawing method, but also by the processing equipment, such as sharpness and design of the grinding blades. An added non-meat protein ideally compensates for drip loss, though it is important that the right blending sequence is followed to ensure optimum migration of the protein solution into the meat membrane. Once the meat mix has been formulated, temperature variations and residence time at the production floor should be minimized.

Total mixing/blending time is dependent on the degree and complexity of the reformulating, but seldom lasts more than 5 min. Cryogens such as liquid nitrogen (N_2) or carbon dioxide snow (CO_2) can influence forming performances considerably. Both over-use and under-use of cryogens can create sub-optimal conditions, causing deformation, rejects and increasing manufacturing costs.

There are some noticeable differences between N_2 and CO_2. Nitrogen has the tendency to chill faster and more evenly, thus reducing the chance of the infamous little pocket formations. The latter is especially apparent in poultry patties that contain skin. It has been reported that the use of CO_2 slightly improves microbial conditions, and thus greater safety margins are obtained.

The right degree of tempering is important for both cost control of cryogens and for obtaining the ideal forming temperature. In almost every case, the meat needs only to be partially frozen to form. Over-use of cryogens not only increases final costs but also influences patty shape control. The newer designs of blenders allow cryogens to be injected from the bottom, thus eliminating or reducing loss of cold air through the top vents. However, the bottom line is the cost of the cryogen, and that does vary considerably between countries.

Most meat processors have empirical

knowledge that failure to properly temper meat during blending and final grinding not only causes severe shape definition problems, but that insufficient temperature control leads to dehydration, cellular damage, yield loss and discoloration. However, it is less well known that those fresh and previously frozen meats have different behavioural properties when mixed and formed, and that adjustments need to be made depending on the actual percentage of the meat. Even when temperatures remain constant at 0°C, the water's state can change and ultimately influence forming quality and characteristics. Therefore, for reformulated formed ground meat products with a relatively high inclusion level of fresh meat, it is usually necessary to chill the meat one or two degrees colder.

The knockout cups of a patty former should be tightly set in order to minimize excessive sheer and temperature increase. The growth of microorganisms does not take place at temperatures of 8°C or lower. This temperature is significantly higher than forming temperatures. Yet it is important to consider the microbial quality of the meat patty prior to freezing, since a lower initial count will lead to a longer shelf life under frozen conditions. Most probably this difference is due to bacterial enzymes. CO_2 and N_2 inhibit growth of many bacteria, moulds and yeast and also inhibit oxidative rancidity, thus minimizing degradation reactions and delaying the onset of off-flavours. Therefore, the four main variables to consider are lower processing temperatures, lower storage temperature, shorter storage time and a close-fitting packaging system.

It often can be noticed that when formed and frozen meat patties are made, the surface colour becomes rather dull and unattractive. This phenomenon is caused by very rapid freezing, and may be corrected, if necessary, by using infra-red heaters to slightly thaw the surface of the patty before refreezing at a slower rate. Also a slight water-spray after initial freezing may enhance the desirable red colour of beef patties. For uncoated poultry patties, rapid freezing actually improves the consumer appeal, since it creates the much-wanted white surface colour.

Many formulated meat patties contain seasonings and flavourings. Freezing does have a negative impact on flavour, while at the same time off-flavours can be created due to oxidative changes of polyunsaturated fats. Certain catalytic factors, such as salt, ions and lipolytic enzymes, remain active at low temperatures and result in the accumulation of free fatty acids. It has been mentioned before that this ingredient has proven antioxidative properties, attributed to the presence of polyphenolic acids and isoflavones. A relatively small inclusion level of 1–2% functional soy protein assures a significant improvement of meat patty properties, including improved flavour retention at longer storage times, while maintaining juiciness and textural properties as the most important end-product characteristics.

Protein Granules

Patty reformulation provides more than just savings on food costs. Product requirements do change. For example, fast food chains that operate on the world market have started to realize that they cannot continue exporting dogmatic specifications. After the first thrill of eating an 'imported cultural sandwich' is gone, regional differences continue to have a strong following. For example, the gyro flavourings in the Middle East, exquisite garlic/sugar/soy sauce in the Philippines, ginger-and-sake meat flavourings in Japan, and curry-flavoured mutton patties in India have made strong comebacks.

However, to fully optimize the effect of flavours and spices, a certain degree of flavour diffusion into the meat membranes is necessary. Because of delayed gelation characteristics, soy proteins generally possess unique properties for binding formula water – and thus integrating meat-like gelation with ground meat particles – and also assisting in flavour diffusion. Actually, cross-flavour diffusion technologies have made it possible to have a pork-textured and -flavoured breakfast sausage made from beef, or to have a beef-flavoured patty made from pork.

To be prepared for a catastrophe, like a massive outbreak of health-threatening diseases, fast food companies have a contingency plan in place: to quickly switch muscle meat sourcing, replacing beef with chicken and turkey, while maintaining the beef flavour and texture the consumers have come to expect. Flavour diffusion and meat source transformation will ultimately change the position and price structures of the meat supplies to least-cost protein selections.

It also should be noted that in this rapidly changing environment one way to start to boost production output is by augmenting the primary meats with pre-structured granulated gels or textured soy protein concentrate.

Protein granules are made according to a patented technology and enable meat processors to achieve significant cost savings, nutritional positioning and performance ability prior to re-thermalization and serving. These granules can be made using a batch production system (bowlchopper) or semi-continuous mixer/grinder system. High-volume processing lines generally use the mixer/blender online method. This granule extrusion technology reduces the manufacturing time of the protein granules to a few minutes, and these computerized systems can be set up for in-line formulated meat production. The texture of the granules can be regulated by modifying the water:protein levels together with varying temperature and friction conditions. Once the soy protein isolate has gone into gelation, individual particles are generated that won't re-adhere. This is an important phenomenon, though in quite a number of cases it is still necessary to create an additional 'cementing matrix' to integrate meat, additives and the non-meat protein into one homogeneous mix. By using certain blending techniques, the protein granules will absorb some meat myoglobin, and other added flavours, colours and spices, and become totally integrated and encapsulated, and thus nearly invisible in both the uncooked and cooked state.

Although preparing soy protein granules using a bowlchopper is the most efficient process in terms of gel elasticity and gel strength, it is evident that this type of equipment cannot generally be considered for in-line processing. For in-line granule processing, a patented technology has been developed using a mixer/blender in conjunction with a grinder.

When using this technology, it is important to assure proper watertight shaft and release door seals so that no water can escape prematurely. After the mixer/blender is filled with chilled or tap water, the functional soy protein is quickly added while the paddles or ribbons are in motion. The protein powder needs to be added quickly into the mixer/blender to avoid lumping and to assure rapid protein wettability and water absorption. The mixer/blender should not be overfilled because prolonged mixing or blending leads to complete protein solubilization, which usually translates into volume expansion.

The mixer/grinder should be filled to about 70% of its capacity. Compared to the bowlchopper, the optimum water:protein ratio is slightly different. For example, when the new generation of high gelling soy protein is used, 3.5 parts of water can be combined with 1 part of soy protein isolate. An additional benefit is that the latter protein is user-friendly with minimal dusting and rapid dispersibility. That, in turn, assures shorter processing times.

An innovative and patented method to combine meat trimmings with fat, water and functional soy protein is the formation of a meat-like granular that can be used as a characterizing meat replacement in coarse ground meat products. This process combines 3 parts of water, 2.5 parts of meat (80/20), 1.5 parts of fat and 1 part of soy protein isolate. The procedure is as follows: grind meat and fat through a 3 mm plate, and blend it at high speed for approximately 5 min with all the water and 1/2 the amount of soy protein. Switch to low speed blending/mixing and add the remainder of the soy protein while continuing blending for another 5 min. The integrated or combined meat product needs some 4 h to set in a chill room. Then the combined meat aggregate is ground into definite meat-like granulates in sizes ranging from 3 to 8 mm.

In addition to the specific added protein performance characteristics, the design of the blending equipment also greatly influences the speed and degree of protein solubilization and gelling. Large rounded corners provide a completely clean surface interior, forcing intense contact between water and protein. The single or double ribbons or scraped-surface paddles, in combination with vacuum and double jackets for cooling, are all variables that ultimately add to granulation optimization.

Proper functional protein selection is important, as it will ultimately carry through in the manufacturing processes, cost and organoleptical properties of the end product. Also important is the speed of the paddles or the ribbons. At a rotation speed of 20 rpm, the total blending time for obtaining true solubilization and gelling is about 20–25 min. This time is dependent on variables such as the influence of viscosity friction and equipment design. When the rotation speed is increased to 40 rpm, initial gelling time is reduced to about 15 min. The speed of protein gelling will also be influenced when a vacuum is applied during blending. Viscosity in the mixer/blender increases friction, which in turn increases temperature. Therefore, an end-temperature of 13–16°C can be expected. At this temperature the protein paste is too warm for granulation, and the protein has not been fully gelled to provide strong elasticity.

After the initial protein gelling has been completed in the mixer/blender, the protein paste is discharged into flat containers for storage in a cooler. During storage the protein paste slowly transforms into a firm translucent gel. This process requires at least 4 h at a temperature below 8°C, though it is possible to keep the protein gel overnight in the cooler to maximize gel setting.

Before inclusion in the final product, it is necessary to run the translucent protein gel through a grinder or flaker. Depending on the specific processing set-up and product specifications, the grind size ranges from 3 to 8 mm. The grinder creates individual protein granules that can easily be mixed into ground meat systems and other processed meat, poultry, fish and lifestyle foods. These protein granules allow rapid distribution throughout the product matrix without smearing, clumping or disintegration. As a matter of fact, its strong elasticity can be designed in such a manner that the granules quickly absorb the meat myoglobin to eliminate possible colour variations.

Although the use of this patented technology to make soy protein granules in a mixer/blender is a major step forward in creative product reformulation, there are situations that do not permit sufficient storage time of the protein paste to allow proper gel setting. For these situations a compromise can be considered by rapidly chilling the protein paste with CO_2 or N_2 in the mixer/blender to allow granulation by grinding, even though the protein has not been truly transformed into a translucent gel.

The specific technology that is most appropriate depends on processing conditions. There usually is an answer for most processing variables. The versatility of added functional non-meat protein ingredients allows a wide range of inclusion levels to optimize results. Despite the advantages that can be obtained using protein granules made in a bowlchopper or mixer/blender, the real breakthrough comes when these intermediate ingredients are made by extrusion technology as part of an in-line set up. That way, processors are able to feed the meat flow with a continuous output of extruded protein granules to allow rapid processing and HACCP control.

Of course, an added benefit is the significantly improved processing yield, with a reduction or preferably elimination of rework that subsequently reduces the risk of food-borne pathogens, such as listeria, salmonella, hepatitis A and *E. coli*. Ultimately, use of rework should be avoided or controlled with great caution, especially for uncooked chilled or frozen hamburger patties.

Partially or Fully Cooked Patties

Perhaps the most compelling reason for pre-cooking both formulated coated and uncoated meat patties is to address food safety and the speed of food preparation. With the rapid progress in thermalization and re-thermalization technologies – such as the belt grill and microwave heating and holding systems – it is now feasible to go well beyond cross-product innovation and allow the introduction of partially or fully pre-cooked meat patties.

It won't be easy to develop a partially or fully pre-cooked hamburger patty with the same sensory qualities as a raw frozen patty unless some of the dogmatic restrictions on meat content are not relaxed. In a meat processing plant, time–temperature parameters are usually the critical control points to destroy pathogens in the product. Currently, extraordinary amounts of energy are spent on microbial testing throughout the meat production line. And rightfully so!

The Hazard Analysis Critical Control Points system (HACCP) strives to ensure product safety through systematic prevention and solutions for safety and quality problems by enforcing objective, measurable standards along the processing chain from transport of the meat to the plant to delivery of the finished product to the end-consumer. HACCP is an effective and rational method of assuring food safety from harvest to consumption, with the prevention of the occurrence of problems being the paramount goal. Seven basic principles are employed in the development of HACCP plans that meet that stated goal. These principles include hazard assessment, CCP identification, establishing critical limits, monitoring procedures, corrective actions, documentation and verification procedures. Under such systems, if a deviation occurs, indicating that control has been lost, the deviation is detected and appropriate steps are taken to re-establish control in a timely manner to assure that potentially hazardous products do not reach the consumer.

In the application of HACCP, the use of microbiological testing is seldom an effective way of monitoring critical control points (CCPs) because of the time required to obtain results. In most instances, monitoring of CCPs can best be accomplished through the use of physical and chemical tests, and through visual observations. Microbiological criteria do, however, play a role in verifying that the overall HACCP system is working.

However, even with a dedicated HACCP programme firmly in place, further innovative and drastic improvements still can be made when a hamburger patty is developed that offer both significant improved food-safety standards, coupled with faster and more efficient re-thermalization and menu-serving.

Despite the availability of modern double spiral ovens, it appears that a 100% ground formed meat patty does not possess the necessary organoleptic properties of texture, bite, flavour and especially juiciness. There is little doubt that the entire fast food industry is moving towards even faster standards, ultimately leading to the kitchenless restaurant. Today's fast food is not fast enough for tomorrow's consumers.

There is also little doubt that part of the innovation answer to addressing the product development issues will have to focus on a closely related integration of ground meat, non-meat protein and flavour diffusion technology, together with modified thermalization equipment. However, a considerable amount of research still needs to be done to fine-tune required patty quality properties, preferably in the setting of a fully automated processing line. To preserve flavour to its fullest, it can even be suggested to forego the usual freezing of partially or pre-cooked patties and opt for gas-flush packing instead. Using modified atmosphere packaging it becomes plausible to bypass a distribution centre for frozen foods and directly deliver just-in-time quantities that subsequently are prepared in-store by regeneration ovens. These developments are technologically within reach, but need considerable additional research before large-scale implementation can become reality.

An often overlooked advantage of formulated meat products is the ratio of time-to-cook over holding time in the stage before serving to the consumer. In other words: the shorter the reconstitution time and the longer the holding time at which a product retains quality, the better the yield-value for the food service operator.

Regardless of the specific processing methods, including semi- or fully cooked meat patties, any time that meat patties are exposed to ambient conditions and the human touch, recontamination can occur. Especially for the ready-to-eat labelled product category, there is a danger that these products are considered safe by consumers, though in fact it is still necessary to reheat or cook prior to consumption.

For the further processing plant, it is therefore recommended to implement strict additional operation rules, such as: treating the meats with salt or other anti-microbials, e.g. activated lactoferrin, prior to grinding, eliminating all unnecessary physical handling by workers and also eliminating ground meat rework.

More Variables

Other functional ingredients that have shown beneficial results in formulated meat patties are fruit flakes or fruit powder derived from cherries, plums, apples and pears. These ingredients allow creative product development, not least because of positive consumer awareness, and their positive organoleptical effects, such as moisture retention and improved flavour and texture. For example, it has been reported that a 3% addition of dried plum paste to raw ground meat is effective in suppressing the growth of pathogens like *E. coli* O157:H7, salmonella, listeria and staphylococcus. Other gifts of nature such as sage, oregano, cinnamon and garlic also have a certain degree of microbial suppression.

Pre-cooked meat patties often are susceptible to warmed-over flavour (WOF). Warmed-over flavours are off-flavours produced by antioxidation, where chemical reactions involving oxygen take place causing oxidative rancidity. As a result, meat loses its fresh-cooked flavour. The latter is also termed 'meat flavour deterioration'. These hard to define warmed-over flavours are often characterized as 'stale', 'rancid' and 'cardboard-like'. Auto-oxidation is promoted by pro-oxidants such as salt, heat, ultraviolet light, low pH and metal ions. Iron should be mentioned in particular, since it acts as a catalyst in the lipid oxidation reaction. In ground and comminuted meat products, iron is liberated from the meat pigment myoglobin. Particularly when in combination with entrapped air and liberated fat from its cell walls, warmed-over flavours can develop. Meats high in polyunsaturated fatty acids (PUFAs) are particularly prone to warmed-over flavour development. Modified-atmosphere packing is an option to avoid or reduce the onset of warmed-over flavour. A variety of ingredients have been shown to be beneficial to antioxidative capability. For example, liquid smoke and rosemary extract have oxidation-inhibiting properties. The same is true for soy protein isolate and soy protein concentrate. Warmed-over flavour development does not happen in cured meat products. The reason is the presence of nitrite, which is a strong antioxidant. During the curing reaction, the meat colour changes to pink pigment (nitrosylhaemochromogen) with the iron compound immobilized in the complex, which renders the iron incapable of catalyzing the oxidation of the unsaturated fatty acids.

The increasing emphasis on taste, convenience, price and nutrition as a way of differentiation in the marketplace will continue to evolve and creative solutions will remain the cornerstone for product innovations. Major brand mega-national fast food restaurants have recognized that formulated and flavoured meat patties are a logical extension to their core menu selections, and represent a major opportunity for differentiation and incremental market development. Not only that, but in some countries flavoured meat patties are outselling the 100% pure-beef patties in the same restaurant. These menu additions have not only contributed to incremental sales with very little cannibalizing of existing products, they have also allowed market positioning to a significantly larger consumer base. These developments clearly indicate that future consumer satisfaction is not served with foods created by dogmatic corporate offices, but with innovative options that can include regional variables in food costs, nutrition and taste preferences.

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Formulation Examples: Meat Patties

Formulated beef patty (USA)

Ingredient	%	%
Beef meat 85CL	48.00	40.40
Beef meat 50CL	41.20	38.50
Soy protein isolate[a]	1.50	0.80
Soy protein granules[b]		15.20
Water	9.00	4.70
Encapsulated salt	0.20	0.20
Phosphate	0.10	0.10
Flavouring		0.10
Total	100.00	100.00

[a]Suggest low gelling SPI.
[b]Soy protein granules are made in a chopper or blender and/or used to replace part of the lean meat. It is suggested to use soy protein isolate.

Flame broiled beef patty (China)

Ingredient	%	%	%
Beef meat 70CL	72.00	76.00	80.00
Soy protein granules[a]	20.00	16.00	
Salt	0.30	0.30	0.30
Phosphate	0.10	0.10	0.10
Beef flavour + seasoning	0.80	0.80	0.80
Water	6.00	6.00	15.00
Soy protein isolate[b]	0.80		0.80
Soy protein concentrate[b]		0.80	
Textured soy protein concentrate[c]			3.00
Total	100.00	100.00	100.00

[a]Soy protein granules are made according to patented technology. Use chopper or paddle mixer for granule manufacturing. Temper soy protein granule to <8°C and grind through an 8 mm blade setting. Use soy protein isolate for granule preparation.
[b]Suggest high gelling SPI or FSPC.
[c]Alternative: TSF.

Procedure:
1. Pre-grind beef through an 8 mm plate.
2. Add water and dry ingredients and blend for 90 s.
3. Add ground soy protein granules or hydrated textured soy and mix until in total 4 min have elapsed.
4. Add CO_2 or N_2 and temper to –3°C.
5. Form and flame broil with flip mechanism.
6. Freeze.

Pinoy patty (Philippines)

Ingredient	%	%	%
Beef trimmings 70CL	50.00	44.00	62.00
Soy protein isolate[a]	3.00		3.00

Soy protein concentrate[a]		3.00	
Textured soy protein concentrate		1.00	3.00
Water	16.00	16.00	22.70
Soy protein granules[b]	20.00	20.00	
Cooked rice	4.00	9.00	2.30
Salt	1.30	1.30	1.30
Phosphate	0.20	0.20	0.20
Seasoning	2.50	2.50	2.50
Soy sauce	1.00	1.00	1.00
Chopped onions	2.00	2.00	2.00
Total	100.00	100.00	100.00

[a]Suggest high gelling SPI or FSPC.
[b]Soy protein granules – patented technology – are made in a chopper or blender and can replace up to 30% of lean meat. Use soy protein isolate for granule preparation.
[c]Alternative: TSF.

Food service patty (UK)

Ingredient	%	%	%
Beef flanks meat	32.00	36.50	37.50
Beef fat trimmings	20.00	20.00	20.00
Soy protein isolate[a]	2.00		2.00
Soy protein concentrate[a]		2.00	
Textured soy protein concentrate		5.00	4.00
Water	12.00	22.50	22.50
Salt	1.00	1.00	1.00
Phosphate	0.25	0.25	0.25
Rusk	5.00	5.00	5.00
Potato flakes	5.00	5.00	5.00
Onion flakes	1.00	1.00	1.00
Soy granules[b]	20.00		
Seasoning	1.75	1.75	1.75
Total	100.00	100.00	100.00

[a]Suggest high gelling SPI or FSPC.
[b]Soy protein granules are made in a chopper or blender and replace part of the lean meat. Use soy protein isolate.

Dôner burger (Turkey)

Ingredient	%	%	%
Beef meat 70CL	64.00	58.00	54.00
Sheep tail fat	5.00	5.00	5.00
Water	15.00	20.00	26.00
Salt	0.50	0.50	0.50
Phosphate	0.20	0.20	0.20
Sugar	0.60	0.60	0.60
Soy protein isolate[a]	5.00		2.00
Soy protein concentrate[a]		6.00	
Textured soy protein concentrate			2.00
Onions	9.00	9.00	9.00

Dôner burger (Turkey) (*continued*)

Ingredient	%	%	%
Gyro seasoning[b]	0.70	0.70	0.70
Total	100.00	100.00	100.00

[a]Suggest high gelling SPI or FSPC.
[b]Gyro seasoning suggestion: MSG 20%; onion 20%; oregano 15%; garlic 15%; black pepper 5%; leaf spearmint 5%; dextrose 20%.

Procedure:
1. Pre-grind meat through 18 mm plate.
2. Mix meat, phosphate, salt for 30 s.
3. Add water, soy protein and seasoning and mix until in total 2 min have elapsed.
4. Add isolated soy granules, or hydrated textured soy and mix until in total 4 min have elapsed.
5. Add onions and mix until in total 5 min have elapsed.
6. Temper with CO_2 or N_2 to –3°C.
7. Final grind through 3 mm plate setting.
8. Form patties and freeze.

Pizza burger (Mexico)

Ingredient	%	%	%
Beef meat 70CL	44.00	40.00	36.00
Turkey thigh meat	40.00	40.00	36.00
Water	12.00	16.00	22.00
Salt	0.60	0.60	0.60
Phosphate	0.10	0.10	0.10
Soy protein isolate[a]	1.60		
Soy protein concentrate[a]		1.60	1.60
Textured soy protein concentrate			2.00
Dextrose	0.60	0.60	0.60
Paprika powder	0.20	0.20	0.20
Oregano powder	0.20	0.20	0.20
Fennel (whole)	0.20	0.20	0.20
Anise seed (powder)	0.10	0.10	0.10
Pepper	0.30	0.30	0.30
Onion powder	0.10	0.10	0.10
Total	100.00	100.00	100.00

[a]Suggest high gelling SPI or FSPC.

Beef patty (Malaysia)

Ingredient	%	%	%
Beef meat 85CL	10.00	10.00	18.00
Beef meat 70CL	63.00	58.00	57.00
Water	10.00	10.00	16.00
Soy protein granules[a]	10.00	15.00	
Salt	0.40	0.40	0.40
Onion powder	2.00	2.00	2.00
Wheat flour	3.60	3.60	3.60

Soy protein isolate[b]	1.00		
Soy protein concentrate[b]		1.00	1.00
Textured soy protein concentrate[c]			2.00
Total	100.00	100.00	100.00

[a]Soy protein isolate granules is a patented technology. A chopper or a mixer/blender can be used for the soy protein granules production. Chill with CO_2 or N_2 for immediate use, or chill overnight to < 8°C to size reduce to 8 mm before final blending. Use soy protein isolate.
[b]Suggest high gelling SPI or FSPC.
[c]Alternative: TSF.

Grilled chicken patty (India)

Ingredient	%	%	%
Chicken breast meat	38.00	33.00	27.00
Chicken thigh meat	33.00	33.00	27.00
Chicken skin	10.00	14.00	14.00
Water/ice	15.00	15.00	25.00
Salt	0.80	0.80	0.80
Phosphate	0.20	0.20	0.20
Soy protein isolate[a]	3.00		2.00
Soy protein concentrate		4.00	
Textured soy protein concentrate[b]			4.00
Total	100.00	100.00	100.00

[a]Suggest high gelling SPI or FSPC.
[b]Alternative: TSF.

Procedure:
1. Grind chicken breast meat to 19 mm and chicken leg to 14 mm.
2. Fine grind chicken skin to 1 mm or size down in chopper.
3. Blend ground chicken meat together with salt and phosphate for 30 s.
4. Add water and soy protein and blend until 3 min have elapsed.
5. Or add hydrated textured soy and blend for another 2 min.
6. Reduce temperature to –2°C.
7. Vacuum.
8. Form and freeze.

Teriyaki pork patty (Japan)

Ingredient	%	%	%
Pork meat 80CL	53.00	53.80	50.80
Pork meat 50CL	30.00	28.60	24.60
Water	13.00	13.00	18.00
Soy protein isolate[a]	1.50		2.00
Soy protein concentrate[a]		2.00	
Textured soy protein concentrate			2.00
Teriyaki seasoning	2.50	2.60	2.60
Total	100.00	100.00	100.00

[a]Suggest low gelling SPI or FSPC.

Procedure:
1. Pre-grind pork 6 mm.

2. Blend pork with water and soy protein for 60 s.
3. Add seasoning and blend until in total 90 s have elapsed.
4. Or add hydrated textured soy and mix for another 120 s.
5. Chill to –3°C and final grind to 3 mm.
6. Form and (partially) cook and/or freeze.

Pork breakfast patty (USA)

Ingredient	%	%	%
Pork meat 75CL	70.00	70.00	70.00
Soy protein isolate[a]	1.80		1.80
Soy protein concentrate[a]		1.80	
Textured soy protein conc.[b]			3.00
Water	10.70	10.70	22.70
Soy protein granules[b]	15.00	15.00	
Seasoning	2.50	2.50	2.50
Total	100.00	100.00	100.00

[a]Suggest low gelling SPI or FSPC.
[b]High gelling SPI to prepare soy protein granules. These granules can be made according to a patented technology in a chopper or blender and replace a portion of the meat.

Procedure:
1. Pre-grind pork 2.5 cm.
2. Mix pork, soy protein and water until uniformly blended.
3. Add SPI granules (patented technology) and seasoning, mix 2 min.
4. Or add hydrated textured soy and mix 2 min.
5. Regrind 3–5 mm.
6. Form and freeze.

Chicken steak

Ingredient	%	%
Chicken thigh meat[a]	80.20	79.00
Water	15.00	16.00
Salt	0.80	0.80
Phosphate	0.20	0.20
Soy protein isolate[b]	1.50	
Soy protein concentrate[b]		1.90
Dextrose	1.00	1.00
Non-fat dry milk	1.00	0.80
Pepper	0.05	0.05
Onion powder	0.05	0.05
Lemon juice	0.20	0.20
Total	100.00	100.00

[a]Chicken thigh without skin.
[b]Suggest low gelling SPI or FSPC.

Procedure:
1. Mix soy protein with cold water in high-speed blender.
2. Add phosphate and salt and mix until dissolved.
3. Add marinade seasonings and mix until dissolved.

4. Add marinade to the chicken meat and vacuum tumble until all marinade has been absorbed.
5. Form into a topographic shaped plate (3D) and heat process and/or freeze.

Chicken cutlets (The Netherlands)

Ingredient	%	%
Chicken thigh meat[a]	79.60	79.00
Water	16.00	16.00
Salt	0.80	0.80
Phosphate	0.20	0.20
Soy protein isolate[b]	1.60	
Soy protein concentrate[b]		2.00
Non-fat dry milk	0.70	0.70
Dextrose	0.50	0.70
White pepper	0.10	0.10
Onion powder	0.10	0.10
Garlic powder	0.10	0.10
Lemon juice	0.30	0.30
Total	100.00	100.00

[a]Chicken thigh without skin.
[b]Suggest low gelling SPI or FSPC.

Procedure:
1. Grind chicken thigh meat through a 15 mm plate.
2. Mix chicken meat with salt and phosphate for 15 s.
3. Add water and mix until 1 min has elapsed.
4. Add soy protein and mix until 4 min has elapsed.
5. Temper with CO_2 or N_2 to –3°C.
6. Form into cutlets.
7. Cook in impingement oven to 80°C.
8. Freeze to at least –18°C.

Chicken patty (USA)

Ingredient	%	%	%
Thigh meat	74.00	70.00	66.00
Dark trim	10.00	10.00	10.00
Skin	6.00	10.00	6.00
Water	6.60	6.60	12.60
Soy protein isolate[a]	1.00		
Soy protein concentrate[a]		1.00	1.00
Textured soy protein conc.			2.00
Salt	0.80	0.80	0.80
Phosphate	0.20	0.20	0.20
Dextrose	0.20	0.20	0.20
Seasoning	1.00	1.00	1.00
Lemon juice	0.20	0.20	0.20
Total	100.00	100.00	100.00

[a]Suggest high gelling SPI or FSPC.

Procedure:

1. Grind chicken thigh meat through a 15 mm plate.
2. Grind chicken skin through a 1 mm plate.
3. Mix ground chicken meat, salt and phosphate for 15 s.
4. Add water and mix for 2 min.
5. Add soy protein and mix for 1 min.
6. Add ground chicken skin and mix for 2 min.
7. Add remaining ingredients, including hydrated TSPC and mix for 1 min.
8. Add CO_2 or N_2 and temper to approx. –3°C.
9. Form into desired weights, e.g. 90 g.
10. Freeze to at least –18°C.

Chicken Teriyaki burger (Japan)

Ingredient	%	%
Chicken thigh meat[a]	77.00	75.00
Water	14.20	16.00
Salt	0.80	0.80
Phosphate	0.20	0.20
Dextrose	0.80	0.80
Soy protein isolate[b]	1.80	
Soy protein concentrate[b]		2.00
Non-fat dry milk	0.70	0.70
Soy sauce[c]	2.60	2.60
Mirin rice wine	1.50	1.50
Garlic powder	0.20	0.20
Ginger powder	0.20	0.20
Total	100.00	100.00

[a]Chicken thigh meat w/o skin.
[b]Suggested low gelling SPI or FSPC.
[c]Recommended: Kikkoman brand™.

Procedure:

1. Grind chicken thigh through 15 mm plate.
2. Mix chicken meat with salt and phosphate for 15 s.
3. Add water and mix until in total 1 min has elapsed.
4. Add soy protein and mix until in total 4 min have elapsed.
5. Add all other ingredients and mix until in total 5 min have elapsed.
6. Temper with CO_2 or N_2 to –3°C.
7. Form into patties.
8. Freeze or (partially) cook in impingement oven to 80°C.
9. Freeze.

Chicken mignon

Ingredient	%
White phase	
Chicken breast (boneless/skinless)	40.00
Water	8.00
Salt	0.80
Phosphate	0.30
Soy protein isolate[a]	0.80

White pepper	0.10
Total	50.00
Dark phase	
Chicken thigh meat	40.00
Water	8.00
Salt	0.80
Phosphate	0.30
Soy protein isolate[a]	0.80
White pepper	0.10
Total	50.00

[a]Suggest high gelling SPI.

Procedure:

1. Prepare marinade.
2. Add to separate blenders the white and dark phase and vacuum tumble for 30 min.
3. Fill into casing sleeves using a double-horn extruder pump.
4. Freeze and then temper for band slicing into 2 cm 'steaks'.
5. Heat process and/or freeze.

11
Ingredients for Whole Muscle Meats

In the old days, it used to be easy: simply rub the meat parts with some rock salts or saltpetre to obtain a preserving effect. Rock salts contain some impurities such as nitrates, and it is believed that our ancestors, most probably the Chinese, accidentally discovered the naturally occurring preservative potassium nitrate. Much has changed since then and modern brines are a far cry from the basic additives of salt and sugar. However, during the last 50 years, with the increasing availability of refrigeration, the need for preservation has been gradually replaced by the need to create desirable product characteristics such as colour and flavour.

It is believed that as far back as 1500 BC, the Chinese and the Armenians had developed meat processing skills and were able to preserve raw meat by adding salt and saltpetre. Dry curing originates from that ancient time, and it has been reported that salted meat was also cooked in water, and sometimes smoke was applied to increase shelf life and create taste preferences.

Since there are many different processing systems and many different products, whole muscle meat processing technology can only be discussed in broad and general terms. By strict definition, a ham must be made from the hind leg of pork. But the meat sizes can vary from whole muscles to relatively small chunk-sized pieces that are ingeniously restructured. Then there is also the level of brine, pickle or marinade injection, which can range from as low as 10% to 100% (Fig. 11.1).

In short, cooked ham generally involves curing and cooking of pork leg meat. Traditionally, pork leg meat is

Fig. 11.1. Injection of pork ham. Source: Metalquimia SA, Girona, Spain.

trimmed and then pumped with a brine curing solution. Although this traditional process is still basically unchanged, ham-processing technology is undergoing major changes by implementing more automation to replace the expertise of the grand old Fleischermeister. It will come as no surprise that computers have taken over much of the art of ham processing. Critical parameters such as staged addition of ingredients, temperatures, and massage or tumbling cycles can be properly recorded. This will not only enhance product consistency, but equally important will also provide historical process data to aid food-safety efforts.

Modern processing technologies of whole muscle meats, such as cooked hams, pastrami, corned beef, roasted beef and breast of turkey, all have in common the massaging action required to solubilize meat protein for optimum water-holding capacity, colour development and muscle alignment. Actually, the only characterizing difference in whole muscle meat products is the presence of nitrite, which fixes the colour after cooking.

Of all whole muscle meat products, cooked ham is the world's most popular, followed by pastrami and, particularly in the USA, breast of turkey. There is a world of difference among delicately flavoured whole muscle meats, with literally hundreds of different product and processing descriptions. The world's most famous traditional meat product is prosciutto di Parma, which can only be made by members of the Parma Consortium. This raw ham still manages to keep its many secrets within the Parma region in Italy.

Cooked Ham, Roasted Beef, Pastrami and Breast of Turkey

Pork ham most probably is the meat product with most varieties: bone-in, boneless, skinless, shankless, deli-ham, country ham, spiral-sliced ham and smoked ham. In the USA there are ham products whose names indicate their heritage, such as Virginia ham and Smithfield ham. In Europe, there are old names such as Prosciutto Cotta in Italy, Serrano Ham in Spain, Wacholderschinken in Germany and Bayonne in France. Many of these products are still made using traditional procedures. However, to meet consumers' need for uniformity and economics, a whole new category of cooked whole muscle meats has been developed. These products are cooked in a can, packed in casings, rubbed in spice coatings or packed in nettings. Cook-in-the-bag processing systems are frequently used for delis and food-service operators.

Usually, ingredients are defined as those components or nutrients that are present in the everyday diet, whereas additives are substances not normally occurring as a natural food or in a concentrated version. Additives usually are added intentionally to achieve technological and organoleptic properties.

There are a number of variables that need to be discussed to get a good understanding of the role of each ingredient and additive. For example, polysaccharides such as carrageenan and alginates that are used as binders alone or in combination can both enhance or interfere with protein gelation. While carrageenan supports protein gelation, especially when used with premium soy protein ingredients, sodium alginate and locust bean gum may interfere with protein gelation.

The technical challenges of ham manufacturing are how to control process variables such as uniformity, texture, bind and yield. The future of ham processing is to develop a system with the least amount of human intervention.

Raw Material Variables

Apart from the interactions between ingredients and additives within the meat to reach the most desirable quality parameters, it is important to know that the pH of the meat plays a decisive role in quality. Meat can be divided into three groups: normal meat, PSE meat and DFD meat. Pork and, to a lesser extent, turkey meat are especially sensitive to irregularities in pH.

Normal meat has a pH ranging from 5.8

to 6.2. The meat is typically wet in appearance, but not really watery (that is, no exudation). The meat is firm in texture and the colour attributes range from deep pink to deep red. Colour depends on the particular species and anatomical location.

PSE, or pale soft exudative, meat has a pH <5.8, and the appearance of the meat is watery (with exudation), with a light colour and soft texture. PSE meat has a very good ability to react with nitrite to form the desired colour after cooking. However, its water-holding capacity and flavour leave a lot to be desired. PSE should preferably be removed from the batch and treated separately with other PSE meat for a different application, such as sectioned and formed or restructured meat products. PSE mainly affects pork, specifically hams.

DFD, or dark firm dry, meat has a pH above 6.3, and has a very dark red colour. The meat is dry in appearance and has a firm texture. DFD meat has excellent water-holding capacity, but because of its tight meat membrane structure, the curing effect of nitrite is less intense. Also, because of its high pH, keeping quality often is negatively affected, and a base off-flavour sometimes develops. Actually, DFD is not a frequently occurring problem. Pork hams average about 5% DFD, compared with approximately 25% PSE.

It should be noted that it is not the actual pH itself but the speed of the pH drop after slaughtering that is key. For turkey and pork, pH should be measured within 45 min and 60 min respectively; for beef within 4 h.

Pinking

In cured meat products, 'pinking' is a major advantage for eye appeal. However, for uncured meat products such as poultry rolls or breast of turkey, consumers associate a pink colour with underprocessing. Soy proteins such as soy concentrate (70% protein) and soy protein isolate (90% protein) also can be a cause for creating a pink colour in uncured and cooked meat products. Direct-dried soy protein ingredients in particular should be avoided; these protein products have a relatively high level of nitrate and nitrite. It is therefore suggested to use soy protein ingredients that have been indirect heated during drying. The author of this book reported in 1986 about the use of non-meat ingredients such as certain dairy proteins to reduce unwanted pinking in uncured cooked poultry products. Apart from increasing yields, dairy proteins such as non-fat dry milk or skimmed milk powder, whey proteins and, to a lesser extent, lactose and calcium caseinate can reduce these unwanted colour appearances.

However, the most obvious cause of pinking in uncured poultry products is nitrite contamination. There are other pigments that may cause pinkness in cooked poultry:

- Undenatured myoglobin of raw meat.
- Nitrosylhaemochrome (this is the cured meat pigment).
- Carbon monoxide haemochrome.
- Denatured globin haemochromes.

Myoglobin is the meat pigment in uncooked meat that is normally denatured by cooking (71°C). However, pH levels of >6.0 stabilize myoglobin to the effect of thermalization. This is especially true for thigh meat that is high in pigments.

Nitrosylhaemochrome causes pinking in uncured cooked poultry product if, for example, non-meat ingredients are contaminated with nitrite which may expose it to nitrous oxides in combustion gases, a by-product of natural gas used in direct heating. Therefore, it is important to select functional ingredients such as soy protein isolate or soy protein concentrate that have been subjected to indirect heat during the spray-drying process.

Carbon monoxide (CO) haemochrome is the pink pigment causing surface discolouration on smoked meats or products that are heated in a direct-fired gas oven. Upon slicing it can be noticed that the discolouration has a ring or depth of about 10 mm. To avoid this type of pinking, emissions of CO and NO should be reduced to <20 ppm and <1 ppm, respectively.

Denatured globin haemochromes are pink complexes between the reduced haem iron of heat-denatured myoglobin and some nitrogenous compounds residual in the meat product such as amino acids and vitamin B. Quite often, pink colour develops over time during refrigerated storage. It also can be observed in high temperature (>75°C) uncured cooked meat products.

To fully understand the specific role of additives and functional ingredients in whole muscle meat products it is important to know about their characterizing and influencing properties and their synergies:

- Meat.
- Water.
- Salt.
- Phosphate.
- Lactates.
- Nitrite.
- Sugar.
- Starch.
- Antioxidants.
- Colouring.
- Hydrocolloids.
- Flavour enhancers.
- Soy protein.

Water

In terms of economic considerations, water is the most important ingredient in whole muscle meat products. Not all parts of the world have the same water quality, and the presence of heavy metals such as copper and iron in brine solutions can react with additives such as sodium ascorbate (vitamin C), destroying its antioxidative properties and affecting the colour stability of the end product.

Salt

Salt is the most commonly used additive in processed meat products. In whole muscle meat it serves two main functions: salt imparts a distinct flavour, and it also acts as a suppressor of water activity, thus increasing shelf life. Depending on the type of the whole muscle meat, the salt level varies from about 1.4% to 2.8%. Technologically, salt also is responsible for reacting with the myofibrillar protein to optimize swelling and solubilization. The latter two properties are important for increasing the water-holding capacity and to allow the separate muscle pieces, if necessary, to 'glue' or hold together and realign.

In recent years, salt has been the subject of debate and is believed to be detrimental to health, causing high blood pressure in particular. The taste for salt is mainly an acquired taste and within certain limits it is possible to gradually reduce salt levels to lower the threshold for flavour.

The functional properties of salt (sodium chloride) are directly related to its ability to interact with the meat proteins. When dissolved in water, sodium chloride dissociates into cationic and anionic components (Na^+ and Cl^-). The electrostatic interactions of the protein molecules are influenced by the addition of salt. These electrostatic interactions are comprised of positive and negative charges based on the principle that unlike charges attract and like charges repel. The pH, ionic strength, temperature, friction and the presence of phosphate and other functional ingredients, such as non-meat proteins, influence these charges. Water-holding capacity, or the ability of meat to hold water, is a function of hydrogen bonding, dipole interactions and capillary actions. The least amount of water can be held at the iso-electric point.

Salt influences water-holding capacity significantly. Despite the many positive functions of salt in processed meat products, such as preservation, increased water-holding capacity, flavour and protein extraction, there is a negative impact because of salt's pro-oxidative ability, which can cause colour-stability problems and provoke rancidity development. The solubility and speed with which salt reacts with meat proteins will ultimately determine the functionality. Encapsulated salt is not commonly used in the manufacturing of whole muscle meat products. The encapsulated salts are primarily used in meat products that need low-bind properties, such as hamburger patties.

Phosphate

Phosphate is another key additive that specifically regulates strong chelating actions on calcium and magnesium, loosening the electrostatic bonds within the actomyosin filaments. This function allows sodium chloride to optimize extraction and solubilization of salt-soluble myofibrillar protein. In a way, the role of phosphate can be seen as a functional replacement for adenosine triphosphate (ATP) lost due to depletion of glycolysis after slaughtering. Phosphate also influences pH conditions, and thus has a buffering effect on various muscle parts (Table 11.1). This is especially important when PSE meat is used.

However, not all functions of phosphates are fully understood in meat science. In most food legislation, the maximum permitted amount of phosphate is 0.5%. High inclusion levels of phosphate sometimes can generate an alkaline flavour that often is described as a metallic or 'soapy' taste. Generally, inclusion levels ranging between 0.2% and 0.3% optimize all the required brine functions, without compromising flavour and taste.

Sodium tripolyphosphate (STP) is the most effective of the phosphate salts. In many cases it is beneficial to use a 10/90 blend of sodium hexametaphosphate and STP. Sodium hexametaphosphate sequesters interfering metal ions in hard water and thus supports the dissolution of the tripolyphosphate. Some functional phosphate blends contain small amounts of tetra sodium pyrophosphate, at a high pH, and sodium acid pyrophosphate (SAPP), which has a low pH. SAPP does not really contribute to water retention, but it is effective in protecting typical meat flavour.

Table 11.1. pH effect of phosphates.

Phosphate	1% pH solution
Tetrasodium pyrophosphate	10.5
Sodium tripolyphosphate	9.8
Sodium hexametaphosphate	7.0
Sodium acid pyrophosphate	4.2

The addition of phosphate in whole muscle meat products such as pork ham or roast beef generally means that water content increases while protein content decreases. The presence of phosphate in sliced and vacuum-packed products results in lower drip loss, however, even though a higher amount of moisture is present. Firmness of cooked whole muscle meats increases considerably, even at very low levels of phosphate addition (<0.1%). At higher levels of phosphate (>0.3%), there is a tendency to decreased firmness in these whole muscle products.

Phosphates increase the pH of meat products to an optimal range of 6.0–6.4. These pH-regulating properties are especially important when PSE meat is used. Brine phosphates generally have a pH range between 8.5 and 9.5. The solubility of the phosphates that are used in brine systems should be such that salt recrystallization is avoided. Fast and complete solubilization is essential for phosphate to perform properly. Usually, the higher the ratio of brine or pickle to whole muscle meat, the lower the concentration of salt and phosphate in the brine. Sensory evaluation has indicated that phosphates can improve the tenderness of meat. The specific roles of salt, phosphate and functional non-meat protein in improving cooking yield and product quality are complementary, and these functional ingredients should therefore be harmonized to optimize their performance.

The optimum brine temperature remains a subject of differing viewpoints. It is important to select a phosphate that rapidly dissolves in cold brine systems. The general trend is to use cold processing injection, tumbling or massaging technologies. Although the rate of protein swelling is higher at higher temperatures, the immediate swelling of the protein around the injection needles or meat surface will initially slow down penetration of phosphate into the remaining muscle tissue. Subsequently, a reduced amount of actomyosin dissociation is obtained, which negatively affects yield. At lower processing temperatures, salt and phosphate-containing brine initiates a reduced initial swelling of the meat protein, though the rate of absorption is greater. Because of friction caused by the tumbling or massaging equipment, temperature has a tendency to rise slightly, which often leads to an acceptable compromise in optimizing product properties, including reduced microbial growth, improvement of colour and yield and increased shelf life. (See Muller *et al.*, 2000.)

Lactates

Antimicrobial ingredients are an effective safety hurdle in a multi-hurdle approach to ensure microbial quality of processed meats. A natural form of an antimicrobial agent is made from natural lactic acid, a component that is already present in meat.

Lactate and diacetate additives are effective antimicrobials or pathogen inhibitors. The same is true for acidified calcium sulphate, lactic acids and buffered sodium citrate when examined for the control of *Clostridium perfringens*, salmonella, *E. coli*, *Listeria monocytogenes* and staphylococcus. These antimicrobial ingredients provide additional hurdles such as lower water activity, maintenance of flavour and improved product safety.

Spin-off ingredients of lactic acid are sodium and potassium lactate, and a relatively low percentage of addition – especially in combination with diacetate – has shown to be highly effective in controlling or retarding the growth of *L. monocytogenes*, *E. coli* O157:H7 and salmonella in both cured and uncured meat systems. Sodium lactate and potassium lactate have been used for some time to extend shelf life and suppress the growth of pathogens by reducing the risk of microbial contamination, particularly during handling, storage and distribution. The lactates act as bacteriostats by increasing the lag or dormant phase of microorganisms. During the process, certain mechanisms are at work that interfere with the metabolism of the bacteria; these include intercellular acidification and interference with the proton transfer across the cell membranes.

Lactates are clear and syrupy liquids derived from lactic acid, which is also naturally present in animal meat tissue. Lactate has a dry matter concentration of 60%, and effective pathogen hurdles can be put in place at inclusion levels of up to 4.8% by weight of the total formulation.

Going beyond the known properties of sodium or potassium lactate is the unique blend of potassium acetate and potassium lactate in processed meat products. It has been known for quite some time that each individual component was effective in extending shelf life. However, when combined, these organic compounds have a greater antimicrobial effect than if each were used alone.

This synergistic blend usually contains two parts potassium acetate and one part potassium lactate. Such a concentrated liquid blend of potassium salts of acetic acid and lactic acid functions as a bactericide and bacteriostat by increasing the lag, or dormant, phase of microorganisms and also reduces total plate count. Diacetates are salts of acetic acid. They are bactericidal against spoilage organisms and some pathogens by immediately lowering the pH and reducing the initial microbial load.

The product is a mild-tasting, clear liquid food ingredient providing antimicrobial properties offering protection against many food pathogens. Its use increases shelf life in, for example, whole muscle meats and emulsified sausages. The effective usage level depends on the specific formula, but usually is about half the typical level of lactates, which are usually at 3.0–3.3%. Therefore, the combined acetate and lactate product should provide optimum results in the range between 1% and 2% of the total formula. For example, 1.5% of the combined product has the effect of 2% acetate and 2.5% lactate under certain conditions. Studies indicate that the compound interferes with bacterial metabolism and lowers water activity. Specifically, the lactate effect is described as one of inhibition and delaying of growth – a bacteriostatic effect – extending the lag phase as a result of diverting a major proportion of metabolic energy to maintaining cellular pH.

The interest in the use of sodium or potassium lactate and potassium acetate blends has somewhat shifted from shelf life extension to food safety because of their ability to kill microbiological contaminants. By inhibiting microbial growth, the shelf life of both fresh and processed meats can be increased by up to 50%, though their effectiveness decreases as product storage temperatures increase. In the case of processed meats, the results apply to both cured and uncured products. The USA Department of Agriculture's Food Safety and Inspection Service (FSIS) permits this natural blend for use in meat and poultry products.

Other advantages of sodium and potassium lactate are antioxidant activity as well as improved yields when used in product formulations. Lipid oxidation – the onset of rancidity – reduces proportionally with the usage levels of the lactates. The latter is evidenced by lower TBA values. Lactates suppress off-odours at storage temperatures up to 15°C. In other words, lactate-containing meat products have not only extended shelf life and lock in flavour, but as a result have fewer product returns from point of sale.

The blend of potassium acetate and lactate can be easily incorporated in the processing procedures. The clear liquid can be added directly into brine or pickle to allow flawless injection. There is no antagonistic effect during subsequent processing steps such as massaging, tumbling and thermal processing.

The lactate liquid is nearly always the last additive to either the brine or marinade for whole muscle meat applications, or to the cutter or mixer/blender for emulsified products such as bologna and frankfurters.

Like all other processed meat products, lactate-containing meat products must be chilled immediately following the cooking cycle. The time/temperature relationship is a critical control point that ensures food safety. Propagation of bacteria can accelerate or decelerate, depending on the specific temperature of the product. For example, at a temperature of <12°C propagation starts to slow and becomes minimal at temperatures of around 0°C. But when the cooked meat product is frozen, bacteria stay dormant, only to be reactivated again upon defrosting.

The addition of these functional blends does not replace good manufacturing practices, but it certainly helps to safeguard against microbial spoilage and thus adds a major protective barrier to increase shelf life while optimizing quality. The strong desire for clear labelling by consumers make lactates and the innovative acetate/acetate blends clear and natural organic solutions.

Nitrite

This substance is not really considered an ingredient, but rather an essential additive. Nitrite has a unique role in cured meat products. Whole muscle meat products such as cooked ham and pastrami usually contain 125–250 ppm nitrites to obtain the characteristic colour properties. Nitrite also has a strong bacteriostatic effect.

Nitrite itself does not react with meat, but needs to be reduced to nitrous oxide in order to be effective (Fig. 11.2). Once the highly reactive nitrous oxide is formed, it partially reacts with myoglobin and haemoglobin to form nitrosomyoglobin. This pig-

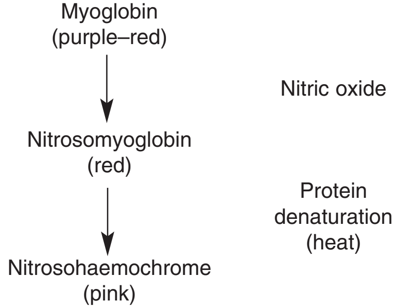

Fig. 11.2. Nitrite/nitrate reduction shown schematically.

ment ultimately is responsible for typical end-product colour. The part of the nitrous oxide that is not used for colour fixation evaporates or reacts with muscle sections and fat.

The remaining nitrite has the potential to react with the antioxidative additives such as sodium ascorbate (vitamin C) or sodium erythorbate. This reaction is rather quick and intense if nitrite and ascorbate or erythorbate are added to the brine at the same time or if the brine is left to stand for a prolonged time. Nitrite has the actual ability to deplete these antioxidative properties and thus renders these additives useless. Nitrosomyoglobin is unstable and it decomposes into globin and nitrosomyochromogen, which in turn fixes the stable colour. The intensity of the stable colour is influenced by cooking temperatures (minimum 65°C), final pH and the presence of antioxidants in the end product. Apart from the colour properties provided by the curing actions of nitrite, of extreme importance is its bacteriostatic effect on *C. perfringens*, enterobacteria and *S. aureus*, and in particular its ability to prevent *C. botulium*. This microorganism is very resistant to cooking temperatures, and thus the presence of nitrite is the only way to safeguard against it.

Recent reports also mention the benefits of the antioxidative effects of nitrite to the overall quality of meats. The level of nitrite addition ranges from 125 to about 250 ppm or 0.0125 to 0.0250%. For safety and convenience, this additive is usually sold premixed with NaCl, hence the name 'curing salt'. Premixed cure or curing salts are usually available in two concentrations: 99.4% NaCl + 0.6% $NaNO_2$, or 93.75% NaCl + 6.25% $NaNO_2$. It is important to ascertain the concentration level of the nitrite in the premixed cure and to strictly follow the dosage instructions of the supplier. The reason is that nitrite is a major chemical hazard. If too much is added to the processed meat product there is a risk of illness or even death. Young children and the elderly population are at increased risk when high levels of nitrite are consumed. (See Wirth, 1991.)

Strict procedures for the handling and documentation of the use of sodium nitrite should be implemented. Using a commercial blend to control the sodium nitrite will provide safety and should be calculated upon the meat content of the formula. For whole muscle meats, the above-mentioned nitrite levels are average, while for emulsified meat products an average of 150–170 ppm sodium nitrite is used, based on the meat content. Considering the presence of formula water and other ingredients, the actual nitrite level in emulsified meats is reduced to about 110–120 ppm. The nitrite ion is not stable and decreases further during processing and storage. Uncured spots in the product indicate insufficient levels of nitrite. However, this problem can also be caused by insufficient meat thawing prior to brine pumping. Generally, it is recommended to withhold nitrite addition to the brine until just prior to injecting.

The USA in particular has experienced a rather steep decline in residual sodium nitrite levels during the last 20 years. The average residual nitrite level in cured meat products has reduced by 80%, or from 52 mg/kg to 10 mg/kg, at time of purchase. The World Health Organization has established the acceptable daily intake of sodium nitrite as up to 0.2 mg/kg of body weight. The maximum amount of nitrite permitted in the USA in cured meat is 156 ppm, except for bacon (120 ppm).

At the permitted levels of nitrite addition, thorough peer-reviewed bio-essays on nitrite concluded there was no substantiated evidence that nitrite causes cancer in laboratory rats and mice. On the contrary, there is some early indication that sodium nitrite acts more like a therapy than a toxicant. Studies indicated a dose–response decline of cancerous tumours in some organ systems with increasing doses of sodium nitrite. (See Cassens, 1990.)

Sugar

Sugars, such as saccharose (sucrose), lactose and dextrose (including glucose syrups), have a wide range of inclusion levels because of varying sweetness profiles. The main reasons for the presence of these ingredients are added flavour and the ability to depress water activity. Usually, sugars with high sweetening profiles have a limited ability to reduce water activity. Sugars with less sweetening power can significantly increase the dry matter content of the brine, and thus are often preferred in high-yielding whole muscle meat formulae.

Lactose is a double sugar of glucose and galactose, has a very low sweetness profile and is frequently used because of its ability to act as a carrier for other ingredients. Its presence is also credited for boosting the typical cured pink colour in cooked ham and pork shoulder or pork loin products.

Dextrose, and to a lesser extent glucose syrup, are susceptible to the growth of lactobacilli, and countries with a humid climate and/or insufficient storage temperature control of the end product should use these ingredients with extra care. The inclusion level of sugar is dependent on, among other factors, the amount of salt, and can range from as low as 0.5% to as high as 4.0%.

Starch

Starch assists with binding qualities in both emulsified and some types of whole muscle meat such as cooked pork ham. Initially, starches were considered cheap fillers. However, new ingredient processing technologies have created certain properties that promote starch into the functional ingredient category. Ideally, starch should hold moisture throughout the processing cycle, and as such it can be considered complementary to the inclusion of gelling non-meat proteins, such as soy protein.

Basically starch is a carbohydrate polymer, and these polysaccharides are made of long chains of glucose: linear amylase molecules and branched amylopectin molecules derived from botanical sources such as wheat, rice, tapioca, potato and maize. In processed meat products starches are used for both economic and functionality considerations. Native starches are not soluble and are generally sensitive to high cooking temperatures and acid environments. When starches are heated in an aqueous suspension they gelatinize. In other words, the molecules absorb water and swell irreversibly. However, upon cooling the amylase molecules re-associate, a phenomenon also known as retrogradation. Retrogradation allows initially bound water to be squeezed out again, leading to syneresis. Purge often is the result, especially when native starch-containing processed meat products are vacuum packed or go through a freeze/thaw cycle. Rice starch probably is an exception to this rule.

Native starch and modified food starch are nearly always used in high-yielding whole muscle meats. Both native and chemically modified starches consist predominantly of amylopectin, the branched form of starch. Upon water contact, the amylopectin swells, giving the starch its viscosity and texture. The primary reason for their use is to boost water retention and thus reduce cooking loss. Modified starches have improved moisture control within the starch granules, while also positively impacting on the freeze/thaw stability. Starches all increase friction and thus have the tendency to increase temperature during tumbling and/or massaging.

The performance of starch depends on maintaining the integrity of the starch molecule and its resistance to high shear pumps of brine injectors and mixer-blenders that have the potential to destroy viscosity and thus reduce texture.

Most starches gel at temperatures between 60°C and 75°C (Table 11.2). Gelling temperature is a function of the size and type of starch particles.

The most widely used carbohydrate-

Table 11.2. The gelatinization points of native starches are respectively.

Potato starch	61°C
Tapioca starch	65°C
Maize starch	67°C
Wheat starch	77°C

based water binder in processed meat products is potato starch. This type of starch has a low gelatinization point and a rapid rate of swelling and moisture absorption. The maximum degree of absorption is at about 70°C, which happens to be about the same as the cooking temperature of most processed whole muscle meats.

The inclusion level of starch is self-limiting. To eliminate or reduce water or jelly exudate or purge in whole muscle meat products, it is important to prevent retrogradation. The latter occurs when starch's molecular structure is changed because of high shear or friction during processing. Improvements can be made by selecting certain modified food starch products whose cross-linking capabilities have the tendency to keep the moisture inside the molecule. An alternative for reducing starch friction is to opt for a tumbling or massaging process in which this ingredient is added later in the processing cycle. For high-pump, whole muscle meat products it also can be an advantage to tumble or massage the injected meat parts only to the point that brine absorption is complete, after which the product is kept refrigerated and the processing cycle continues up to the scheduled packing and cooking cycles.

Modified food starch is especially useful for increasing the functionality of PSE pork restructured meat. But without the synergistic help of soy protein, starch is less suitable for improving textural properties. Approximately 2% of starch inclusion is the threshold when it starts to taste starchy. Because of improved cross-linking, co-processed protein/starch products allow a somewhat higher inclusion level. Co-processed soy protein and starch products allow very rapid dispersion and hydration in all brine systems.

Antioxidants

Sodium ascorbate and sodium erythorbate are very effective antioxidants. In principle these two very similar additives have a number of unique properties in processed meat products. Ascorbate (vitamin C) is permitted in all countries, whereas erythorbate is restricted or not allowed in some countries. Erythorbate contains only 5% vitamin C but is considerably cheaper than ascorbate. The usage level for erythorbate is between 0.05% and 0.08%, and for ascorbate between 0.04% and 0.06%. The most important functions of these two antioxidants are:

- Facilitation of nitrosomyoglobin formation by reducing the nitrite to nitric oxide, which forms the pink colour. Without the presence of ascorbate or erythorbate, the reducing agents naturally present in meat would be available to reduce nitrite. However, this is a much slower process and would leave higher residual levels of nitrite in the end product.
- Ascorbate and erythorbate also prevent the formation of cancer-promoting nitrosamines by hindering the formation of nitrosating compounds such as nitrous oxide (N_2O).
- Ascorbate and erythorbate also inhibit formation of peroxide radicals and thus prevent the decomposition of pigments. Therefore, not only is a typical pink colour created, but these additives contribute to the colour's long-lasting stability under ultraviolet light and in the presence of oxygen.

Both sodium ascorbate and sodium erythorbate are insoluble in fat, and thus these additives have no antioxidative effects on fat and fatty tissue. These two additives together with alkaline phosphate are chelators that assist in reducing oxidation. These additives chelate metal ions, such as iron from the meat pigment myoglobin.

Finally, there are antioxidant-supporting additives: lactate, diacetate and sodium citrate. Lactate mainly functions as an agent for reducing water activity and it's inhibiting effects on the growth of microorganisms, in particular lactobacilli. Lactates are specifically used in uncured whole muscle meat products, such as breast of turkey and poultry rolls. Sodium citrate and diacetate have strong chelating and buffering properties, and sometimes this additive is used in products where the use of phosphates are restricted or prohibited.

Colouring

The colour of a meat product often gives instant eye appeal to the consumer. Colour visualization precedes other organoleptical parameters such as taste, flavour and texture. Particularly in high-yielding whole muscle meat products, e.g. cooked ham and shoulder picnics, the lack of haemoglobin and myoglobin may create end-products with colour flaws. To support the pink cured colour developed by the natural action of nitrite and haemoglobin, carmine is often used. Carmine is a natural red colouring agent made from the desectioned female insect *Coccus cacti*. These insects are present on the cactus plant *Nopalea coccinellifera*, which is cultivated in Mexico, Peru and Guatemala. Carmine is a stable additive under varying processing conditions of pH and temperature, and it is perhaps the only natural colour that remains stable under the influence of light. In its true form carmine is not water-soluble, and therefore it is suggested to use carmine that has been treated with alkaline agents such as sodium bicarbonate.

For hundreds of years, Asian meat and food processors have used fermented rice as a functional colour additive. This colour is made by the pigment-creating mushrooms *Monascus purpurens* and *Monascus angkak*, which develop on moist rice over a period of a few weeks into monascorubin and monascin. Angkak is a very effective, stable colouring agent and frequently used to provide meat analogues with the desirable cured meat look. It has been reported that angkak act as a preservative against *Bacillus subtilis* and *S. aureus*.

Paprika and red beet colour are less effective, since the colour is not stable at varying pH levels and can fade when exposed to light or air. Another colour-boosting additive is erythrosine. This artificial agent provides a less natural pink colour in cured products, but its cost is considerably cheaper.

Hydrocolloids

A colloid is a state of matter where individual particles of a substance are uniformly distributed as dispersion in another substance. When the medium is water, the colloid is called a hydrocolloid. Hydrocolloids lack the lipophilic and hydrophilic properties typical of emulsifiers. Hydrocolloids act particularly well as stability regulators in both whole muscle meat products and in some multiphase products such as low-fat emulsions. In processed meat products carrageenan is most often used. Carrageenan is made from seaweed and is available in semi-refined or fully refined form.

The three main types of carrageenan are kappa, iota and lambda. Kappa and iota carrageenan have gelling properties and thus can be used in cooked whole muscle meats. Kappa carrageenan has a high degree of gel structure firmness, which results in improved binding and slicing properties. These functional hydrocolloids are effective ingredients for controlling purge, increasing yield and improving texture. Carrageenan is particularly beneficial in combination with vegetable proteins and modified food starches in cooked whole muscle meat products and multiphase, low-fat emulsion systems.

In traditional or classic emulsions no specific gel characteristics need to be manipulated. Hence, carrageenan has little beneficial effect in these products. On the contrary, in these sausage products carrageenan might provoke antagonistic behaviour of the protein network.

In whole muscle meats, carrageenan is often used to prevent primary syneresis, or moisture purge, in packaged meats. However, the interbonding systems facilitated by carrageenan might be reduced or weakened if the cooked whole muscle product, such as pork ham, is sliced prior to packaging. The slicing action can destroy the initial bonding and hence promote secondary syneresis. To prevent secondary syneresis, it is therefore recommended to use these hydrocolloids in combination with other ingredients such as functional soy protein and modified food starch.

One of the most dynamic applications is the use of carrageenan in high-pumped pork ham and roast beef. Kappa carrageenan is most often used mainly because of its high degree of gel structure ability and resulting firmness and consistency. It is important to ascertain that carrageenan is properly dispersed in brine. Actual dissolution needs to be avoided, as otherwise brine viscosity can be raised to the point that injector needles become clogged.

Salt renders carrageenan insoluble, hence salt should always be added before carrageenan in the brine or pickle-making process. In an ideal situation, the carrageenan is added to the brine after the solubilization of phosphate and salt. This sequence allows the carrageenan to disperse and hence solubilization is avoided.

During the cooking cycle, dispersed carrageenan will swell and solubilize to be followed by gel setting upon cooling of the finished product. At times it can be observed that a carrageenan-containing brine results in the appearance of stripes or striations. The stripes run parallel with the meat fibres, or can show up as voids in the meat filled with gel. Striping or striations can be the result of allowing the carrageenan to prematurely solubilize, or of using different types of carrageenan in the same brine formula. The salt concentration in brine will also affect carrageenan properties, such as swelling. At higher salt levels, a higher cooking temperature is needed to obtain swelling. During thermal processing, carrageenan increases in viscosity and thus increases water retention. Upon cooling of the cooked product, the carrageenan forms a gel within the product matrix when the temperature drops to below 60°C.

Flavour Enhancers

Flavour enhancers are additives that, without altering the product's typical flavour, increase organoleptical properties such as smell and taste, without actually negatively affecting the basic four flavours such as sweet, salty, acid and bitter.

The common flavour enhancer is monosodium glutamate (MSG). MSG is industrially produced by the fermentation of molasses, and in cooked ham usually doses of between 0.2 and 0.6 g/kg finished product weight are used. Other flavour enhancers that are less commonly used because of cost constraints are sodium inosinate and sodium guanylate. Compared to MSG, these nucleotides have greater flavour-enhancing capability at considerably lower doses.

Soy Protein

Non-meat protein ingredients are very important in modern processing systems for whole muscle meat products. In the past, some cooked ham manufacturers used a combination of protein ingredients to increase yield. These blends usually contained varying levels of functional proteins, such as blood protein, milk by-products (sodium caseinate), egg albumen and powdered connective tissue. However, the protein of choice has become vegetable protein in general and soy protein isolate specifically. The ease of addition and the excellent water-holding and gelling properties have contributed to soy protein's popularity.

In brine systems, many variables influence the performance of soy protein ingredients. For example, the sequence of additive and/or ingredient addition, temperature of the water, and viscosity and shear force all impact on the true performance of the brine. Cold water slows down the hydration of soy protein, but at the same time it will minimize lump formation of the protein particles and will improve dispersion and solubilization of the soy protein ingredient.

Although it still is generally recommended to first hydrate the soy protein before the other brine ingredients and additives are added, it now has also become feasible to select a different sequence of addition. The processing flow may even be designed so that the new generation of soy protein ingredients is simply added as a dry powder directly into tumbling or massaging equipment. These proteins generally allow for higher inclusion levels, which translate into higher extension levels. To optimize dispersibility, very often the soy protein is treated with lecithin during spray drying, while also certain enzymes are used to lower viscosity. Obviously lower viscosity in a brine system will provide ease of use, especially when dense and small needle patterns are being used for high-pump whole-muscle meat.

Low-viscosity soy protein ingredients do not affect phosphate or salt solubility. The key is to allow proper hydration of soy protein isolate, though it is possible to add the protein before or after the phosphate with no difference in solubility. It is even possible to add the easily dispersed protein ingredients in the form of a blend to be added to the water with the phosphate and other functional ingredients. This system needs special rapid-dispersing brine rotating equipment. At times, foaming is reported as a negative side effect of using protein-containing brine ingredients. Foaming nearly always is caused by excessive air entrapment in the brine liquid, which can worsen when the brine is pumped or recirculated to a multi-needle injector. Innovative soy protein isolate technology minimizes or eliminates foaming, while maintaining optimal product functionality in the whole muscle foods.

The newer generation of enzyme-treated soy proteins are generally salt-tolerant and come with varying levels of viscosity and gelling properties. For high percentage levels of soy protein usage, the premium soy protein isolates are generally a better choice. In comparison, certain functional soy protein concentrates can be considered in moderately pumped meat products. It is, however, important that specialty soy protein ingredients are selected because these soy proteins have a clean flavour, low-gelling and elasticity, while at the same time excellent wetability and dispersibility. For cured whole muscle injection and marination, a small protein particle size is also important for improving injectability and penetration into the muscle meat. Moreover, these functional low gelling vegetable protein ingredients are ideally suitable for manufacturing phosphate-free and/or salt-reduced products.

Once the treated ham muscle meat has gone through cooking and chilling, these products will remain juicy and succulent and their texture will be infinitely superior. The cook yield is consistently higher when compared with other functional protein ingredients when used at similar inclusion and extension levels.

Additionally, this new generation of soy protein ingredients has seen a major flavour improvement, which allows processors to increase the percentage of inclusion, allowing delicate and distinct meat flavours to emerge quickly and without masking. Flavoured functional soy protein ingredients can be expected, further boosting the typical meat flavour profile. The protein's gelling properties are strikingly similar to that of lean meat, and ideally will reduce the typical rubbery or 'plastic' texture that often is associated with high yielding whole muscle meats containing excessive amounts of starch and hydrocolloids.

Ingredient levels are a function of the amount of added brine. If the pump level changes, it will be necessary to recalculate the percentages of the additives and ingredients. When whole muscle meat is packaged in permeable casings, moisture transfer is possible and the only likely change during thermal processing is loss of water. Although the yield will change in such cases, the amount of ingredients and additives present in the product will remain the same, though their concentration will change.

The optimum inclusion level of isolated protein generally varies from 1.0 to approximately 4.0%. The criteria are that for every 20% brine addition beyond 20% starting brine, about 1.5% soy protein isolate is needed. Thus, a brine addition of 60% would require about 3.0% soy protein isolate, and a brine addition of about 80%

Table 11.3. Brine conversion table.

% Pump	% SPI in finished product		
	2.0	1.5	1.0
10	22.00	16.50	11.00
20	12.00	9.00	6.00
30	8.67	6.50	4.33
40	7.00	5.25	3.50
50	6.00	4.50	3.00
60	5.33	4.00	2.67
70	4.86	3.64	2.43
80	4.50	3.38	2.25
90	4.22	3.17	2.11
100	4.00	3.00	2.00

would require 4.5%. It is obvious that with increasing brine addition levels, curing colour will be affected accordingly (Table 11.3). Modifications thus need to be made to substitute for the changed nitrite/myoglobin interactions.

Soy Protein Benefits

The benefits of soy protein in whole muscle meat products can be summed up as follows:

- Increased yield to green weight versus traditional brines as well as other functional proteins via better muscle absorption and marinade retention.
- Improved flexibility in developing optimal end products.
- Higher quality finished products versus traditional brines, which may dry out end product, and starches alone, which may cause soft product.
- User-friendly handling characteristics through the production process.
- Potential new finished product claims such as 'better texture' or 'improved succulence' or 'improved quality upon heating and holding'.
- Antioxidant properties may assist in the removal of warmed-over flavours.
- Maintenance or improvement of nutritional value of end-product.
- Functional soy protein concentrate can, in certain products, replace soy protein isolate at significant cost savings.

Brine Preparation

Brines can be described as suspensions consisting of stable fluids made of solid particles dispersed in a liquid. When the dispersed phase is no longer visibly distinguishable, the dispersion is ready for injection into the muscle meat. For brines and/or marinade injection systems, it is important that the 'liquid' can be injected before the dispersed or solubilized phases start to separate. Not only should brine or marinade ingredients and additives be harmonized and balanced, but it is equally important that the right equipment, such as rotor/stator mixers and circulation pumps, and proper passage through the dense needle pattern of the injector are used (Fig. 11.3).

To obtain optimum product characteristics it is important to weigh water and ingredients, rather than measure by volume. For traditional brine preparations, the water should be as cold as possible. If cold water is not available, ice should be used to cool down the brine. Brine ingredients and additives should be added in the appropriate sequence. (See Freixanet and Lagaras, 2001.)

Ingredients and additives used in whole muscle meats usually need to be hydrated and/or dissolved in brine, pickle or marinade. Conventional portable agitators and prop mixes may be acceptable in low-yielding cooked whole muscle meats, but they may be insufficient for high-yielding products. It can be quite a challenge to properly hydrate, disperse or solubilize ingredients and additives such as phosphate, soy protein, starches and hydrocolloids. In general, ingredients and additives used for these whole muscle meats are fairly expensive, and these ingredients therefore should be utilized in the best possible conditions (Table 11.4).

Brine preparation instructions:

1. Add soy protein slowly into a vortex of

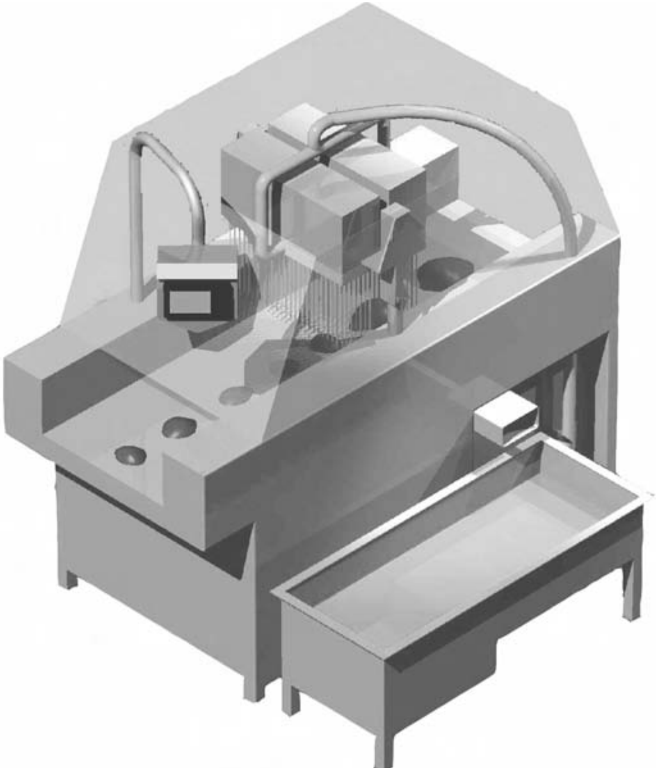

Fig. 11.3. Multi-needle brine injector. Source: Convenience Food Systems (CFS).

cold water (<10°C).
2. Use high-shear mixer and mix until smooth and shiny.
3. Hydrate the protein for at least 15 min.
4. Add phosphate and mix until dissolved.
5. Add salt and mix until dissolved.
6. Add seasonings and starches.
7. Add colouring and curing agents.
8. Add balance of ice, if necessary, to cool down brine temperature.

Alternative method:

1. Add phosphate to brine vessel and mix until ingredient is dissolved.
2. For best results use instantized phosphate and/or use high-shear mixer.
3. Add soy protein slowly into the vortex for lump-free hydration.
4. Depending on the type of vegetable protein, it will take some 15 min until the non-

Table 11.4. Brine absorption table.

	% Brine for absorption					
	15	20	25	30	35	40
Water	83.44	87.04	89.20	90.60	91.67	92.45
Salt	7.05	5.53	4.60	4.00	3.55	3.22
Phosphate	1.38	1.08	0.90	0.80	0.69	0.64
Dextrose	2.30	1.80	1.50	1.30	1.15	1.05
SPI	5.83	4.55	3.80	3.30	2.90	2.65
Total %	100	100	100	100	100	100

meat protein is completely dissolved.

5. Add salt.

6. After the salt has gone into solution, add seasonings and curing agents.

7. If applicable, add starch.

NB: If the brine is kept overnight, it is recommended to add the sodium ascorbate or sodium erythorbate prior to actual use.

Traditionally, brine solutions are normally prepared and preferably injected at temperatures of approximately –2°C. This temperature can be achieved by adding salt to the water, which allows the freezing point to drop below 0°C. When hydrocolloids such as carrageenan are part of the brine formula, brine temperatures are often lower. One can expect that when ingredients and additives are not fully dispersed or dissolved, the peak or optimum performance will not be reached. If the latter is the case, quite often the optimum quality is not obtained and brine ingredients or additives are wasted.

Calculation of brine additives and ingredients:

$$\frac{\text{\% ingredient desired product} \times \text{\% pumped product} \times \text{yield}}{\text{\% pump}}$$

$$= \text{\% ingredients in brine}$$

EXAMPLE:
A processor injects a ham 50% above green weight (=meat weight) and obtains a 90% cook yield. The cooked product has 1.5% soy protein, and 2.0% salt.

How much of each ingredient is needed in the brine?

$$\text{SPI} = \frac{1.5 \times 150 \times 0.90}{50}$$

$$= 4.05\% \text{ of brine is soy protein isolate}$$

$$\text{Salt} = \frac{2.0 \times 150 \times 0.90}{50} = 5.4\% \text{ of brine is salt}$$

Or a simplified calculation:

$$\frac{\text{\% ingredient desired in product} \times \text{\% yield}}{\text{\% pump}}$$

$$= \text{\% ingredient in brine}$$

EXAMPLE:

$$\frac{1.5 \times 135}{50} = 4.05\% \text{ of brine is SPI}$$

Actual percentage added ingredients:

$$\frac{\text{finished weight} - \text{total meat weight}}{\text{finished weight}}$$

$$= \text{\% added ingredients}$$

EXAMPLE:

$$\frac{1323 - 1000}{1323} = 24.4\% \text{ added ingredients}$$

Method of calculating product additives and ingredients:

$$\frac{\text{\% ingredient in brine} \times \text{pump}}{\text{\% pumped product} \times \text{yield}}$$

$$= \text{ingredient in product}$$

EXAMPLE:
A processor pumps 55% above green weight, and obtains a 94% cook yield. There is 4.1% soy protein and 5.8% salt in the brine.

How much of each will be pumped into the product?

$$\text{Soy protein } \frac{4.1 \times 55}{155 \times 0.94}$$

$$= 1.55\% \text{ soy protein in product}$$

$$\text{Salt} = \frac{5.8 \times 55}{155 \times 0.94} = 2.19\% \text{ salt in product}$$

Control percentage brine injected:

$$\frac{\text{weight of injected meat} - \text{weight of trimmed meat}}{\text{weight of trimmed meat}} \times 100$$

More Variables

Uniformity, colour, texture and yield are the major parameters for ham processors. The optimum brine or pickle temperature is a subject that meat technologists can not stop debating. Ideal brine temperatures for whole muscle meat applications range from below 0°C to as high as 38°C. In general, it can be concluded that elevated brine temperatures do significantly improve colour formation and colour retention in cured whole muscle meats, though it is also true that extra precautions need to be taken in order to avoid premature reduction of the sodium nitrite.

These modern ham processing systems allow staged addition of ingredients and together with manipulation of processing temperatures serve the purpose of optimizing processing controls precisely at the right time (Fig. 11.4). Obviously, optimum protein extraction is achieved through cold temperatures (–4°C) coupled with the right amount of salt and phosphate.

On the other hand, it is theorized that the solubility of most functional brine ingredients, such as salt and phosphate, is markedly better at higher water temperatures. Additionally, warmer water temperature accelerates the reaction time of active ingredients such as phosphate, ascorbic acid and nitrite. It is further theorized that less cooking energy is needed, and because of the higher temperature, the injected meat goes faster through the microbial propagation zone (7–52°C). On the other hand, depending on the type of whole muscle meat and the percentage of injection, prolonged massaging or tumbling times can be required at lower processing temperatures in order to optimize protein solubilization and brine absorption.

Phosphates, functional soy proteins and hydrocolloids need high-shear agitation in order to expose the individual particles to water for full hydration, dispersion and/or solubilization. This is necessary not only to avoid or minimize sludge in the brine tank or tumbler, but also to avoid injector needle clogging, which affects quality and causes purge. Also, target yields may become inconsistent. High-pumped brines usually contain a significant amount of dry ingredients, many of which are difficult to hydrate or dissolve. This tends to create a heavy and viscous slurry.

Some dry powder ingredients that are added to the water may form agglomerated particles or 'fish eyes' and thus it will be necessary to use high-shear mixing equipment such as the Admix/Rotostat™ or Molistick™ from Metalquimia to avoid lumping. This equipment is designed to reduce batch times to less than 10 min, eliminate clogged injection nozzles with optimum particle size reduction and provide full hydration, dispersion and/or solubilization. Additionally, round brine tanks are preferred over rectangular tanks. A round or cylinder-type vessel provides ideal vortex conditions, allowing rapid ingredient and additive hydration, dispersion and/or solubilization. It is recommended to mount the high-shear mixer off-centre to reduce excessive vortex in a cylinder vessel.

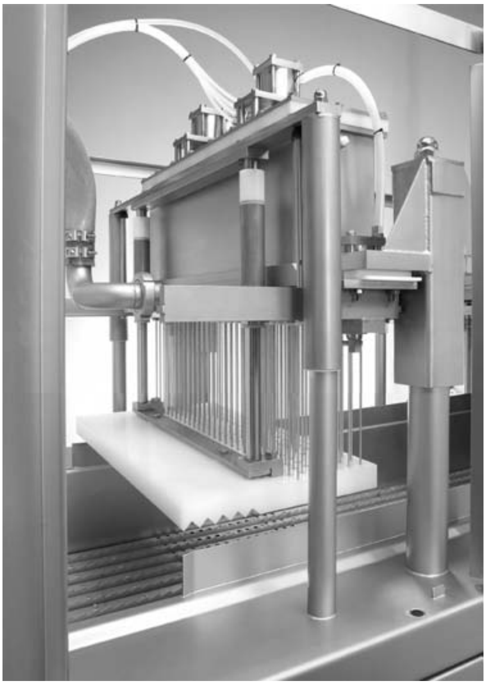

Fig. 11.4. Close-up photograph of ham injection. Source: Convenience Food Systems (CFS).

There seems to be some ongoing controversy about the ideal sequence of addition to the water. Generally speaking, ingredients and additives preferably should be added slowly but continuously and directly into the vortex. The suppliers of phosphate and soy protein both claim that their product needs to be added first. There are indeed reasons to add phosphate or soy protein first. It just depends which ingredient is deemed more important.

When soy protein ingredients are used, it is important to select a fast hydrating type. Usually soy protein ingredients with ultra-low viscosity perform best. There is little doubt that when soy protein isolate is added first into the water vortex optimum hydration is achieved, although it is true that foam might sometimes form. Low viscosity properties of the functional soy protein ingredient allow the solubilized protein to settle within the meat fibre structure without negatively affecting massaging temperatures, i.e. causing no friction. These functional soy proteins mimic cooked meat characteristics in terms of texture, colour and appearance. Subsequently, these ingredients can be used to reduce food costs while maintaining or improving nutritional quality.

Phosphates are much more difficult to dissolve, and that is why phosphate often is added first to the water vortex. To improve further phosphate solubilization, warm water is often used. Phosphates should be dissolved under continuous stirring or agitation. This step is followed by the addition of soy protein isolate, and full hydration usually is achieved in about 8–12 min agitation. At this time (nitrite) salt is added, followed by carbohydrates such as dextrose and maize syrup. After these ingredients have been thoroughly dissolved, modified food starches and sodium ascorbate or sodium erythorbate are added while the high-speed mixer is at full speed.

To aggressively lower brine temperature, it is common to initially withhold water, which is later added to the brine in the form of ice. A suggested starting ratio of water to ice is 80:20.

Hydrocolloids such as carrageenan should be added to the brine after the salt has been solubilized. To optimize hydration of carrageenan, it is recommended to pre-mix carrageenan with dextrose. Depending on the specific carrageenan type being used and the type of high-shear agitator, dispersion is achieved after between 6 and 12 min.

When blends of soy protein and modified food starch are used, it is recommended to add these ingredients following the phosphate addition. If anti-foam agents need to be used, it is suggested to add these aids prior to salt addition.

Spice extracts are generally recommended for injected whole muscle meats.

The purpose of purge control is to bind or stabilize water within a product so that moisture release is prevented. Purge control often means close interactivity of fine-tuning influences of ingredient selections as well as packaging criteria such as temperature and film properties. For example, vacuum skin packaging technology which actually locks free moisture in the product. For meat processors, purge control directly impacts on the bottom line, whereas for consumers purge control translates into aesthetics and eye appeal. Quite often purge control issues are related to shelf life issues. Purge needs to be masked in order not to ruin the merchandisability of the product. Consumers almost immediately associate purge with a safety risk. Functional soy proteins together with carrageenan and phosphates, for example, are often used in combination with antimicrobials, having a positive effect in vacuum packaged processed meat products. It happens that purge is neglectable when the processed meat remains uncut or unsliced. However, secondary purge can develop as a result of gel interference when the protein:hydrocolloid:water bonding is destroyed during slicing of the whole muscle meat product. Compared to food starches and carrageenan, soy protein ingredients are effectively binding or immobilizing free moisture while helping to maintain or enhance meat-like textural properties.

Injection

The purpose of a brine injector is to inject or pump brine into the meat muscle to obtain optimum distribution and weight gain. Nearly always a part of the brine drips out and together with meat juices is collected and recirculated back to the brine holding tank. Brines are expensive and recirculation and reusing makes good economic sense. However, apart from potential microbial contamination, recirculated brine is slowly diluted to the point that it interferes with end-product specification. Hence, quality flaws can result.

Extra precautions should also be taken that brine foam – which often is the result of poor brine preparation – does not get injected into the meat muscle. Injected foam can create entrapment of air bubbles, resulting in small pinholes or air pockets in the cooked meat product. Air pockets can contribute to oxidative rancidity and cause bacterial spoilage. Needle holes in cured products also are an indication that the injector needles are too large, possibly in combination with too high a pump pressure. If fat is still attached to the ham muscle, care should be taken that the hams are injected with the fat side down to minimize fat streaks.

When discussing whole muscle meats, usually products such as cooked hams and roast beef come to mind. These classic products are sold in transparent packaging containing ready-to-eat sliced processed meat products and mostly consumed as a sandwich topping. However, with the rapidly growing home meal replacement category, a new product range of protein-enhanced case-ready meat products is emerging. For these products, it is essential to maintain juiciness during regular shelf life when sold fresh, or when thermalized at the processing plant and finally reconstituted, prior to consumption.

Optimization of flavour and moisture distribution in whole muscle meats can be accomplished using an injector with a close needle pattern and a relatively low pump pressure. Additional vacuum tumbling or massaging will further disperse the marinade throughout the meat membranes. For large-volume operators, however, massaging or tumbling is not always an option. It is important to maintain optimum marinade quality and extra care should be given to the filtration system of the marinade recirculation. A clear distinction should be made between marinade injection for yield gain and marinade injection for improving sensory quality. Usually 10–15% marinade injection is sufficient to optimize sensory quality during final reheating. Marinade injection levels of >20% will increase yield, but can have a detrimental effect on product quality for these types of pre-cooked and ready-to-eat products. The latter, of course, is also greatly influenced by the marinade formulae, including the selection of functional non-meat protein ingredients.

Tumbling or Massaging

Massaging is usually accomplished by filling asymmetric containers with injected meat which are treated with a soft and gentle action at low speed (Fig. 11.5). It is typically a form of meat-on-meat massaging: the meat is not lifted and hence there is little or no destruction of meat fibres and connective tissue, resulting in high-quality meat products, albeit at lower injection levels. Meat tumbling is a system in which asymmetric carriers rotate in one direction at high speed, during which the injected meat is lifted (Fig. 11.6). This is a more aggressive treatment, which has shorter processing times and usually is used for meats that have been injected at higher levels. Tumbling usually results in a firmer texture, while massaging gives a more open, softer texture in cooked whole muscle products. For both methods, however, the action is enough to extract the optimum amounts of salt-soluble proteins needed to provide strong, close binding between individual muscle pieces. Massaging and tumbling is usually done under continuous vacuum, with the vacuum snorkel placed well above the meat

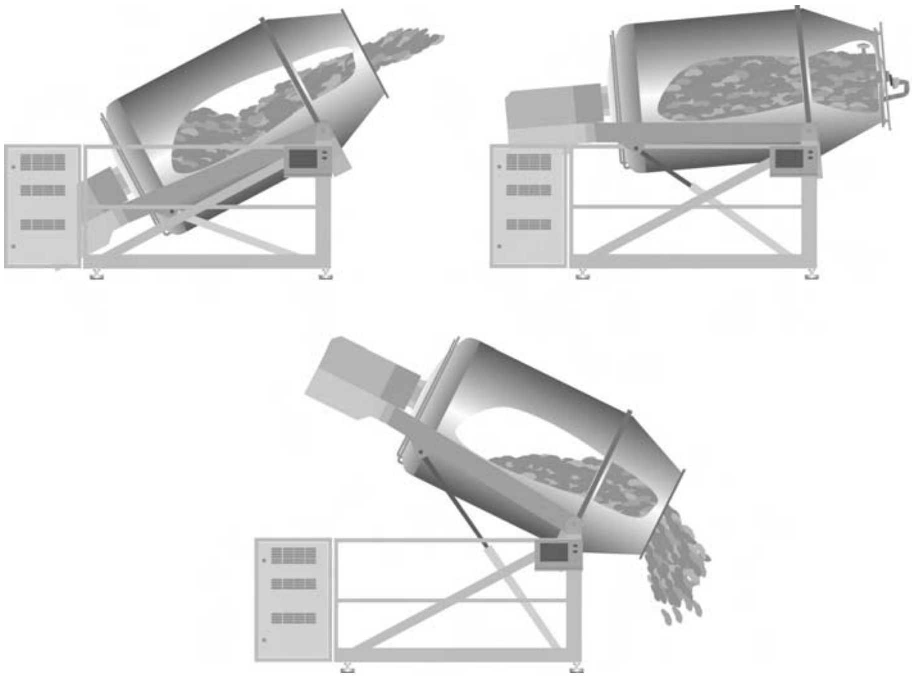

Fig. 11.5. Drawing of a massaging system. Source: Convenience Food Systems (CFS).

level. Emptying the drum effectively is ensured by tilting the drum to a negative angle.

The time needed to accomplish the protein extraction depends on many variables, such as temperature, brine formula, equipment and shearing actions (Table 11.5). As a rule of thumb it can be stated that sufficiently tumbled or massaged meat must show a thick layer of protein exudate on the meat surface. The latter can be significantly improved when fat layers are removed or trimmed down and connective tissues such as silver skin membranes are removed prior to injection. If fat or connective tissue removal is not possible, the second best option is to disrupt the layer by intensive macerating prior to tumbling or massaging.

As the amount of added water in high-moisture restructured cooked hams increases, the ability of the protein exudates to bind individual muscle pieces and retain added water decreases. Figure 11.7 shows examples of cooked hams.

Cooking and Post-process Surface Pasteurization

The minimum internal cooking temperatures required by processing regulations often exceed what is needed for food safety. For example, the degree of readiness in an uncured breast of turkey can be based on product characteristics, rather than upon killing pathogens. Often, meat processors and their food service customers target levels that are higher than the regulatory standards. The reasons are to build in safety zones, obtain desirable product characteristics and to eliminate certain heat-resistant spoilage bacteria. Usually non-cured products are cooked at higher temperatures than cured products.

Another area of increased attention is the need for post-process surface pasteurization for ready-to-eat deli meats. Foodborne pathogens have resulted in many fatal cases of listeriosis in high-risk segments of the population, causing massive product recalls by major producers. As

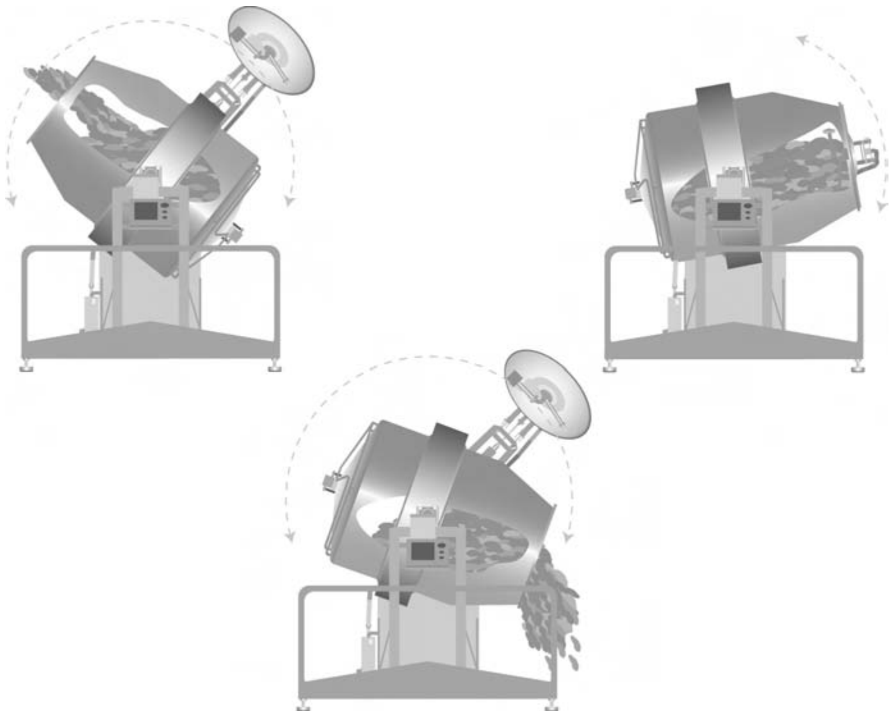

Fig. 11.6. Drawing of a tumbling system. Source: Convenience Food Systems (CFS).

a result of a variety of outbreaks of *L. monocytogenes*, the USDA Food Safety and Inspection Service (FSIS), as well as the American Meat Institute, have developed strategies aimed at reducing the risk of these foodborne pathogens in ready-to-eat (RTE) deli products. Rules proposed by the FSIS focus on Hazard Analysis and Critical Control Points (HCAPP) as well as sanitation SOPs. Producers of RTE products have various alternatives or combinations of alternatives to comply with FSIS require-

Table 11.5. Recommended mechanical conditions for whole muscle meats.

Tumbling	1–6 h cycle. About 4000–8000 revs. 10 min rest per hour 0–8°C processing temperature 10–20 rpm use vacuum
Massaging	6–24 h cycle 4–10 rpm 0–8°C processing temperature intermittently and reverse modes
Mixing	10–30 min cycle 20–30 rpm 0–8°C processing temperature preferably use vacuum
Macerating	for all treatment methods the use of mechanical macerators will shorten the processing time and may increase yield

Fig. 11.7. Injected and tumbled whole muscle meats – cooked hams. Source: Convenience Food Systems (CFS).

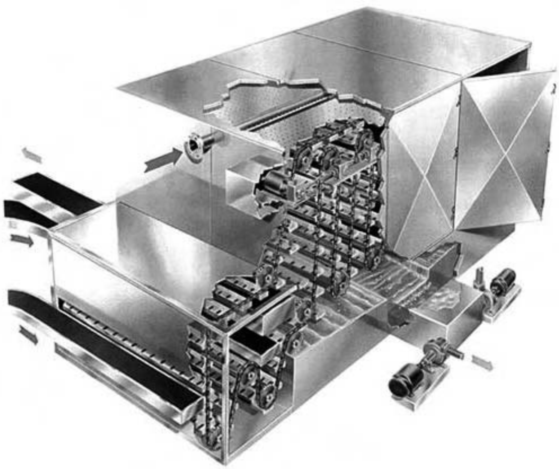

Fig. 11.8. Drawing of a post process surface pasteurization.

ments. In particular, surface thermal treatment, through post processing pasteurization, has proved itself to be an excellent way of reducing surface pathogen contamination. Effective surface pasteurization can be accomplished through the use of a water deluge, water immersion, steam application or infrared technology.

A typical post processing system consists of a heating zone and a chilling zone (Fig. 11.8). The product, for example a 5 kg roast beef or turkey ham in a barrier bag, would be loaded into trays at a rate of 30–35 pieces per minute. The product entering the system at a temperature of about 0–4°C will be retained in the heating zone for 3 min at a temperature of 94°C in order to achieve a surface temperature penetration of about 3 mm. Chilling the product back to its original temperature of 0°C is accomplished in the chilling zone with a deluge of either brine, water or a water/glycol mixture. Product retention time, using 0°C water, is 15 min.

Various scientific studies have provided support for the use of post process pasteurization heat treatment as an effective way of reducing *L. monocytogenes.* Depending on pasteurization temperatures and retention time, reductions of 4–5 log are achievable, representing a reduction in bacteria of 99.99–99.999%. Additional advantages are increased product quality as well as increased shelf life.

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Formulation Examples: Whole, Sectioned and Formed Meat

Smoked pork ham

Packaging	Shrink casing or net
Injection	55% pump over green weight
Yield	93% (expected)
Meat sources	Defatted and macerated ham, ground shanks (5 mm)
Tumbling	8 h, 50/10 cycle; 6–8 rpm; 60% vacuum; 5°C

Ingredient	% in brine	% in product
Ham	–	58.04
Shanks	–	6.45
Water	83.36	29.15
Soy protein isolate[a]	4.19	1.60
Salt	5.50	2.10
Phosphate	1.05	0.40
Dextrose	2.62	1.00
Modified food starch	2.62	1.00
Nitrite[b]	0.04	0.01
Sodium ascorbate[c]	0.13	0.05
Seasoning/flavourings	0.49	0.20
Total	100.00	100.00

[a]Suggest low-viscosity SPI.
[b]140 ppm.
[c]Alternative: sodium erythorbate.

Boneless deli ham

Packaging	Vacuum, cooked-in-bag
Injection	35% pump
Yield	98% (expected)
Meat source	Defatted and macerated pork and ground shanks (5 mm)
Tumbling	Intermittently 6 h; 20/20 cycle; 8–10 rpm; vacuum

Ingredient	% in brine	% in product
Ham	–	69.140
Ground shanks	–	4.410
Water	75.800	20.050
Soy protein isolate[a]	5.670	1.500
Salt	7.560	2.000
Phosphate	1.130	0.300
Dextrose	2.650	0.700
Brown sugar	1.890	0.500
Modified food starch	1.890	0.500
Carrageenan	1.890	0.500
Nitrite[b]	0.053	0.014

Boneless deli ham (*continued*)

Ingredient	% in brine	% in product
Sodium ascorbate[c]	0.190	0.050
Flavourings	1.277	0.336
Total	100.00	100.00

[a]Suggest low viscosity SPI.
[b]140 ppm.
[c]Alternative: sodium erythorbate.

Boneless smoked ham

Category	Ham and water product, X% added ingredients
Meats	Pork insides and outsides; fat trimmed
Packed	Fibrous casings when smoke-cooked Impermeable casing when water/steam-cooked
Process	Injected, macerated, vac. tumbled, 3 h, 10 rpm Rest overnight, retumble 15 min prior to stuffing Cook in graduated cycle to 72°C core temp.

Ingredient	%	%
Pork ham	57.00	57.00
Water	37.00	37.00
Salt	2.00	2.00
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Phosphate	0.40	0.40
Sodium ascorbate	0.05	0.05
Soy protein isolate[a]	2.20	
Soy protein concentrate[a]		2.20
Dextrose	0.80	0.80
Ham flavouring	0.20	0.20
Seasoning	0.20	0.20
Total	100.00	100.00

[a]Suggest low viscosity soy protein.
Results %: extension 75%; cook yield 90.6%; finished yield 158.5%; added ingredients 37%.

Chunked and formed ham

Packed	Vacuum/cook-in-the-bag
Meats	Defatted, desinewed, fist-sized ham or shoulder Ground shanks; lean ham/shoulder trimmings
Cook	Internal temperature of minimum 71°C

Ingredient	%	%
Chunked, defatted ham	44.00	44.00
Ground shank and lean trimmings	8.00	8.00
Soy protein granules	10.00	10.00
Water	25.00	25.00

Soy protein isolate[a]	3.00	
Soy protein concentrate[a]		3.00
Salt	2.60	2.60
Phosphate	0.40	0.40
Cure (6.25% $NaNO_2$)	0.20	0.20
Sodium lactate	2.40	2.40
Modified food starch	2.00	2.00
Maize syrup solids	2.20	2.20
Soluble ham seasoning	0.15	0.15
Sodium erythorbate/ascorbate	0.05	0.05
Total	100.00	100.00

[a]Suggest low viscosity soy protein.

Combi smoked ham

Added ingredients	41%
Meat sources	70% Ham meat 30% Turkey thigh meat
Curing system	Dry addition of all ingredients

Ingredient	%	%
Ham cushions	39.96	39.96
Turkey thigh meat	17.27	17.27
Pork back fat	1.76	1.76
Wheat starch	3.25	3.25
Ice water	28.46	28.46
Salt	1.43	1.43
Phosphate	0.40	0.40
Curing salts (6.25% $NaNO_2$)	0.15	0.15
Ascorbate/erythorbate	0.07	0.07
K-sorbate	0.20	0.20
Soy protein isolate[a]	2.88	
Soy protein concentrate[a]		2.88
Maize syrup	0.96	0.96
Dextrose	0.64	0.64
MSG	0.32	0.32
Pork flavourings	0.16	0.16
Carmine colour	0.05	0.05
Smoke flavour	0.15	0.15
Spices	1.89	1.89
Total	100.00	100.00

[a]Suggest low viscosity soy protein.

Procedure:

1. Add 50% of ice/water to macerated meat, mix for 2 min.
2. Add soy protein, continue mixing for 8 min.
3. Add remaining water, and add phosphate, salt and curing salt, mix for 10 min.
4. Add starches and sugars and mix for 10 min.
5. Add carmine solution, flavourings, erythorbate, seasoning and continue mixing, under vacuum if possible, for 30 min.
6. (Preferably) Rest overnight and fill in casings or moulds at <5°C.

Whole muscle ham (Belgium)

Ingredient	%
Pork ham (defatted)	66.00
Water	26.00
Salt	2.30
Curing salt (6.25% $NaNO_2$)	0.20
Phosphate (STPP)	0.40
Phosphate (SAPP)	0.10
Dextrose	0.50
Maltodextrine	1.60
Soy protein isolate[a]	1.30
Sweet whey powder	0.50
Sodium caseinate	0.50
Sodium ascorbate	0.05
Monosodium glutamate	0.05
Ham seasoning	0.50
Total	100.00

[a]Suggest low viscosity SPI.

Procedure:
1. Inject pork ham muscle meat to 50% extension and macerate about 2–3 cm deep.
2. Vacuum massage for 4 h at 12 rpm.
3. Hold overnight and retumble prior to stuffing for 30 min at 12 rpm.
4. Fill under vacuum into moisture-proof casings.
5. Place into moulds.
6. Steam or water cook using a cycle of respectively 60 min at 60°C, 90 min at 68°C and 80°C to finish at an internal temperature of 72°C.

Formed and pressed ham (Brazil)

Ingredient	%	%
Pork ham meat	40.00	40.00
Pork trimmings 3 mm	6.00	6.00
Pork knuckle meat	6.00	6.00
Pork skin (rind)[a]	6.00	6.00
Water	28.50	28.50
Salt	2.20	2.20
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Phosphate	0.40	0.40
Non-fat dry milk	1.00	1.00
Dextrose	1.15	1.15
Soy protein isolate[b]	2.50	
Soy protein concentrate[b]		2.50
Carrageenan	0.30	0.30
Wheat starch	2.00	2.00
MSG	0.20	0.20
Carmine colour	0.20	0.20
Sodium ascorbate[c]	0.40	0.40
Sodium lactate	2.40	2.40
Ham seasoning	0.60	0.60
Total	100.00	100.00

[a]Soften pork skin (rinds) with acid-treated water. For example: 60% pork skin (rinds) and 40% water + lactic acid. Rinse thoroughly with fresh water, and chop or grind to fine paste.
[b]Suggest low viscosity soy protein.
[c]Alternative: sodium erythorbate.

Procedure:
1. Macerate pork ham and pork knuckle or grind through kidney plate.
2. Grind pork trimmings through a 3 mm plate.
3. Add meat to paddle blender or tumbler together with half the water, (curing) salt, phosphate and mix for 30 min.
4. Add balance of water, soy protein ingredient, carrageenan, starches, all other ingredients and massage intermittently for 10 h, 50 min ON/10 min OFF.
5. Add 'pork skin (rind) emulsion' to massaging unit or tumbler about 4 h before end of massaging cycle.
6. Keep ham mix overnight and re-massage approximately 20 min prior to filling or press-forming for cook-in-the-bag processing and thermalization.
7. Cook to a core temperature of 72°C.

Pizza ham (Finland)

Ingredient	%	%
Pork shoulder (trimmed)	40.00	40.00
Pork trimmings 75CL	13.00	13.00
Water	33.00	33.00
Salt	1.80	1.80
Phosphate	0.40	0.40
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Dextrose	1.00	1.00
Soy protein isolate[a]	3.50	
Soy protein concentrate[a]		3.50
Potato starch	3.50	3.50
Sodium ascorbate[b]	0.05	0.05
Sodium lactate	3.00	3.00
Ham seasoning	0.60	0.60
Total	100.00	100.00

[a]Suggest low viscosity soy protein.
[b]Alternative: sodium erythorbate.

Procedure:
1. Grind all meat through 3 mm or 5 mm plate setting.
2. Add brine and mix under vacuum for 1 h.
3. Fill into casing and hold overnight before cooking.
4. Cook to an internal temperature of 72°C.

Retort ham sausage (China)

Ingredient	%	%
Lean pork (pre-cured)	50.00	50.00
Pork fat	9.00	9.00
Chicken skin	3.00	3.00

Retort ham sausage (China) (*continued*)

Ingredient	%	%
Water/ice	22.00	22.00
Soy protein isolate[a]	2.30	
Soy protein concentrate[a]		2.30
Salt	1.90	1.90
Phosphate	0.30	0.30
Curing salt (6.25% $NaNO_2$)	0.15	0.15
Maize starch	7.40	7.40
Non-fat dry milk	1.00	1.00
Egg powder	1.00	1.00
White pepper	0.10	0.10
Ginger	0.05	0.05
Garlic powder	0.15	0.15
Nutmeg	0.10	0.10
Sodium ascorbate[b]	0.05	0.05
Sugar	1.35	1.35
MSG	0.10	0.10
Vetcin	0.05	0.05
Total	100.00	100.00

[a]Suggest high viscosity SPI or FSPC.
[b]Alternative: sodium erythorbate.

Procedure:
1. Add pre-cured meat together with the chicken skin to chopper on slow speed and ice.
2. Add (nitrite) salt, phosphate, together with balance of water and chop on high speed.
3. Add soy protein and chop to approximately 10°C.
4. Add all other ingredients and sodium ascorbate and continue chopping to 14°C.
5. Fill into PVDC casings and retort to an F^o of about 4. The 'F'-value determines the degree of retorting or sterilization of a food or meat product in a can or PVDC casing.

Chunked and formed breast of turkey

Ingredient	%	%
Coarse inclusions:		
Turkey breast	40.30	40.30
Turkey white trimmings	20.00	20.00
Water	12.00	12.00
Salt	1.50	1.50
Phosphate	0.30	0.30
Soy protein isolate[a]	0.60	
Soy protein concentrate[a]		0.60
Sub total	74.70	74.60
Binding emulsion:		
Turkey wing meat	20.00	20.00
Salt	0.20	0.20
Phosphate	0.10	0.10
Butter flavour	0.20	0.20
Water	3.80	3.80
Soy protein isolate[a]	1.00	

Soy protein concentrate[a]		1.00
Sub total	25.30	25.30
Total	100.00	100.00

[a]Suggest low viscosity soy protein.

Procedure:

1. Tenderize or macerate turkey breast and add together with the trimmings to the tumbler or blender.
2. Add water, phosphate, salt and soy protein, and tumble or blend at 8–12 rpm for 60 min.
3. Chop turkey wing meat with remaining ingredients to a coherent emulsion, and add this emulsion to the pre-tumbled or blended turkey breast meat.
4. Continue tumbling or blending for 60 min, preferably under vacuum.
5. Reassemble meat sections into desired shape, and heat process.

Deli smoked pork loin

Ingredient	%	%
Pork loin	77.00	77.00
Water	20.00	20.00
Salt	0.70	0.70
Phosphate	0.40	0.40
Soy protein isolate[a]	1.60	
Soy protein concentrate[a]		1.60
Pepper	0.10	0.10
Garlic	0.05	0.05
Onions	0.10	0.10
Smoke flavour	0.05	0.05
Total	100.00	100.00

[a]Suggest low viscosity SPI or FSPC.

Procedure:

1. Prepare brine, adding soy protein first, then phosphate and salt.
2. Inject pork with 30% brine.
3. Vacuum tumble for 30 min.
4. If necessary, apply seasoning coating rub.
5. Vacuum tumble for 5 min.
6. Stuff into netting and smoke/cook to a core temperature of 72°C.

Chicken breast deli-style

Ingredient	%
Chicken breast	72.00
Water	19.30
Soy protein isolate[a]	2.50
Salt	0.80
Phosphate	0.40
Chopped or ground chicken skin	5.00
Total	100.00

[a]Suggest low viscosity SPI.

Procedure:
1. Grind chicken breast meat through a kidney plate.
2. Mix chicken meat and add soy protein, and cold water and blend for 10 min.
3. Add phosphate and salt and blend for 10 min.
4. Add ground chicken skin 3 mm and continue mixing until 30 min have elapsed.
5. Vacuum pack into moulded forms, or stuff into moisture-proof casings.
6. Thermalization.

Whole muscle turkey ham

Ingredient	%	%
Turkey thigh	50.00	50.00
Turkey thigh ground	5.00	5.00
Water	31.00	31.00
Soy protein isolate[a]	3.00	
Soy protein concentrate[a]		3.00
Carrageenan	0.30	0.30
Salt	2.30	2.30
Curing salt (6.25% $NaNO_2$)	0.20	0.20
Phosphate	0.40	0.40
Sugar	1.00	1.00
Liquid smoke	0.05	0.05
Sodium ascorbate	0.05	0.05
Monosodium glutamate (MSG)	0.05	0.05
Carmine colour	0.01	0.01
Potato starch	4.00	4.00
Sodium lactate	2.00	2.00
Ham seasoning	0.64	0.64
Total	100.00	100.00

[a]Suggest low viscosity SPI or FSPC.

Procedure:
1. Prepare brine by first mixing in soy protein, followed by salt and phosphate.
2. Inject turkey thighs to about 80% and macerate thighs to 25 mm.
3. Add ground turkey (3 mm) together with balance of brine and vacuum tumble for 4 h at 12–16 rpm.
4. Hold overnight and retumble for 20 min.
5. Fill into shrink casings or forms.
6. Cook to core temperature of 75°C.

Pastrami brine

Ingredient	%
Water	84.00
Salt	6.00
Sodium nitrite	0.06
Sodium ascorbate[a]	0.14
Phosphate	1.20
Dextrose	1.20
Soy protein isolate[b]	6.00
Onion powder	0.20
Garlic powder	0.40

Liquid smoke	0.20
Soy sauce	0.60
Total	100.00

[a]Alternative: sodium erythorbate.
[b]Low viscosity soy protein isolate.

Pastrami rub formula (15 Mesh):

- Coarse ground black pepper 33.33%.
- Coarse ground coriander 33.33%.
- Brown sugar 33.34%.

New York style: add 6% rub with 4% caramel colour to final tumbler cycle.
Armenia style: add 2% rub to final tumbling cycle.

Brine emulsions

Ingredient	%
Water/ice	41.00
Pork shank meat	41.00
Soy protein brine[a]	9.00
Soy protein isolate[b]	9.00
Total	100.00

[a]Add soy protein containing brine to chopper or mixer to shank meat and chop or mix until brine has been absorbed.
[b]Add water and soy protein and chop or mix until a cohesive emulsion is formed. If blended, use 3 mm plate in grinder.

Combi emulsion

Ingredient	%
Water	56.00
Connective tissue	17.00
Beef fat	17.00
Soy protein isolate	8.00
Salt	2.00
Total	100.00

Formulated turkey bacon (USA)

Ingredient	% Dark phase	% Light phase
Turkey thigh	75.00	00.00
White turkey trim	00.00	16.40
Turkey skin	00.00	28.00
Soy protein isolate[a]	00.00	7.50
Water	10.90	22.20
Ice	10.90	22.20
Salt	1.50	2.00
Phosphate	0.30	0.30
Sugar	1.00	1.00
Charoil	0.35	0.35
Sodium erythorbate[b]	0.04	0.04

Formulated turkey bacon (USA) (*continued*)

Ingredient	% Dark phase	% Light phase
Sodium nitrite[c]	0.01	0.01
Total	100.00	100.00

[a]Recommend high gelling SPI.
[b]Alternative: sodium ascorbate (vitamin C).
[c]Alternative: curing salt (6.25% $NaNO_2$).

Procedure dark phase:
1. Add turkey thigh to chopper. On slow speed add ice, (nitrite) salt and phosphate.
2. Chop on high speed for approx. 90 s.
3. Add water.
4. Add remaining ingredients and continue chopping until a strong binding meat batter is formed.

Procedure white phase:
1. Add white turkey trim and turkey skin to chopper together with (nitrite) salt, phosphate and chop for 15 s on slow speed.
2. Add ice/water and soy protein and chop on high speed until in total about 3 min have elapsed.
3. Add remaining ingredients and chop until strong meat emulsion is formed.
4. Stuff and cook.

Use double extrusion piston stuffer to simulate desired bacon swirl. For example, use 65% dark phase and 35% white phase.

Deli roast beef (USA) (30% added ingredients)

Ingredient	%
Beef rounds	66.60
Water	28.70
Salt	1.20
Phosphate	0.30
Dextrose	1.00
Soy protein isolate[a]	2.00
Onion powder	0.05
Pepper	0.05
Beef flavour	0.10
Total	100.00

[a]Recommend low viscosity SPI.

Procedure:
1. Hydrate soy protein isolate in cold water. For optimum results, a high-speed mixer is recommended.
2. Add phosphate and mix until dissolved.
3. Add salt and remaining ingredients and dissolve.
4. Inject brine and vacuum tumble for 2 h.
5. If necessary, rub with coat seasoning.
6. Fill into impermeable bag and vacuum seal.
7. Cook with live steam to a core temperature of 72°C.

8. Remove bag and roast in oven to finish cooking.

Restructured roast beef (USA)

Ingredient	%
Beef top rounds (diced)	63.55
Beef plates	16.00
Beef fat	4.40
Water	12.00
Salt	1.50
Phosphate	0.30
Sodium ascorbate	0.05
Soy protein isolate[a]	2.00
Seasoning	0.20
Total	100.00

[a]Suggest low viscosity SPI.

Procedure:
1. The diced beef top rounds are tumbled together with the brine for 20–25 min at 10 rpm.
2. Add 8 mm ground beef plates and 3 mm ground beef fat and continue tumbling until in total 40 min have elapsed.
3. Store overnight and tumble for 10 min.
4. Stuff into casings. Stuff loosely if the casings need to be reshaped under pressure.
5. Freeze.
6. Reconstitute at point of consumption. Remove casing and wrap the frozen or tempered beef-block into aluminium foil and roast for approximately 3.5 h at 93°C.
7. (Or in-plant roast thermalization immediately following stuffing.)
8. Cool down for slicing.

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Breaded Poultry Foods

Looking at today's huge success of poultry meat consumption in the Western world, it is hard to imagine that the chicken was first domesticated in India around 2000 BC. From there, the fowl, originally a sacred bird, moved both East and West. Chickens were present in the Philippine islands and other Pacific islands, long before the Spanish arrived. Also, the Chinese originated around 1400 BC what is now known as incubation of eggs. Europeans had to wait 3000 more years before they too mastered the art of egg incubation. From India, the chicken actually arrived in the Mediterranean countries sometime around 1400 BC, whereas central Europe started to domesticate chickens some 100 years later. It was actually Christopher Columbus, landing in the West Indies in 1493, who brought chickens to the Americas. The early European settlers of the eastern coast of what now is known as the USA introduced chickens in 1580.

Although chicken and eggs have been primary sources of protein for many centuries, only in the last 20 years has the consumption of chicken meat dramatically increased. Chicken, more so than beef or pork, is very suitable for people who have a hectic and time-pressed lifestyle.

Much of its popularity is due to the consumer's perception of quality attributes such as flavour, texture, taste and especially its white colour. Moreover, chicken is a neutral protein source accepted by all world cultures and religions, and is increasingly seen as an environmentally friendly source of nutrition. Because of chicken's versatility, it can be expected that chicken consumption will continue to grow. However, in some countries, such as the USA, it seems that the per capita consumption has peaked, possibly nearing saturation point. With no further product innovation, a saturation point will be reached and the only logical way to increase market share is to capture it from beef and pork.

A possible growth area for poultry is the breakfast meat market and ready-to-eat (RTE) meals in which poultry is used as a centre-of-the-plate item or as a characterizing ingredient of an integrated food such as tacos or lasagne. Another way is to create combination or fusion foods in which poultry functionally integrates without the consumer being able to detect its presence. Value-added further processing has been the major force to catapult poultry into cost-efficient, nutritional and tasty foods, mostly at the expense of red meat products. The early introductions of these poultry muscle foods were simply copycats of their red meat counterparts, such as bologna and frankfurter sausage. Most of these products were finely emulsified and found initial consumer acceptance because of significant cost savings generated by extensive use of mechanically deboned poultry meat.

Evolutionary Development of Poultry Products

In the early 1970s, most value-added poultry products were developed as batter-and-breaded chicken patties, utilizing both breast meat and thigh meat. Chicken meat is divided into white and dark meat. The 'white' breast section accounts for approximately 40% and the wings for 12%. The 'dark' meat thigh accounts for about 34% and the legs 14% of the carcass. Therefore, roughly half of the carcass meat is white and half is dark.

In the USA, the white meat is considered the elite or premium choice. Despite the fact that dark meat has a rich flavour, many US consumers consider dark meat inferior to breast meat. Perhaps the higher fat and calorie content influence the latter. Arguably the single largest drawback of dark poultry meat is that US consumers view it as a by-product. Yet, dark poultry is a very versatile meat, ideally suited for formulated products and exceptionally suited as a meat source in products that need cross-flavour diffusion.

For example, dark meat easily allows other flavours to be absorbed, and new technologies allow this meat to taste like pork or beef. It is obvious that the reasoning behind cross-flavour diffusion is embedded in the fact that dark poultry meat is a relatively cheap protein source. These products have become very popular in some Asian countries, and are best sellers on the menus of the world's largest fast food companies. For the USA market, however, the quest is to find new methods of adding value to dark chicken meat.

People love foods that crunch, and coated poultry products usually have about 25–30% pick-up from non-meat ingredients, such as pre-dust, batter and breading (Fig. 12.1). The early versions had high oil absorption via these coating systems. By

Fig. 12.1. Fully cooked coated food combinations. Source: Convenience Food Systems (CFS).

using forming and coating equipment an added plus of coated poultry was the fact that it became an efficient way to control and monitor portion weights. The introduction of bite-size chicken nuggets in the early 1980s impacted on the further processing industry, and a wide array of spin-off products has been developed using a plethora of coating systems that provide unique sensory characteristics.

New products are introduced at an ever-increasing speed and to be successful not only need to meet price/quality/convenience criteria, but perhaps equally importantly, need to employ unique point-of-sale packaging, for which appearance and durability are the two major product concerns. Institutional food service sales are the fastest growing segment of the RTE meal market. In terms of packaging, the main benefit for the food service operators is that consumers do not see the packaging of the prepared food. The operator only sees the basic packaging, and can fully focus on food integrity and quality, including shelf life.

Poultry's success can also be attributed to its efficient feed/meat conversion. Continuing progress in genetics and growout conditions has made poultry a very affordable source of protein. Another major advantage of poultry is its visual absence of fat. The meat is relatively easy to prepare, and requires much less cooking skill than some traditional cuts of red meat, which often need to simmer for hours in order to obtain the desired texture.

It is expected that the poultry industry will continue to target convenience-oriented and health-conscious consumers with innovative value-added foods. This is true for both classic coated foods and products made with innovative marinating technology, which allows flavour diffusion throughout the meat membranes. Furthermore, poultry is also suitable for inclusion as a characterizing ingredient in lifestyle foods. It is likely that such lifestyle foods will represent the next step in product innovation, offering multiple combinations of chicken meat, vegetables and cheese.

For a few years fried chicken foods seemed to go against the grain of eating habits of a growing number of people. It is therefore expected that the growth of the fried chicken category will be off-the-bone items. For example, oven-roasted products without skin will increasingly gain popularity. The real challenge is how to keep the fried chicken vibrant and relevant and, at the same time, not ignore people's desire for crunchy foods while keeping nutritional guidelines in check.

A most recent development is the removal of trans-fatty acids from batter and breaded foods. While beef, pork and chicken are naturally low in trans-fat, the substance can be found in significant quantities in certain added ingredients, such as breading and cooking oils. Today's consumers are more health-conscious than ever before and have increased awareness of the nutritional composition of the food they eat. Child nutrition, in particular, including school food service programmes, is an initial target market for these reformulated foods.

Large food companies, who have been traditionally slow to recognize the health-conscious changes in society, are now increasingly taking a leadership position in promoting well-balanced eating practices, moderation and physical activity that power healthy lifestyles.

Poultry Meat Variables

Poultry foods can be divided into cured and uncured products. Cured products are nearly always similar in appearance to red meat and include hot dogs, bologna, turkey ham, pastrami, and bacon-analogue and smoked sausage. Many of these are available with varying levels of fat. Most of the innovative poultry foods are made from uncured meats, and it is obvious that these nitrite-free products have become favourites of consumers because of their strong preference for white muscle appearance. As a result, poultry has become a popular choice that is versatile as a so-called 'fusion food' or cross-ethnic foods for a multitude of further processing systems.

Poultry is also versatile because of its unique ability to allow flavour diffusion by marinating. True membrane diffusion supports product characteristics for improving upon reconstitution time and holding time for fast-food preparations.

Technologically, poultry is similar to red meat. The main difference between the beef and pork equivalent is the rather fragile collagen structure of poultry muscle segments. This is explained by the fact that poultry meat generally is very young and therefore the carcass has not fully developed. After slaughtering, the glycolytic rate is rather fast – about 45 min – and the glycogen transformation or depletion determines the ultimate pH. Unlike red meat, the pH of poultry usually is considered of less importance. Still, pH levels of poultry have significant influences on properties such as texture, yield and juiciness of the end product.

In nearly all further processed poultry products, including bone-in products such as Buffalo wings and rotisserie chicken, mechanical action is needed to activate, swell or solubilize myofibrillar proteins and assist the marinade in penetrating the meat muscle. The degree of protein extraction is dependent on the required product characteristics, but usually it is safe to say that the smaller the particle size of the poultry meat, the greater the need for solubilization of the actomyosin proteins. Upon heating, proteins act to bind the individual meat pieces together. This fragmentation of the surface meat fibres is especially important if different skeletal meat sources such as breast meat, trimmings, thigh meat and skin are incorporated into the same product. The release of meat proteins, predominantly actomyosin protein, is a function of the type of mechanical action and the presence of functional additives such as salt and phosphate. These mechanical influences are usually driven by the specific design of equipment and meat blending temperature.

To maintain whole muscle integrity, mixer/blenders and tumblers are used. However, if meat of lower skeletal value is used, such as mechanically deboned poultry or trimmings, it often is necessary to develop restructuring features to re-create whole muscle appearance. For these products, use of fine grinding plates of 1 mm and bowlchoppers continue to prove beneficial for the preparation of pre-made emulsions to be integrated into restructured or simulated whole muscle products.

Meat protein extraction will also be improved if the poultry meat is first macerated (opening up of muscle parts) before it is blended with salt, phosphate and soy protein. White breast meat has a higher protein extraction, and therefore better adhesion and yield, than the rather collagen-rich thigh or dark meat. Poor binding often results in a watery texture of the product. However, this does not necessarily mean that the salt and phosphate are performing below standard. Apart from low pH, high blending or massaging temperatures often cause insufficient myofibrillar protein extraction and thus can cause unwanted premature partial denaturation of the meat protein. Therefore, poultry meat should preferably be kept at processing temperatures of about 2–4°C.

Of major concern is the colour of cooked, uncured poultry products. In cooked poultry, a pink colour is associated with under-processing, which consumers translate into health risks such as the presence of salmonella. Ingredients, additives, processing equipment using natural gas, environmental variables such as carbon monoxide, and myoglobin in highly pigmented thigh meat all can contribute to nitrite contamination. Indeed, very little nitrite ($NaNO_2$) is needed (<6 ppm) to 'jump start' unwanted curing and pinking of poultry meat.

The biggest potential sources of pinking are nitrite or nitrate in water, high levels of salt and alkaline phosphate, and high cooking temperatures. There are a number of causes, but to complete the list it is necessary to point out that soy protein that has been spray dried with direct heat also can contain increased levels of nitrite and nitrate. Pinking would increase by increasing inclusion levels of proteins that are actually not suited for application in uncured further processed poultry foods. Pinking occurs because of heat denaturation of NO-myoglobin (nitrosylhaemochrome). It is therefore important to select soy protein ingredients that have been indirectly heated during manufacturing.

Shelf Life Control

The optimum percentages of salt and phosphate, if desired, are almost self-regulating. Because of the perceived bland taste profile of poultry meat, salt levels seldom are higher than 1.0%. Phosphate levels are usually regulated by the food legislation, and are generally set at maximum inclusion level of 0.5%, though in blended poultry products phosphate levels are typically 0.2%.

Besides the protein extraction capabilities of salt and phosphate, there are a number of very important properties that need to be understood. First of all, salt is a pro-oxidative agent causing oxidative rancidity that shortens the shelf life of further processed poultry foods. The pro-oxidative value of salt is dependent on its inclusion level and the relative presence of fat, especially a high percentage of polyunsaturated fatty acids (PUFA). The latter is true for both par- or flash-fried and for fully cooked poultry products.

To diminish oxidation and rancidity, it is recommended to keep the inclusion level of salt at or below the 1.0% threshold. If, for sensory reasons, a higher salt level is needed, add the additional salt to the batter or breading, rather than directly to the meat.

By contrast, phosphate has antioxidative properties and therefore reduces off-flavours related to lipid oxidation in processed meats.

Generally, turkey meat is more prone to oxidation than chicken meat, and thigh meat has an increased susceptibility to oxidative rancidity compared with breast meat due to increased fat and myoglobin levels. Subsequently, higher amounts of phosphate in the formula mean lower development of oxidative rancidity. However, there is a taste trade-off. Not all phosphates are created equal and often have different flavour attributes. Generally speaking, the maximum allowable inclusion level of 0.5% phosphate often creates increased ‘soapiness’, sourness or bitterness in fully cooked poultry products. An acceptable compromise is an inclusion level of 0.8% salt and 0.2% phosphate.

There is little doubt that phosphate also influences the degree of juiciness. Proper juiciness – as opposed to sogginess – is obtained when the marinade has truly migrated into the meat muscle. This also explains why phosphate has such a significant influence on processing and cooking yield. The downside of increased juiciness is the observation that cooked poultry meat becomes softer and less firm. Phosphate inhibits lipid oxidation by acting as a chelator of free metals such as iron, and/or by increasing pH. The degree of oxidative rancidity is also influenced by cellular disruption of fat tissue, caused by grinding and/or emulsification. Subcutaneous fat can produce an abundance of volatile flavour compounds, also influenced by the previously mentioned ratio of saturated versus polyunsaturated fatty acids. In modern formulated poultry products, phosphate can impact on the texture and structure. Sodium tripolypyrophosphate (STPP) typically closes or tightens the texture, while sodium acid pyrophosphate (SAPP) generally opens up the meat texture. These variables are influenced by the percentage of phosphate addition and time/intensity of mixing. For example, prolonged mixing time will tighten up a meat texture when STPP is used.

To optimize shelf life, flavour retention and marinade holding capacity it is therefore important to incorporate functional non-meat protein ingredients. Soy protein isolate and soy protein concentrate are the proteins of choice to accomplish those objectives.

A number of scientific research studies have revealed the excellent antioxidative properties of soy protein, primarily attributed to polyphenolic acids and isoflavones – both excellent free radical reaction terminators. The combination of both the ‘scavenging’ soy protein and phosphate in a further processed poultry product resulted in a significantly longer shelf life (lower TBA) than either ingredient alone. Apart from improved shelf life, it is also believed that the combined presence of these two ingredients reduces the infamous warmed-over flavour developments.

It should be noted that soy protein is especially effective at lower cooking temperatures; phosphates are more effective at higher cooking temperatures. In many cases, the shelf life improvements and the reduction of warmed-over flavours are obtained at an added soy protein inclusion level of as low as 1.5%.

Fat Distribution

The presence of disrupted fat cells greatly influences cooking and yield results. If fat or skin in formed and/or coated poultry products is insufficiently stabilized, the fibrosity of the meat and other textural properties of the patties is generally lessened. Stabilized or restricted fat and skin levels in formulated poultry foods reduce moisture loss during thermal processing and/or reconstitution. This is especially important for poultry products that are fully cooked at the plant.

The presence of functional soy protein will greatly improve textural characteristics and increase cook yields. A possible explanation is that functional soy protein ingredients can entrap fat and moisture in a semi-emulsion that is either pre-made from skin, water and soy protein or unintentionally made during mechanical blending or mixing. It can be hypothesized that solubilized soy protein is interfacially adsorbed to liberated fat droplets, restricting its movement, if sufficient extracted salt-soluble protein is present, thus minimizing the fat/water tensions. It is also known that the use of a pre-made emulsion can significantly whiten the final product appearance. This is especially important for cosmetic appeal, since consumers prefer a white appearance of the meat.

Chicken Skin

Skin is used in chicken nuggets and patties in the range of 5–12%, though cheaper formulae can contain up to 25% skin. Chicken skin supports the typical chicken flavour and boosts juiciness while also reducing costs and contributing to whiteness if sufficiently emulsified with vegetable protein and water. To shorten mixing times and reduce cryogen use, and to avoid the extra effort in pre-emulsifying chicken skin, new technologies are being developed. Basically, a finely size-reduced chicken skin is made into a suspension with water and decanted into a closed tumbler or mixer/blender. When this system is used, it will be necessary to make non-meat protein allowances and adjustments to stabilize or bind the skin suspension during the final mixing process.

On the down side, chicken skin contributes to increased fat calories and increased cholesterol content. Technically speaking, elevated levels of unstabilized skin have a tendency to colour the blended meat formula, giving it a slight off-white or greyish colour. Also, during frying and reconstitution, ground skin can break down to fat and gelatine, often resulting in small pinholes and a spongy texture.

Additionally, skin contributes to increased microbial risks, especially when the product is not fully cooked, and promotes oxidative rancidity. The addition of cryogen may cause stability problems when excessive skin is present, and may lead to coating cracking when fully cooked products are re-thermalized prior to serving. A sufficiently strong cover system will need to be used, especially when the products are reconstituted from a par- or flash-fried state. Often these negatives are reduced or eliminated when functional soy protein is used to pre-emulsify chicken skin. This will whiten up the final product, while the antioxidative properties of soy protein delay the onset of rancidity.

Another very efficient method for utilizing chicken skin is to use soy protein to prepare a skin granule or skin intermediate. The skin granule can be made, for example, from one part of functional soy protein, two parts of water and two parts of finely ground skin. First, the finely ground skin is added into the mixer, followed by the addition of the soy protein. Once the soy protein has been evenly mixed, ice water is added and, depending on the type of equipment, mixed for approximately 20 min. The soy protein granule or skin intermediate is discharged from the mixer and deep-chilled to –2°C. Prior to use, the protein granule or skin intermediate can be given specific definition in a chopper or sized by grinding.

Procedure for Chicken Skin Processing

Depending on the formula and equipment constraints, skin can be added to the formulated poultry foods as a finely ground material, or in the form of a pre-made emulsion.

- Chopper method:
  Add 4 parts of water to chopper; add soy protein while at low speed to wet out.
  Chop at fast speed for 1 min or until glossy.
  Add 5 parts of 3 mm ground skin and chop for 3–5 min to form coherent emulsion.
- Mixer and grinder:
  Add 4 parts of water and 1 part of soy protein to mixer and blend for 2–3 min.
  Add 5 parts of 3 mm ground skin and blend for 3–4 min.
  Pass through 1 mm plate, or Comitrol.

To optimize the functionality of soy protein, it is nearly always recommended to hydrate these vegetable proteins first. When used in a formed poultry product, the suggested rate of hydration is 3–4 parts of water to 1 part of functional soy protein. When used as a marinade that needs to be diffused into the meat membranes, viscosity becomes important and thus hydration is suggested at a ratio of 10 parts of water to 1 part low-viscosity-type soy protein isolate. The most appropriate method of soy protein addition depends on equipment and processing constraints, and above all the specific formula. If a large inclusion level of water and soy protein is present, it is generally recommended to hydrate the soy protein before the meat and other ingredients and additives are added.

Protein Selections

Solvent-free extraction process of soybean curd, i.e. no hexane-addition, have improved much of the soy protein flavour profile. Hence higher soy protein inclusion levels are possible without negatively impacting flavour of the end-product. Still, generally speaking, meat formulations with a comparatively mild or bland flavour such as lightly coated breast of chicken will be more sensitive to soy protein flavour than highly seasoned products. Low flavour profile meat products will favour a protein ingredient with an ultra-clean flavour such as specially processed soy protein isolate.

The use of functional soy protein ingredients offers the processor a platform from which to create a wide range of formulated chicken foods. For standard chicken patties containing breast meat and/or thigh meat, it is also possible to add the functional ingredients in dry form. Good results are obtained when the selected meats are blended for some 30 s with salt and phosphate, after which water is added. The blending continues for another minute, before soy protein is added. This method ensures sufficient meat protein solubilization, while at the same time functional soy protein can be hydrated in the formula water to allow fast uptake by the meat.

Certain types of soy protein ingredients have the capability of whitening the product, especially the darker thigh meat, when using a brine or skin emulsion. If chicken skin is part of the formula, ground skin should be added after the soy protein is sufficiently hydrated. Total blending time should be extended by another 1 min. The optimum blending temperature is approximately 0°C, and prolonged blending or mixing usually tightens the textural properties.

Uniform and low temperatures are critical for obtaining the required product specifications. After the marinade ingredients have been evenly distributed throughout the meat, cryogens such as carbon dioxide (CO_2) snow or liquid nitrogen (N_2) are used to temper the meat to allow forming with control of shape and muscle integrity. Most forming machines produce uniform, consistent shapes and weights at –3° to –1°C. Actual temperatures vary depending on the specific forming system used. The use of cryogenics is important, however its use should be restricted to maintain the forming temperatures, since overuse of cryogens can cause both damage to meat definition, due to textural deficiencies, and to blending and forming equipment. Temperatures below –3°C may affect filling characteristics in the forming plate area and reduce batter adhesion. Temperatures higher than 0°C may affect the knock-out abilities of the former, and will damage the product's integrity when it travels through the coating line and thermal processing zones. The latter is especially true for natural contour products, topographically shaped portions or 3D-formed products using a different type of filling port to maintain whole muscle integrity.

Though many processing instructions require a certain minimum/maximum forming temperature, it is often overlooked that the presence of salt, phosphate and fat also greatly influences the formability of formulated meat or poultry products. It has been reported that CO_2 has a greater tendency than N_2 to create pores or spongy appearance in the cooked formulated poultry product. This is especially the case when unstable chicken skin is present. Overmixing, while trying to reduce the temperature from too high a starting point, actually accentuates the appearance of these little holes. Non-meat protein marination often is necessary to achieve critical control point optimization regarding complete fill, texture, juiciness, colour and whole muscle appearance. Modern blending equipment allows cryogens to be injected from the bottom, and the use of liquid nitrogen (N_2) will chill more rapidly and evenly. In both cases, bottom injection of cryogens will reduce cooling costs because significantly less energy escapes from the top vents of the blenders.

Coating System

The modern form of battered and breaded foods originated in northern England during the Industrial Revolution in the early 1820s. Cotton workers and other industrial workers most often had their main meal of the day at the factory canteens, and quite often these meals served battered, oil fried fish in combination with potato fries. These 'fish and chips' meals, wrapped in old newspapers, became the main staple for many generations. It is widely believed that these batters and breading have evolved from that time into today's convenience food systems.

Although in today's environment the convenience foods are mainly driven by American cuisine, battered or coated foods are relatively new in the USA. Japanese and Chinese cultures have used flour-dipped and oil-fried fish, meats and vegetables for centuries.

There is an endless variety of coating systems. Most of these wheat flour-based products add extra value to formulated muscle foods. Of more recent development is the use of potato starches in coating systems to achieve specific characteristics. Potato starches are high in amylose and are associated with improved textural properties. High-molecular weight amylose starches feature increased crispiness with greater oil resistance. The latter means less oil pick-up during frying, resulting in a crispier and less greasy appearance. Like soy protein, the use of potato starch as a component of pre-dust can also improve adhesion properties of the subsequent batter layers.

Coatings can be divided into the following categories:

- Flour-based breaders.
- Crackermeal breaders.
- Japanese or Oriental bread crumbs.
- American bread crumbs.
- Batters, including Tempura batters.
- Glazes.
- Rubs and rotisserie coatings.

Coated poultry foods have a number of layers and each layer needs to be compatible with the adjacent layer. There are generally three layers given to (formed) poultry products: pre-dust, batter and breading. The function of the pre-dust is to provide adhesion, texture and flavour. Pre-dust is also an easy way to add flours and starches to the

Table 12.1. Typical examples of a coating sequence.

	Step							
	1	2	3	4	5	6	7	8
Nuggets	Forming	Pre-dust	Cooking	Battering	Flouring	Tempura	Frying	Cooling
Nuggets	Forming	Pre-dust	Battering	Breading	Par-fry	Cooking	Cooling	
Chicken fingers	Forming	Battering	Breading	Frying	Cooking	Cooling		
Chicken burgers	Forming	Battering	Breading	Frying	Cooling			
Chicken fillets	Pre-dust	Battering	Breading	Cooling				
Escalopes	Battering	Breading	Cooling					
Whole broilers	Cooking	Cooling						
Half broilers	Cooking	Pre-dust	Battering	Breading	Frying	Cooling		
Chicken thighs	Pre-dust	Battering	Pre-dust	Cooling				

raw surface area of the meat. This increases pick-up and helps obtain cost advantages (Table 12.1).

If coated poultry foods are fully cooked, then it may be necessary to pre-dust formed products. This is also the case when modern convection ovens are used, where the product is first cooked, prior to travelling through the batter and breading applicator. The pre-dust sets up a base, which bridges the bonding between the substrate and the adjacent layers such as batter and crumbs. A conveyor belt carries the product on to a flour bed. Small doses of flour are fed constantly on to the shaker belt, where the flour spreads evenly to create a thin or thick top layer, as desired. Lumps are automatically removed. Optionally, the product runs under an adjustable pressure roll, ensuring optimal flour adhesion. Ticklers remove surplus flour through automatically controlled belt vibration. At the outfeed, excess flour is blown off (Fig. 12.2).

Some pre-dusts contain adhesion-promoting ingredients such as soy protein concentrate. Like vital wheat gluten, a 1–2% addition to the pre-dust formula of soy protein concentrate has proved to be effective in improving the film barrier's retention

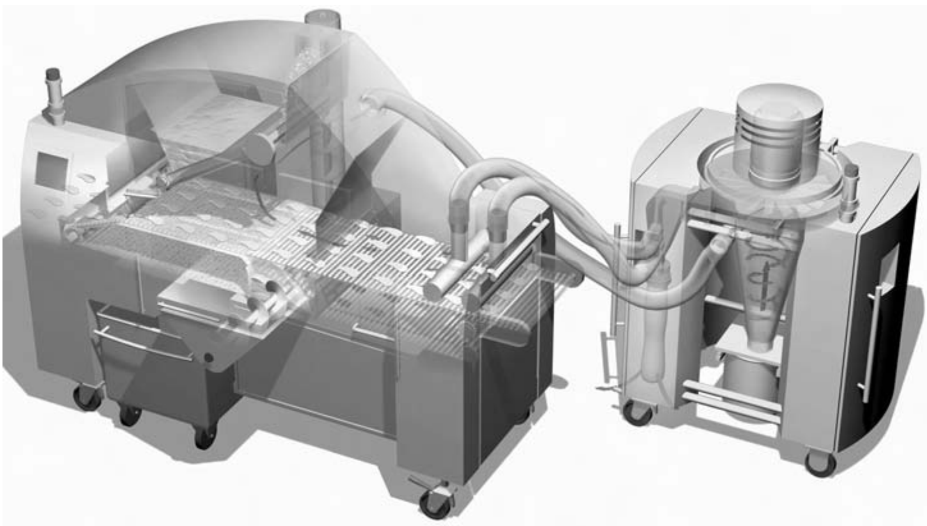

Fig. 12.2. Automated flour coating line. Source: Convenience Food Systems (CFS).

yield and crispiness. Pre-dusting is a good vehicle to carry spices and seasonings. Without pre-dust, a somewhat less strong adhesion will develop between the coating and the (formed) meat, which can cause the infamous ‘blow-away’ from the product. Coating cracking is usually caused by insufficient and irregular uptake of the marinade ingredients in combination with temperature control and humidity. Overmixing can further complicate these variables, especially when traces of CO_2 snow are still present in the formed meat.

The optimum ambient plant processing temperature should be between 4°C and 10°C.

The use of functional soy protein ingredients in formed or marinated meat substrate is of importance in controlling moisture. During thermalization, moisture that has not fully penetrated the meat membranes tends to escape from the substrate and travel through the coating in the form of steam. Apart from negatively impacting on yield, this phenomenon also causes the product to dry out and affect the texture and may cause problems with coating blow-off and cracking. These properties are possibly the main values that functional non-meat protein offers in moisture management during thermalization, including the final reconstitution prior to consumption (Table 12.2).

Batter Characteristics

Batters are a blend of starches, flours, seasonings and leavening agents that need to be mixed with water to form a viscous liquid. The batter liquid that adheres to the pre-dust provides adhesion, texture, flavour and product extension. Batter needs to be evenly applied to the meat pieces to allow uniform breading distribution. Apart from starch and carbohydrates, usually small amounts of gums, such as guar, xanthan and methylcellulose, are added to increase or fine-tune batter viscosity for better adhesion to the substrate. Typically, batter application is accomplished with a batter machine that runs the product through a multi-layer batter curtain and bath, after which excess batter is removed with an air knife.

A spin-off version of adhesion batter is tempura batter. Tempura batters play a dual role, since they serve as the adhesion medium and outer layer at the same time. The main difference is the leavening agent that is added to the batter. Tempura batter is applied when a conveyor belt carries the product through the batter bath. A second belt on top guides the product down into the bath and ensures complete immersion for even coverage. As the product leaves the bath, excess tempura batter is blown off and recirculated. The product continues to a

Table 12.2. Processing of crumbed microwavable food products.

Frozen foodstuffs
↓
Dipping the foodstuffs in a dipping solution
↓
Coating the dipped foodstuffs in a pre-dust
↓
Covering the pre-dust-coated foodstuffs with a batter
↓
Applying breadcrumbs to the battered foodstuffs
↓
Flash-frying the crumbed foodstuffs for 30–60 s at 180–200°C
↓
Blast freezing the flash-fried products for 20–45 min at –21 to –28°C
↓
Packaging and sealing the frozen products
↓
Frozen storing the frozen products at or under –18°C

separate outfeed belt, which can transfer it directly to the fryer with no excess tempura batter, where it will puff up light and crisp around the product.

Typically, leavening agents regulate texture, and usually sodium bicarbonate, sodium acid pyrophosphate and/or sodium aluminium phosphate are used to obtain the right degree of the characteristic open and light structure. Tempura batters puff when fried due to the significant amount of leavening agents that provide the desired appearance and crunchy texture. Tempura batters are usually applied by submerging the formed meats throughout the thick viscous liquid. Since tempura batters cannot be circulated, a different type of applicator is used, sometimes called a 'tempura dipper'. In this system, a top and bottom conveyor transports the product through a batter bath, thereby preserving the batter's puffing effect. If no tempura batters are used, the final layer of coating is the breading.

Breading crumbs are oven-baked cereals applied immediately following the pass through the curtain batter applicator. A conveyor belt transfers the product on to a bottom layer of breading. From a hopper above, a top layer is applied, the thickness of which is manually adjustable. A pressure roller or vibration plate system aids the adhering of the breading to the substrate. Excess breading is then blown off and the product is transferred to an outfeed belt. Excess breading is returned to the circulation system, while the coated product transfers to the next stage of processing. The choice of breading greatly influences final product characteristics, including texture and eye-appeal. First of all, breading can be divided by the manufacturing method: traditionally baked American breadcrumbs with a typical crunchy texture; extruded crumbs made with a continuous cooking extruder that allows textural properties to be regulated from dense to crunchy; and cracker crumbs that have a biscuit-like texture. The latter is called rusk in the UK. A further coating system is the Japanese or Oriental crumb, which is produced from a highly yeast-leavened dough, providing an extremely porous product with a light and crispy texture, suitable for many types of reformulated poultry foods. Oriental crumbs generally have a longer fry tolerance.

Batter and breaded foods usually contain about 8–15% oil absorption, and this is really the only negative that can hinder its popularity increasing even further. Although low-fat coating options are now available, the search is still on for the perfect formulated poultry product that allows microwave cooking while controlling fat calories.

A possible solution to reduce oil absorption is to force a reaction between a calcium-ion source that is present in specially made breading and calcium-reactive pectin. This technology creates a barrier that shields the coated product from the usual oil uptake. Following the coating of the substrate, the product travels for 3–5 s through a pectin solution prior to par-frying.

Another innovative method for reducing oil absorption is to use modified predust, batter and breading to coat the substrate. After coating, products are sprayed with an emulsion of oil, water, protein and flavours. The amount of emulsion sprayed depends on the required fat content. The products are then heated using an infrared oven at 900°C for 40–60 s.

Recent developments are the zero or very low carbohydrate coating systems. To please the 'carb-aware' consumer, batter and breaded entrees are re-positioned to fit a low net-carbohydrate lifestyle. Both crunchy and flour-type low-carb breadings are now available and the predominant proteins are derived from soy and wheat. In these low-carb coating systems, high levels of dietary fibres represent more than 90% of the carbohydrates and together with soy protein both enhance carbohydrate profile as well as promoting controlled browning during frying and oven-cooking.

A multi-step cover system usually is necessary to obtain high levels of pick-up. In recent years, the total amount of pick-up has gradually decreased from about 30% to about 22%. This reflects the desire of modern consumers, who do not want a thick batter interface but prefer a healthier, 'light' coating system. However, there is a danger that taste might be sacrificed and traded for lower fat pick-up. The consumer still longs for traditional golden-coloured batter and breaded foods that are deep-fried in oil with a crispy, crunchy texture, albeit at reduced total fat calories.

Glaze basically serves as an edible glue or binder to provide integrity of the product together with flavour-enhancing ingredients or other organoleptical appearance. Glazings are typically applied by either submerging the substrate or the use of an overflow curtain of a typical batter machine.

Reconstituted or reheated coated patties or nuggets should not be soggy, dry and oily or show signs of overcooking. The tolerance for batter/breading defects is rather small and excess ridges and lumps and missing coating should be avoided. Final product should be free of rancidity and carry no metallic, scorching or burnt taste.

Despite the perceived high fat absorption of fried breaded chicken, the products continue to enjoy wide popularity. Throughout the world of further poultry processing there always seems to be some confusion on how to calculate yield and pick-up. In the USA – under USDA requirements – marinade pick-up is based on green weight, while total breading or coating pick-up is calculated upon finished weight. Subsequently, a 25% marinade pick-up means 80% meat portion and 20% added marinade [100 :(100+25)=80]. However, a 25% breading pick-up reflects 75% meat portion and 25% added coating or breading ingredients. Products that have more than 30% breading need to be labelled 'fritter' under USDA regulations. In other parts of the world, these standards are often different and can be further complicated by the calculation methods of yield of breaded products that have been par-fried or fully cooked. (See Mandava and Hoogenkamp, 1999.)

The percentage of yield and pick-up is calculated as follows:

$$\%\ \text{Yield} = \frac{\text{finished weight}}{\text{starting weight}} \times 100$$

$$\%\ \text{Pick-up} = \frac{\text{finished weight} - \text{starting weight}}{\text{finished weight}}$$

Cook yield is the percentage weight after the par- or fully cook process.

Overall yield is the percentage weight at the end of the processing cycle after cooling or freezing.

Example:

$$\text{Cook yield} = \frac{1300}{1250} \times 100 = 104.00\%$$

$$\text{Overall yield} = \frac{1230}{1250} \times 100 = 98.40\%$$

There is a growing trend toward lighter coatings, including glazes, rubs and transparent finishes. Although these coating systems can be oil-fried, the real value is mainly for products that are baked. Glazes are coatings added to (formed) marinated poultry products either in liquid or dry form. These coatings transfer during thermalization into a semi-liquid state. Like rubs and rotisseries, the main function of glazes is to add eye appeal, while at the same time provide specific seasoning profiles.

Fully Cooked Convenience

The early versions of further processed poultry products that were fully cooked in oil at the plant frequently turned dry when reconstituted for final consumption. These poultry products had excessive moisture loss, a problem that worsened when kept in a holding oven to maintain serving temperature. During prolonged frying, the outer surface rapidly dehydrates. The main purpose of frying coated foods is to seal the product and to provide its typical golden colour. However, in terms of optimization of both product quality and convenience, much has changed in recent years. Both food service operations and consumers want more convenience, albeit for different reasons. Convenience can be driven by the need to minimize food-borne diseases and health risks and by the pressing need for improved food-handling tolerance, such as faster re-thermalization by low-skilled food handlers, and still improves upon faster consumer throughput. The consumer prefers to have 'goof-proof' foods that they just need to heat and eat.

It is obvious that marinade distribution and moisture retention are key requirements for formulated poultry foods. Poultry meat will retain a fibrous appearance if the marinade is fully absorbed. For reformulated boneless products, it often helps to increase the surface area of the meat by macerating, to allow higher absorption. Macerating is actually a trade-off; the larger the surface area of the meat, the higher the absorption. Or to put it differently: the smaller the meat pieces, the less the simulation of whole muscle appearance. However, protein-marinated meat has the tendency to realign itself. Apart from the selection and fine-tuning of marinade ingredients such as salt, phosphates, flavourings and the right type of non-meat protein ingredient, forming equipment, coating systems and thermal processing conditions are the main criteria for optimizing quality.

Marination

Poultry is not only bland in taste, it also has excellent properties in accepting added flavours. Improved marinating technologies, coupled with improved thermalization equipment, have given poultry processors many new options for new flavours, while significantly increasing both processing and cooking yield.

Brining, marinating and infusion are methods for adding unique flavours to muscle foods. Brining can add moisture for improving sensoric quality, as well as diffusing ingredients and flavours throughout the muscle structure. These systems generally also add weight to the finished product which generates cost reductions. Acidic marinade acts as a tenderizer and is frequently used to soften texture of tough cuts of meat. It is obvious that acidic marinades usually are used to improve textural quality of less desirable cuts, such as beef skirts.

Functional ingredients directly influence yield. A well-rounded marinade will allow complete diffusion into the meat membranes in the shortest possible time. It is generally known and accepted that the biggest drip loss of marinade-injected bone-in chicken occurs within about 10 min after injection. A marinade or brine containing a functional non-meat protein will significantly reduce the initial drip loss compared to brines or marinades that only contain salt and phosphate. In-going yield improvements ranging between 2% and 6% can be achieved. Some processing systems might find it beneficial to inject concentrated marinade and/or reduce marinade percentage. The theory behind this is to minimize early stage drip-loss. Temperature of the marinade should be kept at a pre-specified constant level. Because of brine or marinade recirculation, the temperature can increase, possibly causing quality and yield irregularities. It is therefore important that the injector screens are cleaned frequently to prevent needle blockage. Needle blockage can be caused by incomplete hydration of the functional (protein) ingredients. Throughout the injection process this situation can worsen when small chicken parts come loose and interact in the recirculated marinade and become entrapped with the binding properties of some of the marinade ingredients.

As moisture levels increase in marinated poultry there is a real need to manage moisture. Most often combinations of some or all of the following ingredients are used:

- Salt.
- Phosphate.
- Soy protein.
- Starch.
- Hydrocolloids.

These functional ingredients need to harmonize in order to improve the overall quality of the finished product. Parameters such as improvement of yield, succulence and holding performance are important considerations.

- Starches are a low-cost solution for improving yield. However at increasing levels of addition, starches tend to soften the meat texture. Also sedimentation problems can arise in a marination system when starches are used.
- Hydrocolloids such as carrageenan and gums perform at very low inclusion levels and usually generate significant yield increase of both uncooked and cooked product. The downside of hydrocolloid addition to marinated poultry foods is the softening of the meat texture (gel-like), whereas ingredient prices are usually considerably higher than alternative ingredient solutions.
- Soy protein in marinated poultry is generally superior when compared to starch and/or hydrocolloid ingredients. Especially meat texture and succulence are attributes that are very positive for soy protein. Yields are also very good, though not as good as with starch and hydrocolloids. However, when yield is plotted against ingredient costs, starches are perhaps a better option. Technologically speaking, soy protein sediment and/or foaming sometimes give reason for concern. It is therefore essential to select the right type of soy protein ingredient to ensure the avoidance of issues like lumping and blockage of injector needles. To provide the most value for these applications the soy protein needs to have high dispersing and low gel strength properties. The key requirements are high water-holding capacity and no interference with natural meat appearance. Wetability, dispersibility and low or no foaming are important considerations also. When comparing protein ingredients it should be noted that physical protein properties do not always predict performance.

There are several methods to hydrate and disperse functional soy protein ingredients in brine or marinade system. Usually the following sequence is selected:

- Place water in mixer (add ice if necessary) and temper to 2°C.
- Add phosphate and mix for 5 min.
- Add salt and mix for 5 min.
- Add soy protein isolate slowly into the vortex and mix for 10 min.
- Transfer the marinade to a holding tank and continue to stir to prevent settlement of protein.

Another sequence of brine preparation is the following:

- Dissolve phosphate in cold water at 2°C and stir for 5 min.
- Add soy protein into vortex and blend for 10 min until fully hydrated.
- Add salt and stir for 5 min.

Ice should be used to keep the water temperature at approximately 2–4°C. It is important not to inject the brine or marinade at lower temperatures as this will increase the viscosity of the brine and subsequently needle blockage might result and reduce yield.

The use of vacuum marinators and tumblers can increase processing yield, though for throughput speed and plant efficiency tumblers are not always an option. For bone-in chicken products, a typical injection level ranges from 10% to 24%. The use of special types of low-viscosity soy protein isolate ingredients has proved beneficial in terms of succulence, especially if the product needs to be reconstituted, and impressive yield increases are also obtained. It is important to point out, however, that yield improvements are difficult to prove at the same level of injection. Therefore, to calculate the real benefits of added functional protein ingredients, it is recommended to increase the level of injection. For example, a control sample of a 20% extended chicken breast might give 108% yield from green when fully cooked. In comparison, a 23% injection-containing chicken breast can give 110% yield from green when fully cooked. These numbers vary, of course, according to the influence of the functional protein ingredient, equipment and specific processing and cooking conditions.

A typical coating addition for skinless chicken parts is 20%. For skin-on chicken parts, usually 28–30% coating is applied. It has been reported that marinades containing functional soy protein reduce the amount of breading blow-off during the various processing steps, including thermalization. It can also be beneficial to spray such a marinade formula separately on to the injected chicken to enhance pre-dust pick-up and thus further improve yield.

Rotisserie

The popularity of rotisserie chicken in some high-demand markets has seen its up and downs. After declining sharply, rotisserie sales have stabilized now that the product has been repositioned as part of a healthy eating experience.

An advantage of functional soy protein-treated bone-in chicken products is the increase in shelf life for both injected and frozen chicken or injected and fully cooked chicken products (Fig. 12.3). This increase can be explained by the antioxidative properties of soy protein isolate, specifically because of the scavenging actions of polyphenolic acids and isoflavones.

Processing flow bone-in chicken:

- Fresh chicken temperature preferably 0°C.
- Injection marinade at temperatures < 4°C.
- Pre-dust.
- Batter.
- Breading. 3 × flipper belt.
- Pre-fry 185°C for 90 s.
- Fully cook in a spiral hot air oven:

Temperature	165°C/165°C
Humidity	80°C dew point
Dwell time	33 min
Fan speed	1100

- Freezer.
- Pack.
- In restaurant prior to use: thermalize for 150 min at 60°C.
- Reconstitute/fry at 182°C for 100 s.

Honey is frequently used to create specific aromas, flavours and colour. However, honey is also a distinctive antioxidant, with the degree determined by the floral source of the nectar. The colour and taste of honey

Fig. 12.3. Close-up photograph of whole chicken injector. Source: Metalquimia SA, Girona, Spain.

are interrelated; usually, the darker the colour the stronger the flavour. A darker colour is an indication of a more potent antioxidative effect.

Since honey is sweeter than sucrose, it can also serve as an ideal sweetness booster. The latter property makes honey particularly useful in submerging marinade applications.

Chicken skin on further processed products such as rotisserie chicken always significantly increases the total fat, cholesterol and calorie content. The presence of skin probably played a role in declining sales of this otherwise very popular food choice. Consumers love these products because of the superior sensory characteristics. The issue of calories versus organoleptical properties is often a true dilemma for product development. The removal of chicken skin from the pre-marinated chicken breast, together with the inclusion of honey in the marinade, can provide a satisfactory compromise. The presence of honey does not affect marinade absorption, while it does restore the much-wanted golden brown colour and moist glossy appearance of the baked product.

Besides meat yields, the presence of functional soy protein-injected bone-in chicken will also exhibit improved holding time together with enhanced succulence. The use of modified food starch in conjunction with functional soy protein improves the water retention further, but will slightly reduce the typical meaty texture and juiciness. Recent co-processing technology improvements of functional soy protein and food starch have enabled native starch to be in-line converted to a unique modification of protein and starch ingredients. These co-processed ingredients can provide synergy of properties exceeding the sum of the individual ingredient. Significant yield and texture improvement can result, while reducing variability in processing.

Thermalization

There are several methods to transfer heat for poultry foods that need to be fully cooked: conduction, convection and radiation. Radiation ovens that use infrared energy or gas flame broilers are especially suitable for cooking and browning uncoated formulated meats. Conduction cooking can be described as direct contact cooking by means of oil frying and/or steaming.

Frying is a method to (par) cook foods by submerging into hot oil or fat. The hold-down conveyor, which can be automatically adjusted in height, may be used to ensure the products remain immersed. The PLC-controlled oil circulation system maintains a constant temperature throughout the oil, ensuring consistent, evenly fried products. Crosswise scrapers remove sediment at the infeed, while a scraper belt and horizontal auger removes the floating sediment at the outfeed.

Deep oil frying is a proven way to add extra interior texture while creating a crunchy exterior. Most coated meat products travel through an oil bath for initial setting of the coating system (Fig. 12.4). Cooked meat products can be fully cooked when submerged in this oil bath at low belt speeds, with the retention time dependent on product size and internal temperature requirements. The product can also simply be par-fried or flash-fried for 30 s, after which the coated poultry is either frozen or fully cooked in steam tunnels or convection ovens. Fully cooking in oil tunnel-ovens has lost much interest, because of high oil uptake and sensory negatives such as lack of juiciness when reconstituted for final consumption. The availability of fat-free oil, a synthetic fat made from polysucrose (table sugar) and oil that cannot be absorbed by the body might change some of the perceived negatives of fully oil-cooked coated poultry products. However, the chances are that other thermalization methods will be given preference.

Fully cooked processed meat products offer at least two major advantages. Fully cooked products eliminate the fear of undercooking or cross-contamination via handling at a food service outlet. These products are user friendly, have a greater speed of service and provide ready-made

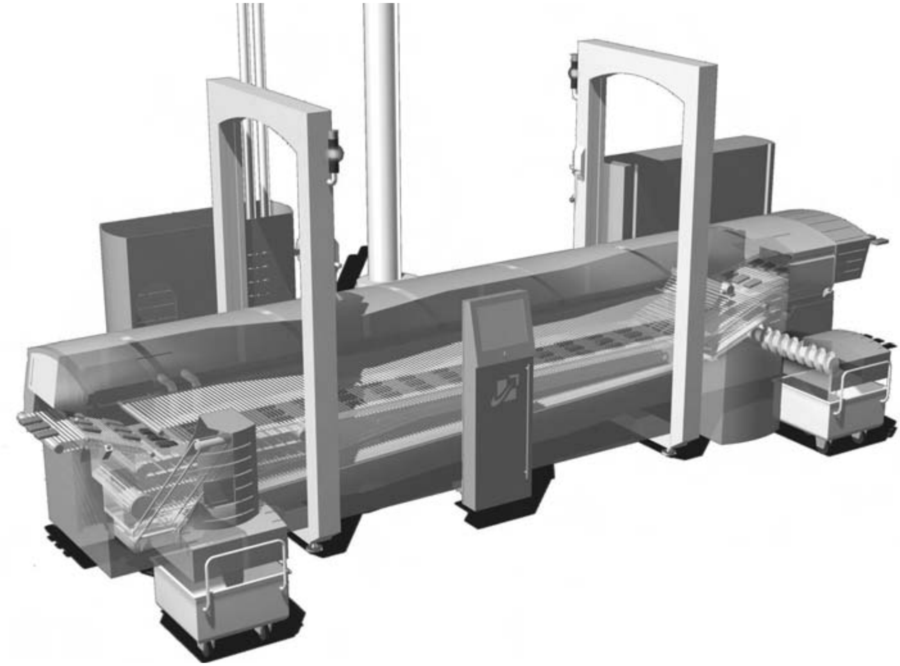

Fig. 12.4. Drawing of an oil fryer. Source: Convenience Food Systems (CFS).

convenience. Fully cooked frozen products allow the operator easier physical distribution and allow inventory build-up for peak demand periods.

Oven cooking involves three variables: time, air velocity and dew point. In further processing there are basically two product dimensions, namely a two-dimensional patty or nugget shape with a horizontal and vertical side, and three-dimensional products such as topographically shaped chicken kiev or a bone-in rotisserie chicken.

The type and design of the thermal oven significantly affects product quality, yield and food safety. There are two types of cooking oven, the in-line (tunnel) oven and a double-zone spiral oven. In-line ovens are restricted in length and are mainly designed for one-process temperatures at maximum throughputs. To accomplish this, cooking temperatures are usually higher than strictly needed. But too high, aggressive cooking will usually result in product flaws for both two- and three-dimensional shapes for uncoated and coated products. For example, thinner parts of bone-in chicken might be overcooked creating colour irregularities, while the thicker parts might be undercooked.

For coated products, heat that is too high in temperature can force free product moisture to come to the surface and wet the product, resulting in coating separation or sogginess. In one-zone impingement ovens, temperatures can vary across the width of the belt, which can also cause over- or undercooking. However, in reality this means that the temperature settings are usually higher in order to eliminate the danger of undercooking. The downside is that at increased cooking temperatures yields go down accordingly, and the appearance of different surface characteristics tend to increase.

Convection ovens are either gas or electrically heated with efficient heat transfer to the product. The latest convection ovens allow steam injection and combine humidity, belt speed and temperature to create equilibrium between the inside moisture level of the formulated poultry product and the surrounding conditions.

Some recently introduced convection ovens divide the cooking chambers into two separate units, allowing faster heat transfer for cooking and maintenance of the temperature and humidity at different levels. These ovens can use dry or moist heat or a combination of the two. Moist heat cooking produces a more tender end-product because the surface area will not dehydrate, although because of the high humidity browning will not occur. These ovens are ideal for optimizing yields, while minimizing energy costs.

A spin-off version of the convection oven is the double zone spiral oven (Fig. 12.5). These thermal processors divide the cooking area into two independently controlled, completely insulated spiral heat zones. The main part of the spiral oven is a specially designed belt conveyor shaped similar to a double spiral. This feature allows both long and wide belts at varying heights to be accommodated in a remarkably small floor print. Within certain limits, the dual chambers allow separate regulation of temperature, air velocity and humidity. These ovens are available with either electricity or thermal oil heating systems.

For emulsified and large shapes and sizes of whole muscle meat products, the trend is toward process optimization in terms of higher thermalization at wet bulb temperatures (the temperature at which moisture evaporates). However, for coated further processed meat and poultry products, this trend is quite the opposite. Newly

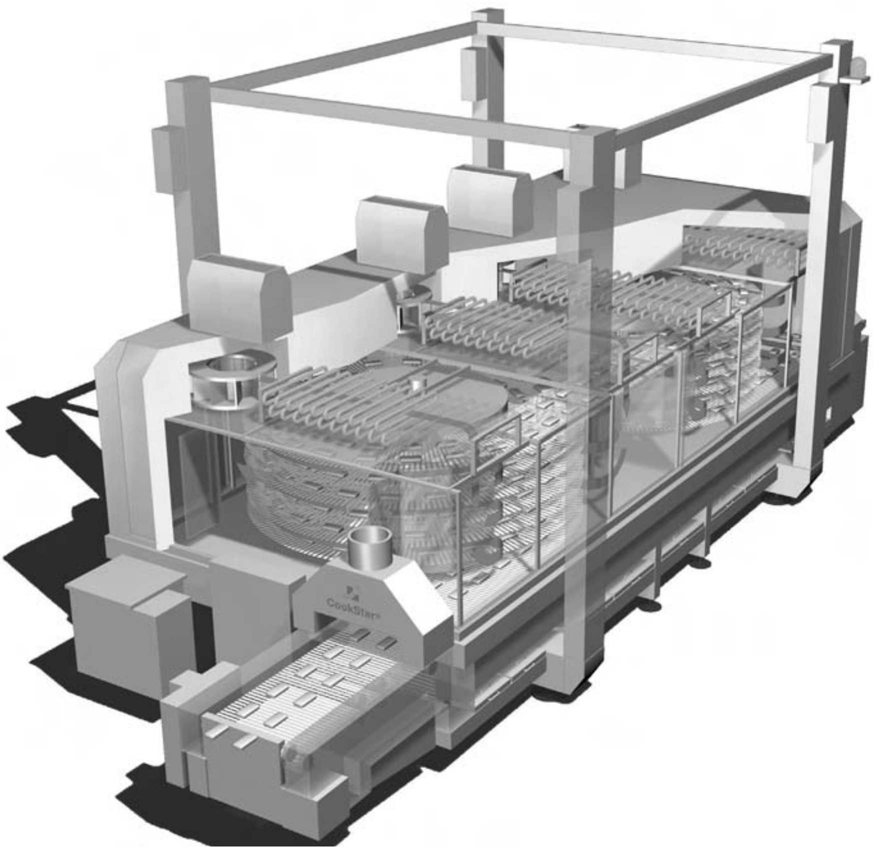

Fig. 12.5. Schematic drawing of a hot air spiral cooker. Source: Convenience Food Systems (CFS).

designed equipment, with the help of functional ingredients, has shown that coated foods, including marinated bone-in poultry, greatly improve when cooking time increases at lower temperatures. The latter means a lower belt speed and/or increased belt length.

The logical answer is the modern double zone spiral oven, which has significantly increased belt length and is suited to accommodate increased belt-load. In the spiral oven air circulates with a precisely conditioned temperature and humidity. Steam is injected into the hood and mixed with hot air. This mix circulates continuously around the products so that they are fully cooked. That allows the product to reach the pre-set fully cooked temperature specifications, despite slower cooking times. The typical parameters of these spiral cooking systems are also less likely to generate steam build-up under the surface of the batter and breading causing cracking and colour defects. Additionally, a prolonged cooking time improves product yields compared with tunnel cooking systems. The result is a crispier, more attractive product appearance.

The operating principle is the fact that longer cooking time at lower temperatures in separately controlled heating zones produces more even product temperatures, better product colour and appearance, and an increase in yield. In the oven, steam is injected into the hood and mixed with hot air. This mix circulates continuously around the substrate so that the product can be cooked at a pre-set temperature. In addition, the fully insulated oven is divided into two zones in which air temperature can be regulated independently within certain parameters. This unique feature enables cooking of products in the first zone with a high relative humidity that limits cooking losses, and finishes cooking and browning in the second cooking zone with low humidity. This system provides a flexible cooking process with steam/roast or steam/steam combinations.

Various advantages result from this processing method. First of all, flash-fried, breaded products have better coating adhesion resulting from the lower cooking temperatures, while at the same time product colour is enhanced. Second, non-breaded products, such as bone-in parts or marinated items, will obtain an even colour formation with reduced risk of overcooking of the thinner parts. Products also retain a higher level of natural and marinated or injected juices at lower cooking temperatures.

Additionally, by using hot air at high air speed, a chargrill effect can be easily achieved for marinated fully cooked uncoated poultry foods. Furthermore, a safety zone keeps the product in the cooking environment longer in order to sustain the required core temperature for maximum product safety. Finally, longer cooking times, combined with lower temperatures, have resulted in an actual increase in yield of up to 2% for fully cooked par-fried, breaded products.

It is essential to ascertain that products leave the oven properly in order to maintain product specifications. These new ovens allow computer monitoring, and settings such as temperature, humidity and steam can be checked at one work station in a fast and reliable fashion. The equipment industry has engineered many efficiency improvements, especially the use of computer technology that is now universally integrated in equipment such as formers and spiral ovens. This has permitted not only product quality improvement, but also removed a significant amount of labour. No doubt microchips and data technology transfer will increasingly result in improved processing efficiency and economics.

The availability of the latest technologies of convection cooking has revolutionized the traditional thinking of the processing line set-up of coated poultry foods. For example, it is no longer necessary to first apply batter and breading followed by par-frying. The hot air oven cooking technology allows the product to be cooked first, before travelling through the coating sequences, followed by par-frying to set the coating systems. Ultimately, par-frying will be eliminated and replaced with unique systems such as oil misting and infrared heating.

Additionally, most of today's systems are conveyorized to allow continuous in-line throughput. The conveyor systems are either spiral belt or straight-line belt. Spiral belt cooking ovens have high capacity on a relatively small footprint, resulting in high production capacities per square metre of floor space. These ovens are truly versatile because they allow control of belt speed, humidity and temperature. These three variables determine the final cooking time in relation to product characteristics, including yield control.

Implementation of microwave thermalization should be mentioned also. A microwave oven is based on magnetrons that convert electric energy into electromagnetic energy. Friction heat is created by reversal of field polarity and microwaves penetrate solid matter faster and more efficiently. These ovens ideally can be used for thawing frozen meat, but ultimately they will become the method of choice, in conjunction with double spiral/double chamber hot air ovens, to regulate automatic in-line process cooking, including browning and grill marking.

The same efficiency is true for the post-cooking stage. Processed products are conveyed into a tunnel or spiral freezer from which cascading or shuttle belts feed packaging systems, which eliminate labour-intensive product handling and improve product accuracy. Packaged products then pass through metal detectors before being packed into distribution boxes.

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Formulation Examples: Batter and Breaded Meat

Chicken patty and nugget

Ingredient	%	%
Chicken breast meat	85.00	80.00
Water	12.00	16.00
Soy protein isolate[a]	1.60	
Soy protein concentrate[a]		2.60
Salt	0.80	0.80
Phosphate	0.20	0.20
Dextrose	0.20	0.20
Seasoning	0.20	0.20
Total	100.00	100.00

[a]Suggest high gelling SPI or FSPC.

Procedure:

1. Add chicken breast meat to blender together with salt and phosphate and mix for 30 s.
2. Add water and mix for 2 min.
3. Add soy protein, and mix for 2 min.
4. Add remaining ingredients, including flavourings, and mix for 1 min.
5. Temper meat mix with CO_2 or N_2 to –3°C to –1°C.
6. Form, batter and breading.
7. Fry and freeze.

Note: Depending on forming equipment and product requirements, the meat mix can be ground before or after the blending. Or the chicken meat might be introduced into the forming equipment in whole muscle pieces.

Chicken patty and nugget (USA)

Ingredient	%	%
Chicken breast meat	80.00	70.00
Chicken white trimmings	10.00	10.00
Chicken skin		10.00
Water	7.80	7.80
Soy protein isolate[a]	0.80	
Soy protein concentrate[a]		0.80
Salt	0.80	0.80
Phosphate	0.20	0.20
Dextrose	0.20	0.20
Seasoning	0.20	0.20
Total	100.00	100.00

[a]Use high gelling SPI or FSPC.

Procedure:

1. Grind chicken breast meat through a kidney plate.
2. Grind chicken skin through a 1 mm plate.
3. Add chicken breast meat to blender together with salt and phosphate and mix for 30 s.
4. Add water and mix for 1 min.
5. Add soy protein and mix for 2 min.

6. Add chicken skin and remaining dry ingredients, including hydrated TSPC and mix for 2 min.
7. Temper meat mixture with CO_2 or N_2 to –3°C.
8. Form into desired shaped patties or nuggets.
9. Pre-dust followed by hot air/steam-cooking, coating and par-frying.
Or:
Pre-dust, batter, breading, par-frying and fully cooking in a hot air/steam oven.
10. Freeze.

Formulated chicken patty and nugget

Ingredient	%	%	%
Chicken breast (boneless)	76.50	66.50	58.50
Water	11.50	11.50	17.50
Soy protein isolate[a]	1.00		1.00
Soy protein concentrate		1.00	
Salt	0.80	0.80	0.80
Phosphate	0.20	0.20	0.20
Skin[b]	5.00	10.00	10.00
Water[b]	4.00	8.00	8.00
Soy protein[b]	1.00	2.00	2.00
Textured soy protein conc.[c]			2.00
Total	100.00	100.00	100.00

[a]Use high gelling SPI or FSPC.
[b]Pre-made emulsion (pre-emulsion made in chopper or mixer/ or grinder/emulsifier).
[c]TSPC.

Procedure:
1. Add chicken breast to blender with water and soy protein.
2. Mix for approx. 3 min.
3. Add salt and phosphate and mix for 2 min.
4. Add pre-made skin emulsion, hydrated TSPC, and mix for 2 min.
5. Temper meat mixture with CO_2 or N_2 to –3°C to –1°C.
6. Forming.
7. Further process according to line configuration.
8. Thermalization.

Whole muscle chicken patty and nugget

Ingredient	%	%
Chicken breast meat	43.00	38.00
Chicken thigh meat	43.00	38.00
Chicken skin		9.00
Water	12.00	12.30
Soy protein isolate[a]	1.00	
Soy protein concentrate[a]		1.50
Salt	0.80	0.90
Phosphate	0.20	0.30
Total	100.00	100.00

[a]High gelling SPI or FSPC recommended.

Procedure:
1. Add chicken breast and thigh meat into blender.
2. Add salt and phosphate and blend for 30 s.
3. Add water and mix until in total 90 s have elapsed.
4. Add soy protein and mix until in total 4 min have elapsed.
5. Add chicken skin and blend until 5 min have elapsed.
6. Temper mixture with CO_2 or N_2 to –3°C to –1°C.
7. Form and apply coating system.
8. Thermalization.

Note: final product grinding for size reduction can either be done before blending or after product tempering.

Chicken patty and nugget

Ingredient	%	%	%
Breast of chicken	78.00		35.00
Chicken dark meat		61.00	35.00
Chicken skin	6.00	6.00	6.00
Water	12.60	25.10	18.60
Soy protein isolate[a]	2.00		2.00
Soy protein concentrate[a]		6.50	
Textured soy protein concentrate			2.00
Salt	0.70	0.70	0.70
Sodium phosphate	0.30	0.30	0.30
Seasoning	0.40	0.40	0.40
Total	100.00	100.00	100.00

[a]Use high gelling SPI or FSPC.

Procedure:
1. Grind chicken breast meat through a 3 cm plate.
2. Grind chicken dark meat through a 2 cm plate.
3. Grind chicken skin to 3 mm.
4. Mix meat, water and soy protein for 1–2 min.
5. Add phosphate and salt, mix for 1–2 min.
6. Add skin and seasoning, mix until uniform.
7. Temper to –3°C.
8. Form and apply coating system.
9. Pre-cook in oil to set the coating system.
10. (Optional) fully cook in a hot air tunnel or oven.
11. Freeze.

Chicken Tatsuta patty (Japan)

Ingredient	%
Chicken breast meat	76.70
Water	8.40
Soy protein isolate[a]	1.50
Soy sauce (dry)	7.80
Soy sauce (liquid)	2.00
Mirin rice wine[b]	2.20

Ginger (liquid)[b]	1.20
Phosphate	0.20
Total	100.00

[a]Low gelling SPI recommended.
[b]Add at end of mixing cycle.

Procedure:
1. Hydrate soy protein in water.
2. Add phosphate and salt.
3. Add other marinade ingredients.
4. Options:
a. vacuum tumble for 20 min or
b. inject marinade and tumble for 5 min.
5. Temper to –3°C.
6. Form and add batter mix.
7. Par-fry and freeze.

Chicken patty and nugget

Ingredient	%	%	%
Chicken breast meat	61.00	58.00	54.00
Chicken skin	12.00	14.00	10.00
Water	20.00	20.00	26.00
Soy protein isolate[a]	5.00		6.00
Soy protein concentrate[a]		6.00	
Textured soy protein conc.[b]			2.00
Salt	0.80	0.80	0.80
Phosphate	0.20	0.20	0.20
Flavouring	1.00	1.00	1.00
Total	100.00	100.00	100.00

[a]Use high gelling SPI or FSPC.
[b]Alternative: TSF.

Procedure:
1. Grind chicken meat through kidney plate.
2. Grind chicken skin through 3 mm plate.
3. Mix chicken meat with salt and phosphate for 30 s.
4. Add water and mix for 1 min.
5. Add soy protein and mix until 4 min have elapsed.
6. Add chicken skin, hydrated TSPC and flavouring, and mix until in total 6 min have elapsed.
7. Temper mixture with CO_2 or N_2 to –3°C.
8. Form and apply batter and par-fry, or
9. Form and pre-dust, and fully cook in hot air tunnel.
10. Apply cover system and par-fry.
11. Optional: fully cook.
12. Freeze.

Food service chicken patty and nugget

Ingredient	%	%	%
Chicken breast fillet	35.60	29.60	30.60
Chicken thigh	20.00	20.00	20.00
Chicken skin	12.00	18.00	10.00
Water/ice	23.80	23.80	28.80
Soy protein isolate[a]	6.00		
Soy protein concentrate[a]		6.00	5.00
Textured soy protein concentrate[b]			3.00
Salt	0.80	0.80	0.80
Phosphate	0.20	0.20	0.20
Seasonings	1.60	1.60	1.60
Total	100.00	100.00	100.00

[a]Use high gelling SPI or FSPC.
[b]Alternative: TSF.

Procedure:

1. Grind chicken meat through kidney plate.
2. Grind chicken skin through 3 mm plate.
3. Emulsify chicken skin in chopper with 6% water and 3% soy protein.
4. Mix ground chicken meat with salt and phosphate for 30 s.
5. Add water and mix for 1 min.
6. Add soy protein and mix until 4 min have elapsed.
7. Add ground chicken skin or chicken skin emulsion and mix until 6 min have elapsed.
8. Temper mixture with CO_2 or N_2 to –3°C.
9. Form and apply coating system for par-fry or fully cook in hot air spiral cooker or form, fry for coating setting.
10. Freeze.

Chicken patty and nugget (China)

Ingredient	%	%	%
Chicken breast (boneless)	62.50	58.50	50.50
Chicken skin	10.00	12.00	12.00
Water	20.00	22.00	28.00
Salt	1.00	1.00	1.00
Phosphate	0.20	0.20	0.20
Soy protein isolate[a]	5.00		
Soy protein concentrate[a]		5.00	5.00
Textured soy protein concentrate[b]			2.00
White pepper	0.10	0.10	0.10
Garlic powder	0.20	0.20	0.20
Onion powder	0.20	0.20	0.20
Sugar	0.60	0.60	0.60
Lemon juice	0.20	0.20	0.20
Total	100.00	100.00	100.00

[a]Use high gelling SPI or FSPC.
[b]Alternative: TSF.

Procedure:
1. Grind chicken breast through kidney plate.
2. Add chicken breast meat together with soy protein and water to blender and mix for 1 min.
3. Add hydrated textured soy protein and remaining ingredients and mix until 5 min have elapsed.
4. Chill with CO_2 or N_2 to –3°C.
5. Form and apply coating system.
6. Par-fry, or fully cook and freeze.

Restructured chicken patty and nugget (Thailand)

Ingredient	%	%	%
Chicken thigh meat/trimmings	20.00	16.00	16.00
Chicken skin	14.00	18.00	18.00
Ice/water	22.00	25.00	25.00
Soy protein isolate[a]	5.00		
Soy protein concentrate[a]		6.00	6.00
Textured soy protein concentrate[b]			2.00
Salt	0.80	0.80	0.80
Phosphate	0.40	0.40	0.40
Flavouring/seasoning	1.40	1.40	1.40
Frozen breast or thigh meat	36.40	32.40	30.40
Total	100.00	100.00	100.00

[a]Use high gelling SPI or FSPC.
[b]Alternative: TSF.

Procedure:
1. Chop water and soy protein for 2 min.
2. Add ground or frozen chicken skin and chop to smooth paste.
3. Add ground or frozen chicken thigh meat or trimmings, together with salt, phosphate, and flavourings/seasonings.
4. Continue chopping until a strong and coherent meat matrix has been formed.
5. Switch the chopper to low speed. Add breast or thigh meat for particle definition. Allow only a few revolutions of the bowl to maintain optimum product integrity.
(If soy protein granules, or skin intermediate particulate or hydrated textured soy protein concentrate are used, the preferred addition is just before the frozen breast or thigh meat for particle definition.)
6. Energy release from the frozen meat will reduce the temperature of the meat matrix, but in order to obtain optimum forming knock-out properties, a temperature of –3° to –1°C should be aimed for.

Whole muscle chicken breast (USA)

Ingredient	%	%
Chicken breast (boneless)	88.00	82.00
Water	10.00	15.00
Salt	0.60	0.60
Phosphate	0.20	0.20
Soy protein isolate[a]	1.00	
Soy protein concentrate[a]		2.00
Pepper	0.05	0.05

Whole muscle chicken breast (USA) (*continued*)

Ingredient	%	%
Lemon juice	0.10	0.10
Onion powder	0.05	0.05
Total	100.00	100.00

[a]Use high gelling SPI or FSPC.

Procedure:
1. Mix soy protein with cold water in high-speed mixer for 4 min.
2. Add salt, phosphate, seasoning and mix for two additional minutes.
3. Inject marinade and/or vacuum tumble until marinade is fully absorbed.
4. Apply caramel for browning.
5. Heat process.
6. Freeze.

Chicken breast classic (Australia)

Ingredient	%	%
Chicken breast fillets	84.00	80.00
Chicken skin	4.00	8.00
Water	9.00	9.00
Phosphate	0.30	0.30
Salt	0.80	0.80
Soy protein isolate[a]	0.90	
Soy protein concentrate[a]		0.90
Dextrose	0.70	0.70
Chicken flavour	0.30	0.30
Total	100.00	100.00

[a]Use high gelling SPI or FSPC.

Procedure:
1. Remove skin and tenderloin from chicken breast.
2. Grind chicken breast through kidney plate.
3. Grind chicken skin twice through 3 mm plate.
4. Blend ground chicken breast meat with salt and phosphate for 30 s.
5. Add water and seasoning and blend until in total 2 min have elapsed.
6. Add soy protein and blend until in total 4 min have elapsed.
7. Add ground chicken skin and blend until in total 6 min have elapsed.
8. Temper with CO_2 or N_2 to –4°C and form.

Alternative method:
1. Prepare brine and vacuum tumbled with the chicken breasts for 25 min.
2. Skin is then added and the tumbling continues for 20 min.
3. After tumbling the marinated chicken meat is tempered down to –4°C.
4. Forming with a breast fillet-shape plate.
5. The product can be either charmarked or spice dipped for direct oven processing, or coated and par-fried and/or fully cooked prior to freezing.
6. The typical oven settings are 145°C using saturated steam when unbreaded products are manufactured.

Chicken wings (USA)

Ingredient	%	%
Chicken wings	81.10	83.10
Water	16.10	14.10
Soy protein isolate[a]	1.20	
Soy protein concentrate[a]		1.20
Modified food starch	1.00	1.00
Salt	0.30	0.30
Phosphate	0.30	0.30
Total	100.00	100.00

[a]Low viscosity SPI or FSPC.
Suggestion: Injection/marinate 20%.

Procedure:
1. Mix soy protein with cold water in high-speed mixer until smooth and fully hydrated.
2. Add phosphate, mix until dissolved.
3. Add salt and seasoning and flavours and mix until dissolved.
4. Add modified food starch and mix until dissolved.
5. Add marinade or inject into bone-in product and vacuum tumble until marinade is absorbed, i.e. 15 min 8 rpm/10 min rest/20 min 8 rpm.
6. Further process. Apply coating system, flavour-dip and thermalize.

Alternative procedure:
1. Mix phosphate with refrigerated water in high-speed mixer, e.g. Rotostat with recirculation pump, until fully dissolved.
2. Add salt and mix until fully dissolved.
3. Add a pre-blend of soy protein ingredient and modified food starch and mix until fully hydrated.
4. Add flavours.
5. Inject marinade or add marinade to the tumbler.
6. Pull vacuum, i.e. 20 psi, and tumble for 20 min. Release vacuum and rest for 5 min.
7. Pull vacuum and tumble for additional 15 min.

Overall:
Batter
Mix thoroughly in the batter equipment about 2 parts of water with 1 part of batter. (Ratio depends on typical batter instructions.)
Transfer the batter to the liquid coating to fill the machine. Viscosity of the batter should be between 12 and 15 s, and target pick-up is approximately 4–6%.
Breading
Fill the breading equipment with the desired breading mixture.
Target pick-up depends on product specifications, but usually is between 8% and 10%.
Frying
The coated product is to be par-fried for approximately 45–60 s at 200°C. Frying time depends on desired breading colour specifications.
At this point the par-fried product can be frozen or fully cooked and frozen.

Fully cook
Cook cycle depends on type of oven. There are tunnel and spiral ovens. Also important is the presence of the number of cooking zones. The ideal is to fully cook in an oven with two cooking zones. This allows temperature/time/belt speed fine tuning. The latter is especially important for yield and the elimination of red bone marrow (splotching).

A typical cook setting is:

Zone One	200°C	Dew point 85%
Zone Two	160–180°C	Dew point 85%
Dwell time	10–12 min	

If high dew points cannot be reached, it is suggested to decrease cooking temperature somewhat and decrease belt speed in order to increase dwell time. Core temperature (IT) should be about 85°C.

Rotisserie chicken (USA)

Ingredient	%
Water	89.90
Soy protein isolate[a]	6.50
Salt	1.80
Phosphate	1.80
Total	100.00

[a]Suggest low viscosity SPI.
Suggestion: level of injection 20%.

Procedure:
1. Mix soy protein isolate with cold water in high-speed mixer system until smooth.
2. Add phosphate, and mix until dissolved.
3. Add salt, seasoning and flavours, mix until dissolved.
4. Inject marinade into whole bird.
5. Heat or freeze thermalization.

13
Dry Fermented Sausage

Compared with emulsified meat processing technology, fermented sausage production is quite different. The water-holding capacity of the meat is of much less importance, since the objective is to drive water out during drying in order to prolong the sausage shelf life and allow the development of a distinct flavour and texture. In fermented sausage, meat protein extraction is minimal compared with other meat products such as emulsified sausage and cooked whole muscle meat products. The role of salt-soluble meat protein in fermented sausage is limited to providing elasticity and arranging cohesiveness between fat and lean particles.

Fermentation

Fermentation is probably the oldest form of meat preservation, going back at least 2000 years. The art of preserving chopped meat stuffed in animal intestines dates back to those early days. Ever since ancient times, humans have harnessed certain enzymes' catalytic properties in making food. The Egyptians and Sumerians, for example, discovered the process of fermentation, and put it to use in baking bread, making cheese and brewing beer.

It is known that the Egyptians and Cypriots used indirect acidification to prolong the keeping time of these foods. Little did they realize that it was actually the presence of the carbohydrates and the bacteria present in the meat that would trigger production of lactic acid, thus lowering the pH. For many foods, processed meat and alcohol products fermentation is essential. After all, this step is needed to get all those vital chemical reactions started, and to get these up to speed. Fermentation enzymes are the catalysts and are an integral part of our biological life; thousands of different combinations occur in every living organism.

Dry fermented sausage, as it is known today, is relatively new, and from history it can be learned that the early versions in Europe were made in Italy in 1730. From there the art of dry fermented sausage-making spread across the continent, first to Germany and later to Hungary. The original formulae were regionally adapted to please local palates and to take advantage of the availability of raw materials. The main difference was that the Germanic countries preferred a slightly smoked version of dry fermented sausage, whereas the Latin countries preferred unsmoked dry fermented sausage made entirely from pork. There is little doubt that Hungary has popularized the traditional salami, as it is known today. Preferably the pig carcasses were pre-cut along the main muscle segments when still warm. This technique creates a larger surface which allows faster water reduction and faster chilling. It is also important to select meat from older pigs. Not only is the colour of this meat darker and more intense, it also holds less water (61% vs. 70% in younger animals). Typical Hungarian 'winter-salami' is cold-smoked for 2 weeks using natural wood smoke. This process ensures a proper diffusion of moisture from the core of the sausage to the outside. During drying or maturing, which generally lasts for up to 70 days, salt content increases proportionally, hence safeguarding stability and shelf life. In the maturing or ripening chambers, the microbial and biochemical processes are optimized for controlled growth of mould spores. At the end of the maturing cycle, the salamis have a water content of about 24%.

The formulae influenced by the Germans are usually made from one-third each of pork, beef and pork fat. All-beef dry fermented sausage has been made for a long time in Middle-Eastern countries, including Turkey and Cyprus. These products are called Sucuk or Soudjouk. For flavour purposes, these popular beef versions also may contain lamb meat and lamb fat.

The real breakthrough for fermented sausage for fast-food applications came much later in the early 1960s, when pepperoni sausage became a necessity as a pizza topping. Progress in technology and an improved understanding in meat science caused the development of a number of spin-off versions of fermented sausages that contained higher water levels and actually had a cooking cycle to improve shelf life. These products are generally classified as semi-dry fermented sausage, such as cooked Danish or Genoa salami, and are generally based on the use of glucono delta lactone (GDL) or encapsulated citric or lactic acid for direct acidification. These additives allow cooking as opposed to the classic ripening process when starter cultures are used.

For classic dry fermented sausage produced with the help of starter cultures, very rarely does the curing and ripening temperature exceed 25°C. There are, of course, exceptions, as in the case of Japan, where dry fermented sausage is heated after ripening to approximately 68°C. The reason for thermalization is influenced by the need to ensure microbial stability, in particular enterobacteria.

China and some other Oriental countries have a totally different view of how dry fermented sausage ought to be manufactured. As a matter of fact, the Chinese are believed to be the originators of dry sausage some 2500 years ago. Contrary to the typical European fermentation process, the Chinese used large amounts of sugar and salt to acquire shelf life properties. The original Chinese dry sausage was called lup cheong, and in this all-pork formula the water activity (A_w) is quickly reduced to $< A_w$ 0.8. The pH in a lup cheong sausage remains relatively high at pH 5.9.

The Chinese do not have an acquired taste for acidified or sour taste, usually associated with the European-style dry fermented sausage. Lup cheong is almost always eaten hot. Diagonal slices of the sausage are typically stir-fried with vegetables and eaten with steamed or fried rice.

Ideally, when dry fermented sausage is produced, the meat and fat components should be frozen or at least very cold. Since water needs to be expelled from the lean meat, it is acceptable to have some portion of the meat in a PSE condition. The freshness of the fat is very important, because during the long ripening and drying process problems with rancidity increase proportionally, which will negatively affect shelf life and taste. The addition of salt is usually calculated on the weight after ripening. In general, the percentage of addition is between 3.5% and 4.5%.

Curing salt is not only important for reducing rancidity and to prevent clostridial botulism, but also is effective in creating a stable colour. Finally, sodium nitrite ($NaNO_2$) is also important for inhibiting the occurrence of salmonella. An addition of sodium nitrite of approximately 125 ppm usually is sufficient to obtain the required properties. During the curing and ripening process, the microbe-inhibiting nitrite is slowly degraded, and the residual nitrite is usually as low as 10–40 ppm.

German-style dry fermented sausage normally contains between 0.3% and 0.7% sugar. Low amounts of sugar are used for products that are cured and ripened over a long period of time, whereas higher levels of sugar are used when accelerated ripening methods are used. The presence of a low inclusion level of sugar is also dependent on the curing temperatures. When these temperatures are lower than 15°C, the presence of sugar is less important. That is the main reason why traditional Italian-style dry fermented sausage does not contain added sugar. In dry fermented sausage some light seasonings are typically used to accentuate flavours, particularly pepper, nutmeg, garlic and cardamom. In Spain, about 2% of paprika is used in chorizo or chourico sausage. Besides some rice-wine, the Chinese lup cheong sausage contains fermented soy sauce as the main flavour contributor.

The selections of starter cultures are critical success factors in the manufacturing of traditional dry fermented sausage. Modern ready-to-use cultures are freeze-dried mixtures of organisms selected from lactobacillus, pedococcus and staphylococcus species. The function of these organisms is to convert added sugar to lactic acid, thus lowering pH as well as achieving a stable red colour and the required flavour profile.

Most certainly, the most important ingredient in dry fermented sausage is the starter culture. These lactic acid bacteria, or to be more precise, lactobacilli, are microorganisms that occur naturally in raw meat. Actually, these microorganisms are ever-present in the curing and drying rooms, and they do literally differ from plant to plant. Each different strain has unique properties, and at times also unique problems. To boost the fermentation process and to accelerate ripening time, starter cultures are added to the meat mix. However, it is not just the lactic acid bacteria that are responsible for the microbial stability of dry fermented sausage. In the early part of the curing and ripening of a dry sausage, a relatively large amount of air is still present within the meat mix, which leads to a high oxidation reduction reaction (redox value). The presence of sugar, micrococcus bacteria and sodium ascorbate lowers the redox value. Because of bacterial multiplication, the amount of oxygen decreases and therefore product stability improves. When the redox value is low, the 'good' lactic acid bacteria obtain a selective advantage that can suppress or eliminate 'bad' microorganisms. The latter is also referred to as competitive flora. A low redox value is also important for colour and fat stability later on during storage and distribution.

Not only lactic acid, but also pH has an effect on the stabilization of dry fermented sausage. For products that have a short curing and ripening time, the use of high-pH DFD meat should be avoided. The pH drop can be manipulated by adding small amounts of sugar and regulating the curing temperature. This is also true for glucono delta lactone that will stimulate the lowering of the pH. However, acidification with GDL alone is rather difficult to control. Fermentation can be controlled by limiting the amount of fermentable sugar, lowering or raising the temperature outside the growth range of the culture. For example, cooking stops fermentation.

The last few years have seen a major change in conceptual thinking about acidification. Though the use of active starter cultures will remain popular, the use of encapsulated acids such as lactic acid has made great strides forward in the manufacturing technology of semi-dry fermented sausage. These encapsulated lactic or citric acids are fat-coated and have a retarded or slow acid release until the hydrogenated vegetable oil or mono- and diglycerides are melted during the heat processing. Encapsulated acidulates allow direct acidification of meat products without damaging texture and appearance. It is obvious that for direct acidified sausage manufacturing, certain changes and increase in processing temperatures will be necessary to melt the protective coating of the capsules. The slow release allows the salt to perform, extracting salt-soluble proteins and thus contributing to the adhesion of meat and fat particles prior to acidification. (See Rust, 1993.)

When using direct acidification it is important to develop processing times and temperatures that guarantee proper release performance of the encapsulated citric acids. If the acid capsules 'pop' too early, a soft or mushy product could result, whereas a late release usually results in uneven final product acidification, sometimes only at the time the sausage is eaten. Encapsulated acids won't replace starter cultures in the near future, but this functional ingredient is a welcome option for producing quality products at significantly increased output because of shorter manufacturing times. The latter is very important in conjunction with similar attributes and supporting properties of special types of added non-meat proteins, if needed to augment the formula. The higher the pH levels of a dry sausage, the more important the effect of the water activity on stability.

Ripening

The manufacturing of a dry fermented sausage made with active starter cultures can be divided into the meat preparation phase, and the curing and ripening phase. Ideally, the temperature of the meat and fatty tissue should be around freezing point or slightly lower. Both chopping and grinding equipment are used to reduce the meat and fat to the desired particle size. Temperature is critical for particle definition and to avoid smearing. Also, to minimize meat protein solubilization salt should be added to the meat at the very end of the chopping or mixing. Some meat mixtures are stored for up to three days to allow precuring, before stuffing in permeable casings. The desired end product elasticity determines the precise processing conditions.

Curing and ripening are dependent on the typical processing conditions and on the diameter of the casing, but generally the process takes a few weeks. The climate-controlled curing and ripening rooms initially equilibrate the raw sausage for some 2–10 h, without increasing the relative humidity. From this point the temperature is slowly increased to about 20–22°C to avoid water condensation and, more importantly, a loss of nitrate or nitrite. After this initial conditioning process, the relationship between water activity (A_w) and the relative humidity (RH) should be monitored closely. Usually there is a difference of 3–5% between A_w and RH. For example, when A_w is 0.95, then RH should be decreased proportionally (Table 13.1).

If the air in the climate rooms is not in motion, a condensation shield could form around the sausage, resulting in a potential nitrate/nitrite loss and excessive mould and yeast growth on the sausage surface. To prevent this from occurring, it is suggested to programme an air motion of 0.5–0.8 m/s.

After the first three days of ripening, the temperature is reduced from 22°C to 20°C, and the RH reduced from 90–92 to approximately 85. Between days 7 and 10, the temperature lowers to 18°C and the RH is programmed at 80%. Thereafter, drying and further ripening take place at a temperature of 15°C and a RH of 75. These conditions need to be maintained until the end of the ripening cycle.

To prevent growth of moulds and yeast in the first few days of curing and ripening, raw sausages are usually treated with a light amount of cold smoke after the colour fixation has been completed. The smoke is normally applied on the third day after the change from curing to ripening. The total processing time of a dry fermented sausage can vary from as little as 2 weeks to as long as 6 months.

Depending on the product specifica-

Table 13.1. Typical cycles for dry fermented sausage.

	Time	Temperature (°C)	Relative humidity (%)
Ripening	1–4 days	20–28	90–96
Smoking	6 h	18	85–90
Drying	Diameter dependent	10–12	78–80
Total	10–14 days with about 14% weight loss		

tions, cold or warm smoke can be applied, though care should be taken that the smoke treatment is not too intense, otherwise the microbial curing process can be negatively influenced. Some non-smoked variations of dry fermented sausage are mould-cured, which provides a favourable yeast coating on the surface of the casing. (See Leistner, 1992.)

Antimycotics

A major problem associated with the manufacturing of dry fermented sausage is the development of unwanted mould and yeast growth on the skin surface of the fibrous reinforced cellulose casings. Effective elimination of these moulds and yeasts is now feasible by treating the casings with polyene antimycotic compounds. Antimycotics are a specially selected strain of the soil fungus *Streptomyces natalensis*. These compounds need to be applied in the various phases of the manufacturing process, ranging from soaking the casings in lukewarm water prior to stuffing to subjecting the same casings to antimycotics prior to and after fermentation. The final step is an antimycotic treatment, with a water-based polyvinyl coating that prevents both mould and yeast growth and reduces further unwanted moisture loss in the finished sausage – with an added bonus of a significant improvement of product appearance, increased shelf life and improved handling.

A New 'Tradition'

For modern processing technologies that use direct acidification for rapid curing and accelerated ripening, vegetable proteins have become the ingredient of choice to improve aggregation during the gel formation that binds meat and fat particles. Major savings can be obtained with this technique as no 'green-rooms' are needed to complete fermentation. It is important that gel formation is achieved without triggering a buffering effect and lowering the pH, which may have a detrimental effect on product quality. Soy proteins isolates have excellent flavour characteristics in these fermented sausages.

There are a number of methods that can be used to incorporate soy protein ingredients in dry fermented and semi-dry fermented sausage. The simplest is to add between 0.5% and 1.5%. This will positively affect the performance of the lactic acid bacteria and produce a corresponding drop in pH. The yield increase as a result of the soy protein addition is only marginal. However, the primary gain is a significant development of firmness. This way, the ripening process can be finished a few days earlier compared with the traditional method, increasing production output and reducing costs.

Lean Meat Replacement

It is also possible to replace part of the expensive lean meat fraction by creating a soy protein isolate–water gel. For some formulae, such a soy protein gel – if necessary reinforced with konjac flour or sodium alginate – can also successfully replace fat. These gels make it feasible to significantly reduce calories in a cost-effective manner.

There is a subtle difference between a protein gel and a prepared protein granule. The latter has a particle definition of its own and will actually substitute for the lean meat fraction while maintaining typical meat-like characteristics. This strong coherent protein granule can replace up to 50% of the formula. The inclusion level of soy protein gel is much lower, and this intermediate ingredient should be regarded as a functional phase to augment some of the formula meat. Soy protein granules and gels can be made using a chopper and/or a mixer/grinder system. In order to have a close colour match of the cured meat, the gels are preferably treated with colouring agents such as carmine, angkak (fermented rice), sandalwood extract, beet extract, paprika extract and pork or beef haemoglobin. If soy granules need to be frozen, it is suggested to use a rapid freezing method in order to avoid sponginess of the granules in the final product.

Soy protein gels or granules for use in dry fermented sausage can be described as a water–protein matrix designed to act functionally like meat protein and to replace meat. The gel or granule can be used to reduce formulation costs and/or improve nutritional quality by lowering the fat content. If a colorant is used, it should be dispersed into the water. A slow chopper or blender speed should be used to disperse the soy protein isolate over the water, which should then be switched to a high speed (chop for about 4 min, or blend for about 12 min), until a glossy gel forms. Chill with CO_2 or N_2 in the chopper or blender, or freeze and hold for use.

The gel can be sized-reduced to a 15 mm granule. These granules are mixed with the size-reduced meats together with all other formula ingredients. Final process chopping or mixing time should be of short duration to avoid smearing and to minimize salt-soluble protein extraction. Overworked meat products lack particle size definition, and 'fattening out' can occur. Salt always should be added towards the second half of the chopping or blending to limit salt soluble protein extraction.

For certain price-sensitive dry fermented products, textured soy protein concentrate can also be used. A good starting point is 10–20% meat replacement. The TSPC should preferably be cold water hydrated, using a water to protein ratio of 2.2:2.5. On this basis acceptable products can be made, though it should be taken into consideration that TSPC will not absorb the typical cured meat colour. Hence the TSPC give the impression of being 'fat' particles. The use of soy protein granules is still the preferred method.

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Formulation Examples: Dry Fermented Sausage

Hungarian salami

Ingredient	%
Beef 90 CL[b]	28.00
Pork shoulder	28.00
Pork back fat	28.00
Soy protein isolate gel[a]	13.00
Curing salt (0.6% $NaNO_2$)	2.40
Dextrose	0.30
Sweet paprika powder	0.05
Garlic powder	0.05
White pepper	0.20
Total	100.00

[a]Suggest high gelling SPI.
[b]Chemically lean.

Procedure:
1. Gel preparation one day prior to use: 1 part of soy protein isolate; 3.6 parts of water; 2% caramel; 0.5% fermented rice (angkak).
2. Store gel overnight at –4°C.
3. Chop semi-frozen pork fat (–4°C) to approximately 6 cm size.
4. Add all meats, gel and curing salt and chop at mixing speed to approximately 4–6 mm size
5. Towards the end of the chopping cycle add starter culture.
6. Stuff mixture into 48–50 mm casings and store overnight at 16°C.
7. Total drying time is 14 days at a temperature range from 20°C to 16°C and a RH from 93% to 78%.

Salchichon (Spain)

Ingredient	%
Pork shoulder meat	50.00
Pork meat 80CL	10.00
Pork belly	24.00
Soy protein gel[a]	10.00
Salt	2.30
Curing salt (0.6% $NaNO_2$)	0.15
Sodium ascorbate[b]	0.05
Dextrose	0.30
Lactose[c]	2.60
Phosphate	0.30
Carmine colour	0.05
White pepper	0.25
Starter culture[d]	
Total	100.00

[a]Suggest high gelling SPI.
[b]Alternative: sodium erythorbate.
[c]Recommended: 200 mesh.
[d]Blend of staphylococci, lactobacilli, pediococci.

Gel preparation one day prior to use: 1 part of soy protein isolate; 3.6 parts of water; 2% caramel; 0.5% fermented rice (angkak) or carminic acid or blood colour; store gel at –4°C.

Procedure:
1. Chop or grind semi-frozen pork fat to approximately 6 cm size.
2. Add all tempered meats, gel and curing salt and chop at mixing speed to approximately 4–6 mm size.
3. Towards the end of chopping cycle add starter culture.
4. Stuff mixture into 60–80 mm casings and calibrate overnight.
5. Fermentation at 24°C, 85–90 RH for 38 h to pH 5.
6. Drying at 12–14°C, 70–72 RH for 33–35 days, yielding 70%.

Chorizo salami (Mexico)

Ingredient	%
Pork trimmings 70CL	72.00
Pork back fat	9.80
Pork salivary glands	10.00
Water	4.00
Salt	1.00
Curing salt (0.6% $NaNO_2$)	0.15
Soy protein isolate[a]	1.00
Glucose	0.30
Lactose	0.20
Oleoresin of paprika	0.20
Spanish paprika	1.30
Sodium ascorbate[b]	0.05
Starter culture	
or encapsulated lactic acid	
Total	100.00

[a]Suggest low gelling SPI.
[b]Alternative: sodium erythorbate.

Procedure:
1. Coarse grind temperature-chilled pork meat and fat to approximately 30 mm.
2. Reduce meat and other ingredients in chopper to about 5 mm.
3. Chop at mixing speed and add starter culture.
4. Fill in 35 mm natural casing and link to size.
5. Ferment at 35°C and 90% RH to pH of 4.8–5.0.

Chicken chorizo (Mexico)

Ingredient	%	%
Chicken trimmings	35.00	35.00
Chicken thigh meat	25.00	25.00
Pork trimmings 70CL	25.00	25.00
Water	8.50	8.50
Salt	2.40	2.40
Curing salt (0.6% $NaNO_2$)	0.20	0.20
Sodium ascorbate[a]	0.05	0.05
Dextrose	1.00	1.00
Soy protein isolate[b]	0.50	

Soy protein concentrate[b]		0.50
Paprika powder	0.80	0.80
White pepper	0.20	0.20
Marjoram	0.10	0.10
Red wine	1.00	1.00
Onion powder	0.10	0.10
Garlic powder	0.05	0.05
Nutmeg	0.10	0.10
Optional: encapsulated lactic acid		
Total	100.00	100.00

[a]Alternative: sodium ascorbate.
[b]Suggest low gelling SPI or FSPC.

Procedure:
1. Fill into 30 mm natural casing and link into lengths of approximately 10 cm.
2. Hold the stuffed chorizo overnight to cure and transfer to ripening room and smokehouse.

Pepperoni sausage (Canada)

Ingredient	%
Beef meat 70CL	20.00
Pork luncheon meat	20.00
Pork 50CL	30.00
Soy protein isolate[a]	2.00
Water	8.00
Dextrose	0.90
Sodium ascorbate	0.04
Pepper	0.20
Nutmeg	0.06
Salt	2.60
Curing salt (0.6% $NaNO_2$)	0.20
Soy protein granules (1:3)[a]	16.00
Starter culture	
Or encapsulated lactic acid	
Total	100.00

[a]Suggest high gelling SPI.

Procedure:
1. Prepare the gel from 1 part of soy protein isolate and 3 parts of water. Freeze the gel and hydroflake or grind before use in final product preparation.
2. Grind or hydroflake all semi-frozen meat and fat (approx. 13–19 mm).
3. Final size (approx. 3–5 mm) pre-ground or flaked meat material together with the gel flakes.
4. Add starter culture, seasoning.
5. Continue chopping or blending until uniformly mixed.
6. Add salt and curing salt.
7. Stuff into 6 cm diameter edible collagen casings.
8. Ferment at 37°C, 90–95% RH until pH reaches 5.2 or less. This will take approx. 12–16 h.
9. Cook to an internal temperature of 54°C and hold for 30 min.
10. Dry at 14°C, 70% RH to a water activity of 0.80–0.85.

14
Liver Sausage and Pâtés

Few processed meat products have evolved into such a variety of distinct flavours, textures and visual appearances as liver sausage and pâté delicacies. Most probably, the original liver sausage finds its roots back in the German town of Braunschweig. This formula was made from pork liver, pork jowls, some milk and seasoning. The original recipe did not contain added water, which was very typical for that time.

The textural characteristics are manipulated by specific temperature treatment of the pork jowls, pork fat and skin or rinds, prior to processing. In liver products, the liver proteins have a unique stabilizing role within the matrix. Unlike myofibrillar protein, liver protein actually creates a granular network. That is the reason that the liver nearly always is used in a raw or blanched form. During comminution, or fine size reduction in the presence of salt, the raw liver proteins form a thread-like network, which changes its behavioural characteristics when the liberated fat from its cell walls is finely distributed into a granular or globular network. This liver protein matrix stabilizes fat when heated. A liver sausage matrix is so vastly different from an emulsified frankfurter sausage that some meat scientists refer to it as stabilized foam, rather than a meat emulsion.

Like dry fermented sausages such as salami, liver sausage has traditionally contained elevated levels of fat. Technologically, the main function of fat in liver sausage or pâté is to regulate texture and spreadability (Fig. 14.1). The desire for fat reduction has influenced some of the formulae of liver products. Most probably, the consumers consider liver products as a delicacy that is beyond the need to reduce calories. However, a number of spin-off liver products, including spreads, have been developed in which the fat has been replaced by a combination of water, oil (or collagen-rich meat) and functional soy protein.

In principle, there are two chopping or blending methods for liver sausage manufacturing. The ideal method depends on whether or not the meat and fat is blanched, or partially cooked. Temperature treatment before the actual processing creates distinct flavour and texture attributes and is often the only difference between regional preferences.

When uncooked meat and fat are used, it usually is recommended to chop the lean

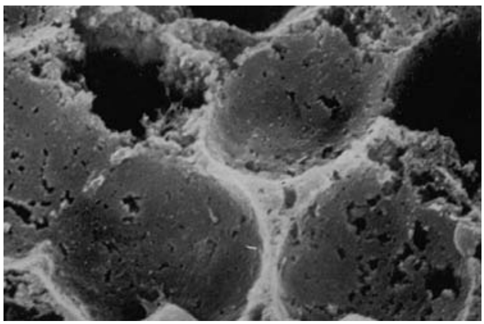

Fig. 14.1. SEM photograph showing cooked liver matrix, indicating fat globule cavities. Source: Meat Research Institute, Kulmbach, Germany.

meat with half the salt and half the water to about 4°C. At that point, the fresh or scaled liver is added, together with the curing salt and the balance of the salt. The temperature slowly will increase, and when a temperature of about 12°C is reached, the chopped liver slurry will start to bubble. At that point, the functional non-meat protein is added, together with the balance of the water and the seasoning. When the bubbles recur, the pre-ground pork jowls and back fat are added. The continuation of the chopping increases the temperature to 16–18°C and the liver emulsion is ready for stuffing and further processing.

It is also possible to opt for a chopping method that allows greater processing freedom, including the choice of raw meat materials. For this method, it is required to blanch the meat, pork jowls, rind or skin and connective tissue. Blanching usually requires heating in a kettle for some 20 min to a temperature of about 70°C, which softens the structure of fat and fatty tissue.

Processing starts by hydrating the functional soy protein powder in sufficient amounts of water, followed by the addition of blanched fat and fatty tissue. Depending on the speed of the chopper, the knives' setting and the water/non-meat protein/fatty tissue ratio, an emulsion will be formed that will serve as the carrier for the liver sausage. For optimum spreadability, the emulsion should reach a temperature of 55–60°C. It will be necessary to continue chopping until the added pre-cooked meat is well distributed throughout the carrying emulsion. To this emulsion, raw or scalded liver is added. The temperature of the emulsion will fall back to about 35–40°C. To prevent premature denaturation of the active liver protein, care should be taken that once the raw liver has been added, the chopping temperature does not increase beyond 45°C.

The use of pre-emulsion technology as a base stabilization for liver products, including pâté delicacies, generally provides a significant larger fat–water stabilization range, including increased variations to manipulate texture and to regulate sliceability and spreadability. As a rule of thumb, at higher pre-emulsion temperatures, or when the fat is pre-blanched, the end product is softer and more spreadable. Lower emulsifying temperatures increase firmness and create sliceable products. The use of frozen liver usually decreases the stability range of the fat–water ratio, but still is better compared with the traditional chopping sequences where extracted liver protein is the predominant provider for emulsification. The same is true for fats that are difficult to stabilize. Pork leaf fat (flare fat), pork soft belly fat and beef suet have a smaller fat–water stability range. Pork jowls are the preferred fat source for liver and pâté products. Pre-emulsions are also ideal vehicles when vegetable oils need to be used as a replacement for animal fats.

Liver sausage emulsion should ideally be filled under vacuum at a temperature of 40°C or slightly higher. The sausage can be heat-treated by water or steam cooking. The core temperature should reach 74°C. Also, smoke can be applied as part of the thermal processing. Finally, the sausages are cooled in a water bath or cold shower, and if desired, cold smoke can be applied when the internal temperature has been reduced to 25–30°C.

Functional soy protein ingredients allow processing and product formulation with a wide range of variations in inclusion levels of water, fat, meats and liver. The possibilities are only limited by the imagination, and the formulae are too many to mention.

Liver Pâté

The transition from liver sausage to the creation of pâté is a logical extension of the product range. Pâté is a traditional upscale French charcuterie product that is available in a wide array of distinctive meats and flavours. These products can be made from all muscle food selections. Within these choices there is great freedom in ingredient selection, including replacing animal fat sources with vegetable fat in order to reduce cholesterol. Also, vegetarian pâtés and vegetable mousses can be made, and are of particular interest for consumers who have special dietary requirements.

It is believed that the original pâté is a regional speciality from Brittany, France, that has been available for over 200 years. This creation, made by combining meats and spices, has reached a high degree of artistry. By varying the individual coarseness of cooked meats and with the use of herbs, seasoning, spices, liquor, port wine and brandy, a multitude of subtle flavours can be created. Pâté with Parma ham and Hungarian salami are without a doubt the ultimate meat products that reflect 'savoir vivre' or 'the art of life'.

These classic products have survived the formula changes that have been so typical for many other processed meat products. Many formulae have been adapted to please regional and even local taste preferences; also the impact of modern dietary requirements has resulted in the development of a range of spin-off versions. For fat-adjusted versions, high fat stability is no longer a prerequisite. Soy protein has replaced much of the role of dairy ingredients. High gelling soy protein ingredients can successfully be used to obtain optimum slicing and/or spreadability.

The French word pâté means 'enclosed in a pastry'. Even the ancient German word pate translates into 'dough'. Quite often the words pâté, galantine, rillettes and terrine are used interchangeably by non-French speaking people. This is not quite right, since there are distinct differences between these delicacies.

These homemade types of delicacies are still part of the haute cuisine culture in a number of European countries.

It is nearly impossible to describe the processing technology for pâté manufacturing. Not only are there many different product descriptions in most countries, but, more importantly, minor modifications in the sequence of ingredient additions and equipment configurations can have major impact on the end results. These variables have only been increased by the many new spin-off versions of calorie-restricted pâtés and spreads. A typical processing method can therefore only be given in very broad terms. The manufacturing process usually proceeds according to the following pattern:

Blanching

All meat and fatty tissue materials are pre-cooked to a temperature of about 70°C for some 20–30 min. The pre-cooking or blanching is not only important for flavour and aroma development but also for fixing the desired textural properties, including mouthfeel and smoothness. Pre-cooking will also inactivate the meat protein and de-stress the collagen-rich material, such as jowls and skin or rinds. All these materials contribute much more efficiently to the stabilization of the base emulsion when denatured. By varying the pre-cooking temperature, textural properties can be manipulated. In general, smooth and spreadable liver pâtés need somewhat longer pre-cooking than the sliceable versions. However, the contributing functional ingredients also influence the texture.

In a basic pâté emulsion, raw liver is a major contributor to the stability of the emulsion. It is important to ascertain that the fat globules are homogeneously distributed throughout the well-developed liver protein structure. It is therefore essential to treat the raw liver with sufficient salt to create the granular, thread-like, liver protein network. At a temperature of 55°C, the liver protein network will change from a granular appearance into a globular structure. Consequently, the interaction of the raw liver proteins and the finely comminuted pre-cooked meat and fatty tissue should preferably occur at a temperature lower than 55°C. Adhering to these temperatures will contribute to the formation of a strong network during thermalization. Liver products with a low liver content, or where part of the liver proteins have been denatured, usually form a stringy protein network, and thus are inferior in terms of holding the irregular shaped fat globules and remaining fat structures. This problem can increase in magnitude when fat globules released from the cell walls are so abundant that there simply is insufficient active protein available to cover the increased surface area.

For these cases, and for a low fat/high-water formula, it usually is necessary to supplement or duplicate the properties of the liver protein. For minor adjustments, there are a number of functional non-meat proteins such as caseinate or egg white that can support the emulsions. However, at a higher inclusion level of 0.8% and more, soy protein isolate is the ingredient of choice.

Assembling

After pre-cooking, meat and fatty tissue are added to the chopper, preferably while still hot, and reduced to a fine particle size. Next, hot water or stock is added together with selected non-meat protein. Chopping continues at high speed until a homogeneous emulsion has been formed. The temperature should be between 40°C and 55°C. At this time, the raw liver is added to complete the final preparation of the matrix. It might be beneficial to pre-chop the raw liver with salt and cure before addition to the fat/water emulsion. The addition of the raw liver to the fat/water emulsion will reduce the temperature to between 30°C and 40°C. To prevent matrix destabilization, a filling temperature of about 38°C is recommended.

After the formation of the basic liver emulsion or matrix, which usually serves as the carrying phase, there are unlimited possibilities for creating final product specifications. Usually cooked coarse ground meat and poultry are blended in the matrix, together with exquisite flavours and seasonings. When a chopper is used, the knives should be set at mixing speed, otherwise the product's coarse attributes will be quickly destroyed.

Depending on packing size and weight, the pâtés are oven-baked for up to three hours to a core temperature of 74°C, a recommendation that provides optimal shelf life without affecting the development of the delicate flavour and aroma profile. Where ceramic or aluminium containers are used, the pâtés are often decorated with condiments after baking or cooking and glazed or flamed with aspic. Aspic and hard lard often are poured as a thin film on to the baked or cooked pâté for eye appeal, and more importantly to maintain colour and reduce microbial spoilage.

References and Suggested Reading

Hilmes, C., Cheong, S.H. and Fischer, A. (1993) Microstructure and stability of liver sausage as influenced by liver content. *Fleischerei, Germany* 4, III–VI.

Hoogenkamp, H.W. (1998) Many options for liver delicacy. *Meat International* 8(2), 35–36.

Formulation Examples: Liver Delicacies

Braunschweiger liver sausage – liver loaf (USA)

Ingredient	%
Pork jowls	40.00
Bacon ends or trimmings	12.00
Liver	37.00
Water	6.30
Soy protein isolate[a]	1.50
Non-fat dry milk	0.50
Dextrose	0.30
Curing salt (0.6% $NaNO_2$)	0.20
Salt	1.60
Seasoning	0.45
Dried onion powder	0.10
Sodium ascorbate[b]	0.05
Total	100.00

[a]Recommend high gelling SPI.
[b]Alternative: sodium erythorbate.

Procedure:
1. Chop raw liver with salt and cure until bubble formation occurs.
2. Add water/ice.
3. Add soy protein and until well hydrated.
4. Add ground fatty tissue and bacon ends.
5. Add remaining dry ingredients and chop until approx. 16°C. Stuff in moisture-proof casings and cook in water or steam at 77°C to an internal temperature of 74°C. Chill in cold water or ice, or cold shower to 32°C.

Farmer style liver sausage – Hausmacher leberwurst

Ingredient	%
Pork liver (fresh or frozen)	30.00
Pork trimmings 50CL[b]	36.00
Pork jowls	15.00
Pork trimmings 80CL	15.00
Salt	1.80
Soy protein isolate[a]	1.00
Sugar	0.60
White pepper	0.15
Ginger	0.05
Marjoram	0.10
Nutmeg	0.05
Allspice	0.05
Onion powder	0.20
Total	100.00

[a]Recommend high gelling SPI.
[b]Chemically lean.

Procedure:
1. Blanch or scald pork liver in hot water.

2. Pre-cook pork trimmings, pork jowl and 1/3 of pork liver to 65°C and grind through a 12 mm plate.
3. Cool temperature to 50°C or lower.
4. Add remainder of blanched pork liver to chopper together with salt (cure = optional), and all other dry ingredients.
5. Continue chopping until pork livers become ‘bubbly’.
6. Add cooked and ground pork inclusions at mixing speed until desired consistency is obtained.
7. Stuff in appropriate casings and water- or steam-cook at 70–80°C until a core temperature of 71°C is reached.
8. (Smoking is optional provided selected casing is smoke permeable.)
9. Cool in cold water or ice.

Liver pâté – base matrix

Ingredient	%
Pre-cooked pork jowls	16.30
Pre-cooked pork back fat	16.30
Pre-cooked pork skin (rinds)	5.00
Water or stock	28.00
Soy protein isolate[a]	2.00
Raw pork liver	28.00
Salt	1.60
Curing salt (0.6% $NaNO_2$)	0.20
Spices and seasoning	0.45
Non-fat dry milk	0.80
Sodium ascorbate	0.05
Dehydrated onions	1.30
Total	100.00

[a]Recommend high gelling SPI.

Light liver pâté – base matrix

Ingredient	%
Pre-cooked pork back fat or jowls	10.00
Pre-cooked pork skin (rinds)	7.00
Water or stock	37.00
Soy protein isolate[a]	3.20
Raw pork liver	36.00
Salt	1.50
Curing salt (0.6% $NaNO_2$)	0.20
Modified food starch	1.00
Dextrose	1.00
Non-fat dry milk	1.00
Vanilla sugar	0.50
Tomato paste	0.50
Spices and seasoning	0.80
Aroma	0.25
Ascorbate or erythorbate	0.05
Total	100.00

[a]Recommend high gelling SPI.

Pâté creme (Belgium)

Ingredient	%
Pre-cooked pork skin (rinds)	8.00
Pre-cooked pork back fat	40.00
Water or stock	20.00
Soy protein isolate[a]	2.00
Raw liver	25.00
Salt	1.40
Curing salt (6.25% $NaNO_2$)	0.20
Port wine	2.00
Dextrose	0.90
Spices and seasoning	0.45
Ascorbate or erythorbate	0.05
Total	100.00

[a]Recommend low gelling SPI.

Procedure:
1. Chop pre-cooked pork skin (rinds) and pork back fat to fine particle size.
2. Add water or stock.
3. Add soy protein, and emulsify at 40–55°C.
4. Add raw pork liver, salt and curing salts, other ingredients and flavours.
5. Continue chopping, temperature not exceeding 50°C.

Liver margarine (Norway)

Ingredient	%
Margarine	40.00
Water	30.00
Soy protein isolate[a]	3.00
Liver (pre-chopped)	20.00
Salt	1.20
Curing salt (0.6% $NaNO_2$)	0.12
Ascorbic acid	0.05
Non-fat dry milk[b]	2.00
Wheat starch[c]	3.20
White pepper	0.20
Mace	0.10
Ginger	0.05
Cardamom	0.05
HVP	0.02
Ground garlic	0.01
Total	100.00

[a]Recommend low gelling SPI.
[b]Alternative: sweet dairy whey powder or lactose.
[c]Wheat starch is not necessary from a stability point of view. However it can be used to regulate texture and mouthfeel.

Procedure:
1. Melted fat is added into the chopper or emulsifying equipment.
2. Water and soy protein isolate are added.
3. Emulsify until a white and stable emulsion is formed. Make sure the emulsion temperature is adequate.

4. With salt and cure pre-chopped liver is added. Ascertain that emulsifying temperature is <55°C.
5. Add balance of salt, seasoning and non-fat dry milk powder.
6. Add wheat starch.

Meat cream (Russia)

Ingredient	%
Pork jowls 25CL	16.00
Pork trimmings 60CL	32.00
Pork skin (rind) (blanched)	16.00
Water	24.00
Salt	1.40
Curing salt (0.6% $NaNO_2$)	0.15
Non-fat dry milk	1.20
Soy protein isolate[a]	5.00
Sautéed onions	3.00
Sugar	0.40
Nutmeg	0.30
White pepper	0.10
Coriander	0.05
Mustard powder	0.40
Total	100.00

[a]Recommend low gelling SPI.

Procedure:
1. Chop blanched pork skin (rind) to fine particle size.
2. Add water and soy protein isolate and chop at high speed to coherent 'emulsion'.
3. Add all meat and fat together with ingredients and chop to strong meat batter.
4. Inject steam or cook in cutter to 50°C.
5. Pass meat batter through emulsifier.
6. Fill in impermeable casings of approx. 50–60 mm diameter.
7. Cook for 1 h until 72°C core temperature.
8. Chill to <6°C.

Liver cream (The Netherlands)

Ingredient	%
Pork fat	38.00
Pork skin (rind/rinds)	8.00
Stock (broth)	20.00
Soy protein isolate[a]	2.00
Wheat starch	4.00
Non-fat dry milk powder[b]	1.00
Fresh onions	1.50
Salt	1.00
Curing salt (6.25% $NaNO_2$)	0.15
Seasoning	1.35
Pre-chopped liver	23.00
Total	100.00

[a]Suggest high gelling SPI.
[b]Alternative: sweet dairy whey powder.

Procedure:

1. Pre-cook pork fat (jowls) and pork skin (rinds) at 80°C for approx. 20 min.
2. Chop pre-cooked fatty tissues to small particle size.
3. Add soy protein isolate.
4. Add broth (stock) and emulsify at high speed until a shiny emulsion has been formed.
5. Add (pre-chopped) liver and chop at high speed until bubbles start to appear.
6. Add non-fat dry milk, seasonings.
7. Add wheat starch.
8. For very fine texture and mouthfeel, pass liver paste through emulsifier or colloid mill.
9. Texture can be regulated by using broth of varying temperature.
10. Fill into casing or glass or plastic containers.

15
Protein-enhanced Fresh Meat

During the lifetime of the Flemish painter Pieter Breughel, food seemed easy. Some of his now world-famous paintings illustrate huge and festive eating parties featuring lots of minimally processed foods.

Unfortunately food is not so simple any more. A rapidly increasingly world population that grows by some 80 million people a year, coupled with demographic changes and evolving social infrastructures in which an increasing number of women enter the workplace, have greatly influenced food production, preparation and point of consumption.

Although many televised cooking shows depict the joys of cooking, the fact is that fewer people have either the skill or time to prepare fresh meat cuts in 'traditional' ways. Modern time-strapped consumers demand a centre-of-the-plate meat portion that can be prepared in minutes – not hours. Ease of preparation at home thus needs to be part of the solution.

Protein-stabilized moisture-enhanced fresh meat is one key to that solution, being less intimidating and more forgiving during cooking and preparation. Such products cook faster and retain higher moisture levels, ensuring premium organoleptical quality, with the added benefits of added flavour sensations.

It is expected that protein-enhanced meat will not only create demands from the cash-rich and time-poor societies in industrialized countries, but will also quickly penetrate developing nations to improve muscle food economics and affordability.

Home preparation and cooking skills of various whole muscle cuts, which seemed so easy a generation ago, have been lost. Not only do most people these days no longer have the skill level, but busy parents no longer have the desire (or the time) to spend hours in the kitchen preparing a nutritious meal from scratch. The same is true for a great many young professionals, single households and empty nesters who are busy kick-starting their careers or pursuing lifestyles in which the consumption of food is more important than preparing it.

Over the years, food manufacturers have introduced many meal solutions to busy consumers, starting with the introduction of TV dinners in the early 1950s, to the current wave of home meal replacements, a development designed to give consumers quick yet consistent, tasty and flavourful eating experiences.

Meeting Expectations

Consumer demands for leaner cuts of meat have prompted the creation of leaner species of livestock that produce more meat and less fat. Unfortunately, especially lean pork can be very sensitive to quality degradation if it is overcooked.

In the USA and European Union, meat processors and retailers have responded and worked to make leaner, case-ready meats available. These cuts are trimmed and generally packaged in a modified atmosphere system using barrier films and trays made with materials such as expanded polypropylene film.

Of course, pre-packed fresh meat has been available in the supermarket meat case for some time, so in that sense, case-ready meats are not really new, though new packing technologies have greatly improved shelf life and meat colour. For example, compared with traditional packaging that provides 2 or 3 days of assured shelf life, modified-atmosphere packaging delivers 4–6 days. Another advantage is fewer product returns. Newer tray-forming technologies produce a tray with sides that are almost vertical, enabling the display of up to 30% more meat in the same space.

It is in the retailer's interest to eliminate meat-cutting activities from the backroom of the store. Increasingly, supermarkets find it difficult to recruit and to retain skilful butchers, while at the same time, a large majority of shoppers place a high value on the store's fresh meat quality and the physical presence of a 'butcher-chef'. Ultimately, the role of the master butcher will evolve from a production-oriented job to a sales-focused role in which customer interactions will provide much needed selection and preparation suggestions. Additionally, case-ready meats are produced under the inspection of the USDA (or similar government programmes), limiting the chances for microbial contamination and redirecting liability to the meatpacker if a food-borne outbreak is traced back to the packing plant. All aspects of sanitation and traceability are handled by the packer, thus freeing up valuable time for the retailer. A number of primary meat companies have reoriented their activities downstream, enabling retailers to customize their purchases of centrally packaged, 'made-to-order' fresh or fully cooked meat products.

The Impact of Packaging

Most consumers do not know that packaging can have significant effects on meat quality. Protein-enhanced, case-ready meat can greatly improve the product's succulence and tenderness. For beef, the maturation process, in which product is aged under vacuum in a shrink bag for up to 10 days, is especially important.

The right case-ready packaging system for fresh meat remains a much-debated issue. No single technology has become the standard. Moreover, agreement has not yet been reached on how to maximize colour and shelf life. Typically, case-ready packaging systems use some combination of carbon dioxide, oxygen and nitrogen gases to flush the product, making package integrity a crucial issue. To maximize shelf life, processors should use modified-atmosphere packaging systems. The aim is to reduce the amount of oxygen, which would otherwise reduce shelf life.

Normally, oxygen should be kept at a level of 1% or less to avoid premature oxidation of the meat. Carbon dioxide inhibits microbial growth, but in order to do so the gas must be present at a level of at least 15%. Then again, when the carbon dioxide level approaches 30%, the meat can be negatively impacted. Nitrogen gas is used to make up for the difference in the case-ready meat packages.

Beyond the above case-ready packed meats, new thermoformable packaging films are available that can be cooked, cooled and displayed in the same overwrap. The cook-in format system uses vacuum skin-packaging technology.

Case-ready meat still finds formidable competition from traditional cuts of meat butchered and packaged at the retail grocery store. The consumer still has a deeply entrenched 'price-per-pound' mentality, and margins for traditional fresh meat cuts are increasingly under pressure. However, meat remains a 'high-involvement' purchase: very often it can be witnessed that consumers take a lot of time at the meat counter before deciding on their purchases.

The growing popularity of the case-ready format is partly the result of more efficient centralized procurement, which ends up with a product mix not much different from that which the store was cutting. But to convince consumers to pay the higher prices, a premium must be put on making sure the displayed quality is closely associated with taste expectations. Young people today, even though they're looking for comfort and simplicity, still demand greater value from their food store and food service purchases. It is very difficult to get consumers out of the mindset that value equals quantity.

Case-ready beef and pork evolved much faster in Europe, especially in the UK. In the USA, case-ready packaging initially received a major boost with the introduction of pre-packaged ground beef, which by 2002 had captured a market share of more than 50%. However, much work still needs to be done at point of retail before a full line of case-ready red meat is available on the shelves at all of America's principal grocery chains. Marketing and branding are needed to educate and convince customers to pay a premium; however, the margins for retailers and processors need to provide a satisfactory return investment, compared with traditional store-packed fresh meats.

Still, there is little doubt that the arrival of many new brands of case-ready meats is transforming the meat case. Often, colourful package banners promote health claims, such as low in fat or natural or organic.

As with all other innovations, though, case-ready meat products end up being heavily promoted by the dominant meat companies, who have the financial 'muscle' to create branded programmes and spend vast amounts on advertising, including print and TV advertising, in-store media and POS-materials and PR support.

Once these efforts are successful, 'me-too' products will follow. There are reputable food brands that strategically create awareness about newly introduced products to make consumers believe that a quality product is now available at a lower price, generally by using similar ingredients and packaging. These 'me-too' products could be considered a copycat of the original, but the fact remains that the new products are nearly always cheaper and generally widen the overall category.

The Next Step: Protein-enhanced Fresh Meat

Within the refrigerated case-ready category there are the following segments:

- Enhanced, unflavoured fresh meat.
- Enhanced, pre-seasoned fresh meat.
- Enhanced, fully cooked meat.

Recently, a new segment arrived: protein-enhanced fresh meat. Protein enhancement or 'deep marinated meat' can be defined as a technology using functional non-meat protein ingredients to diffuse moisture and flavourings – if desired – into fresh meat to expand cooking tolerances and improve upon sensory eating characteristics. This technology is especially relevant for fresh meat cuts that can be modified in such a manner that rapid preparation time in the home or food service kitchen becomes feasible, making it also well-suited for serving situations requiring heat lamps at carving stations or buffet lines.

There is little doubt that refrigerated heat-and-eat meals are the future of the fresh meat department. These tasty, nutritious products simplify consumers' lives without compromise.

These protein-enhanced products can be marketed as unflavoured or pre-seasoned products and are showing great potential, not only at retail but in food service as well. Beef, pork, veal and poultry are well suited to moisture-enhancement technology. At food service preparation stations, skill levels are at a minimum, and the pressure is on greater speed of serving customers consistent, great-tasting foods in the shortest possible time.

Protein enhancement of case-ready fresh meat guarantees that the product will lock in juiciness and tenderness, even if over-cooked. Increasingly, consumers are prepared to pay extra for a product that provides a foolproof method of preparing a tender and perfectly seasoned meal. All protein-enhanced case-ready meats have found an enthusiastic consumer response, for example protein-enhanced turkey has opened up an entire new category and moved this quality protein source beyond the traditional Christmas or Thanksgiving holiday choice.

The Ultimate Convenience

Along with protein enhancement, premium quality and convenience can be optimized by pre-cooking the protein-enhanced meat. This delivers ready-to-eat or ready-to-serve whole muscle foods that eliminate time-consuming preparation, which is arguably the ultimate perceived benefit for future generations. But this emerging category will require a different marketing paradigm for both retailers and end users. Instead of a price-per-pound, a price-per-serving mentality needs to prevail. The latter will be an evolutionary process.

Protein-enhanced meats infused with a balanced marinade allow the creation of intense and bold authentic flavours, while at the same time utilizing subprimal cuts of meat. Examples of protein-enhanced and seasoned meat flavours include peppercorn and teriyaki pork tenderloins, herbed pork chops and roasted pork tenderloin with oregano coriander rub, honey mustard, lemon garlic pork loin steaks, Italian-style pork shoulder roast and St Louis-style spare ribs. Similarly great-tasting beef foods can be created such as mesquite BBQ and teriyaki-flavoured New York strip steak.

Great expectations are on the horizon for underutilized cuts, such as beef chuck and round. For example, shoulder centre beef (triceps brachii), known as Ranch steak and Pub steak, has a chuck flavour and a sirloin-like texture. These cuts have great value potential when enhanced with an unflavoured or pre-seasoned protein solution. Down the road, these enhanced meat cuts will be marketed fully cooked, which totally eliminates the complications of in-home cooking. For example, it is now possible to create real value to these new cuts of steaks and when enhanced with soy protein these cuts offer taste and texture characteristics comparable to premium steaks. Some new categories to arrive are:

- Shoulder tender medallions.
- Top blade steak.
- Shoulder centre steak.

Future expectations for fully cooked protein-enhanced ready-to-eat meat promise phenomenal growth potential. Very few people will argue that the convenience level of today's basic case-ready meat is relatively low. A fully cooked option is already a step in the right direction, though based on the speed of demographic and social changes, centre-of-the-plate meat consumption will only survive if convenience is catapulted into a total meal concept which eliminates not only cooking of meat but also all other meal components such as fresh vegetables, potatoes and other condiments. An example is fully cooked protein-enhanced beef brisket or pot roast together with vegetables packed in a rather revolutionary master tray with separate spaces for all meal components to optimize ideal reheating conditions, if necessary. Less mess, less work, less waste, more taste.

A protein enhancement process is also desirable as a way to maintain HACCP (Hazard Analysis Critical Control Point) controls standards for fresh meat products and retain the juiciness after pre-cooking and secondary reconstitution. The latter process is a major cause of consumer complaints because fresh meat that is not protein-enhanced is often perceived as dry, tough and lacking in succulence. Moisture enhancement by means of functional protein modification can also improve the eating quality of muscles affected with pH irregularities, such as PSE pork schnitzels.

A Strategic Partnership

There are several functional protein ingredients that can enhance case-ready meat. In principle, functional protein ingredients of either animal or vegetable origin could be used. In practice, it is essential to choose a protein that quickly disperses, hydrates fully and solubilizes in water or marinade. Equally important is its ability to diffuse completely throughout the muscle cells without damaging the integrity of the meat structure.

As always, the primary concern is flavour and fresh or fully cooked meat can now be protein-enhanced with novel flavourings or marination systems – a simple way of adding value. Flavour-enhanced meat should preferably mimic authentic culinary blends of herbs, spices, oil, wine, vinegar, with added functional protein ingredients.

The soy protein ingredient selected for this application should combine an ultra-clean flavour profile with rapid absorption properties. The protein's clean flavour uniquely supports added flavour diffusion, while allowing processors to maintain natural, distinctive meat flavours in the final product. Soy protein isolate can help maintain the protein structure of the fresh meat and maintain the juiciness and tenderness when genetics of the animal (especially pork) are prone to PSE (pale soft exudate). Research shows that pigs with more lean have greater toughness and poor water-holding capacity. Soy protein isolate has demonstrated a unique capability for simulating lean meat texture while it remains invisible within the meat structure.

What's the optimal level of added protein in enhanced meat? The percentage depends on cooking and flavour objectives, along with price targets. Usually, fresh meat cuts are enhanced by injecting from 8% to 25% protein-stabilized moisture (with or without added flavours), along with low levels of encapsulated salt, sodium or potassium lactate and sodium diacetate. The latter additives can be replaced by a somewhat more label-friendly blend of buffered vinegar and lemon juice or with citric acid. In either case, the basic ingredient formulation is functionally enhanced by the addition of 0.8–1.4% of soy protein isolate to lock in flavour and moisture during cooking.

Marination Variables

Rubs and marinades are often used to enhance product taste and appearance. Rubs are applied to the surface of the meat and are typically a blend of spices and herbs, available in dry or paste form. Pre-massaging meat generates some salt-soluble protein extraction, which creates a tacky surface which increases adherence of the rub or glazes. Besides flavour enhancement, rubs also can provide texture or crunch characteristics.

Unlike rubs, marinades penetrate deeper into the meat membranes and can deliver texture improvement. Quite often salt, phosphate and functional soy protein are added together with an acidic component such as citrus juice or tenderizing enzymes. Muscle fibres swell when treated with a salt solution, trapping water within the fibre bundle. The presence of small amounts of alkaline phosphate basically raises pH, promoting solubilization. The latter helps to increase the viscosity of the sarcoplasmic fluid. Some caution should be exercised regarding the use of phosphate in protein-enhanced meat. Too high levels of added phosphate are likely to create a ham-like texture, and this particularly occurs when the product is massaged or tumbled. Therefore, if phosphate is used, suggested levels of addition should be approximately 0.10–0.15%. Even then, the presence of added phosphate generally creates tightness and compactness in meat structure which are often seen as less desirable by consumers. On the other hand, alkaline phosphates (and sodium erythorbate) are very powerful chelators that assist in reducing oxidation. Under the right conditions, some metal ions, including iron, are powerful pro-oxidants. Binding these ions reduces their ability to initiate oxidation of the fats, which results in off-flavour and off-odour.

The presence of solubilized soy protein isolate will significantly increase moisture entrapment, preventing it from leaving the marinated product as purge. It is recommended to select low viscosity soy protein ingredients in order to prevent blockages in the injection needles. Vacuum tumbling or massaging accelerates penetration of functional marinade ingredients. The pH of the marinade should preferably be equal to or higher than that of meat. Lower pH can negatively affect the water-holding capacity and can lead to a tougher and drier end-product.

For simple brine systems, the protein-stabilized moisture is normally prepared by firstly dispersing the soy protein isolate, followed by the addition of other components, such as salt and sodium or potassium lactate. Static mixers can be used for this relatively simple process: however, with more complex marinade systems more sophisticated equipment is required.

Depending on the type of protein enhancement, organoleptic properties of the meat can be manipulated to meet consumer satisfaction. Protein enhanced case-ready meat products can only be successful though if the products are of higher quality than that of the original fresh meat cuts. The organoleptic properties are usually characterized in descriptive words such as tenderness, juiciness and flavour. Tenderness is directly related to the degradation of the muscle fibre, the contractile state of the muscle and the presence and location of the connective tissue and fat. Meat juices normally contain many aromatic, volatile components and enzymes which also help to soften the meat and assist in the proper slow release of its juices and flavours during chewing. Flavour and aroma release involves a very complex and intense interaction of the four basic sensations: salty, sweet, acidic and bitter.

Besides economical considerations including cost advantages generated by ease of preparation, and using less skilled labour, the main advantage of meat enhancement is to improve organoleptic parameters and thus reduce the variability of the sensory quality of the meat itself. Subsequently, meat enhancement by means of protein augmentation may be summarized as follows:

- Increased water-holding capacity during thermalization or cooking.
- Relaxation of muscle fibres by boosting the added protein content which allows texture improvement.
- Uniform and even distribution of added ingredients throughout the muscle structure, including the benefit of reduced drip-loss.
- Reducing the impact of meat genetics and pH variations such as PSE meat.
- Maintaining or improving nutritive quality and values.

To accomplish major technological improvement of protein enhanced case-ready meat, it is important to select a brine injector that does not form marinade pockets around the needle, but instead provides high-speed spray diffusion as micro-drops during the needle's downward strokes. This method secures deep penetration of the marinade without causing damage to the muscle structure.

Protein-enhanced flavoured case-ready meats usually contain a number of water and/or fat-soluble spices. It is thus important that dispersion includes a certain degree of homogenization, and that the stability over the time needed for dispersed phases to coalesce or separate is ensured. Marinades containing small amounts of added oil contain an emulsion formed by droplet particles, which are interfacially stabilized or coated by the functional soy protein isolate.

The most efficient method for preparing marinade dispersions is the use of mixing systems such as low-shear or high-shear mixing equipment, depending on the type of marinade used. Oil stabilization in a liquid cannot be accomplished by conventional agitation, and subsequently must be done by a high-shear mixing device. To ensure proper stabilization of the marinade dispersion, a rotor/stator type of mixer is recommended, preferably one with a high-speed rotor with speeds of up to 2000 rpm mounted inside a stationary housing or stator. Other options include a colloid mill, roto-static mixer or similar piece of equipment, for example a high speed device with capabilities to act as a crushing mill specially designed for the preparation of highly viscous brines and marinades.

Marinades can also be injected (Fig. 15.1) under low pressure into whole muscle sections, preferably using a dense needle

Fig. 15.1. Close-up of a brine injector with dense needle pattern. Source: P.H. Hoogenkamp.

pattern (Fig. 15.2). But spray injection under constant pressure is important to ensure uniform distribution of the protein-enhanced marinade without 'dead zones'. The injector should consistently deliver spray injection in a single pass while securing ideal moisture retention and piece-to-piece accuracy. Preferably equipment should be used in which the needle will only inject if it touches the product's surface; if it touches bone, injection stops and the needle retracts in the air head. Lower quality meat can be treated with a built-in tenderizer before or after protein enhancement. Excess brine is filtered in the tank, then recycled. It is important to use an injector that has a feature to provide rapid ammonia or glycol chilling marinade, or brine tanks to rapidly drop liquid temperatures to about 2°C.

Ultraviolet light is a relatively new technology that has become available to disinfect brines and marinades. These opaque liquids often contain solid particles and organic matter and UV can be used for controlling pathogens and this effectively reduces the total plate count, improving product shelf life.

After further processing, such as massaging or tumbling, the meat can be slightly crust frozen to allow more accurate portioning, if desired. Low levels of protein enhancement do not necessarily require tumbling or massaging. However, at levels greater than 10%, tumbling or massaging improves flavour diffusion and final product succulence. After injection of the protein and flavour solution, enhanced meat can be treated with an additional coating or dipping for eye appeal and/or to meet a specified cooked colour (Fig. 15.3).

Health Benefits

Overall, soy protein isolate helps to deliver firm, consistent, meat-like texture and desirable eating qualities, significantly reducing the purge of natural juices and ensuring succulence even under 'abusive' situations, such as extended holding times or home freezing, cooking and microwaving. Soy protein ingredients all have in common a high-quality standard of protein comparable nutritionally to lean meat, milk and egg protein, with no cholesterol

Fig. 15.2. Crates of protein injected pork loins. Source: Convenience Food Systems (CFS).

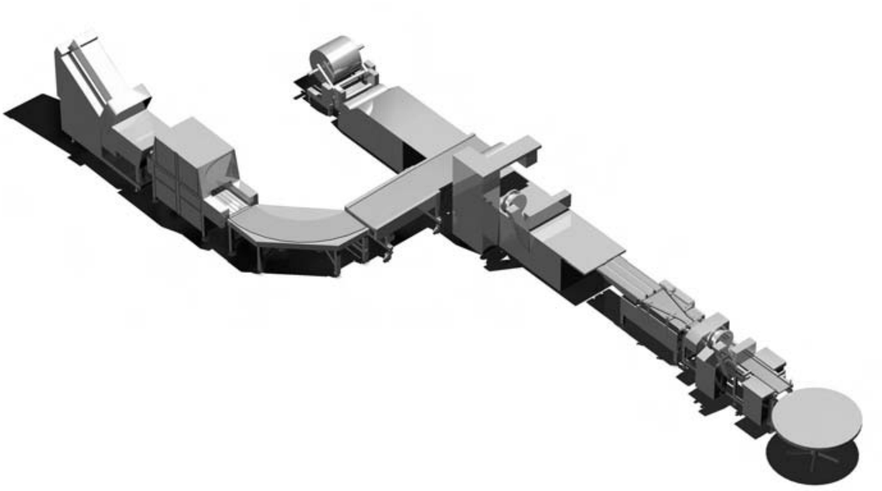

Fig. 15.3. Integrated line set-up of enhanced meat processing. Source: Convenience Food Systems (CFS).

and virtually no fat. In clinical research, compelling evidence indicates that added soy protein offers tremendous potential health benefits.

Protein-enhanced meat is a natural concept that satisfies the consumer's need for convenience and, at the same time, satisfies the desire for no-risk preparation without a lot of culinary skill or knowledge. In spite of a continuing exodus from the kitchen, consumers are increasingly seeking pleasure from everyday meals, and case-ready fresh meat selections should be appreciated as a high-quality compromise for those people who demand convenience, but who still want to cook meat. Eventually, the standard will become enhanced meat cuts that have been pre-cooked to perfection, reflecting memories of the grand old days of enjoying a home-cooked, seasoned pot roast – a time when life was a whole lot simpler.

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Formulation Example: Protein-Enhanced Fresh Meat

Protein-enhanced pork or beef loin

Ingredient	%
Pork loin or beef loin	76.92
Water	20.31
Salt	0.95
Phosphate	0.38
Soy protein isolate[a]	1.44
Total	100.00

[a] Suggest low viscosity SPI.

Procedure:

1. Mix soy protein isolate with cold water in high-speed mixer until smooth.
2. Add phosphate, mix until dissolved.
3. Add salt, mix until dissolved.
4. Inject pork or beef up to 30%.
5. Gentle massaging cycle for 20 min.
6. Fresh tray packing or
7. Crust freeze and slice into chops and cook through impingement or
8. Cook to 71°C and cut at food service station.

Glossary

Adhesion Refers to the degree of stickiness between two muscle parts or how well coated batter sticks to the surface of the substrate. The latter is achieved with temperature, ingredients, absorption and compression.

Air knife An air blower used in batter and breading equipment and co-extrusion equipment to remove excess batter or breading from the coated product. Co-extrusion lines use air knives to remove excess liquid smoke and to reposition sausage to avoid belt imprints.

Air velocity Speed at which air travels as calculated in metres per second.

American breadcrumb Yeast-leavened dough, baked, dried and granulated to desired specifications.

Antioxidant An additive that retards oxidation. Oxidation of fats and oils in particular results in off-flavours and rancidity. Pork back fat has low levels of linoleic and linolenic acids, which makes it less prone to oxidation. Natural antioxidative inhibitors are phosphate, rosemary, sage, garlic, mace, ascorbic acid and isoflavone-containing soy protein isolates. Isoflavones are health-proactive phytochemicals providing biological activity in human cells. TBHQ (tertiary butylated hydroquinone) and BHA (butylated hydroxyanisole) are often added to delay the onset of oxidation and therefore rancidity.

Ascorbate Chemicals of the vitamin C family. Ascorbates are mainly used to accelerate the formation of the curing colour and to establish stable curing colour. An excellent and cheaper alternative for sodium ascorbate is sodium erythorbate.

Auger A diagonal-sloped round device to transport meat or breading to final point of assembly.

Back slopping A term used to describe the old practice of adding raw, unfermented meat from dry sausage production to a new batch to introduce the bacterial culture to a new batch in order to speed up the fermentation process. See also: starter cultures.

Bake Using dry heat to cook food or meat in an oven.

Batter A liquid mixture of water, starches and flour applied to food and meat products prior to cooking. Batter is also a medium to transfer compatible flavour to the substrate and is often the base layer for optimum breading adhesion.

Batter curtain Continuous thin falling layer or flow of liquid batter through which the formed meat product travels.

Batter dip Usually a very viscous batter liquid where submerged substrates travel through on a belt with intermesh fingers, which raises the coated substrate, allowing the batter to flow and avoid belt marks. An air curtain will blow off excess batter. Battered foods usually are par-fried for 20–40 s at 190°C.

Batter fry Typical process for non-leavened batter application to food as a final layer before frying. The objective is to create a rough to semi-rough texture simulating 'home-style' appearance.

Batter (meat) Term defining the final meat emulsion prior to stuffing or filling.

Batter viscosity Typically relates to the ratio of dry mix to water for coated foods.

Belt flip Turning upside down of a formed and coated meat product while product travels from one conveyor to the other.

Belt load The amount of further processed product that can be effectively loaded on and conveyed throughout the processing line. Usually expressed as kilo weight per square metre.

Belt spacing Defined as the distance between two further processed products to prevent touching during frying. Optimization of throughput capacity versus product flaws caused by premature sticking while conveyed into the fryer or cooker.

Binder American–English term for a single ingredient or blend of ingredients which absorb the free moisture in a processed meat system. For example: carbohydrates such as cereal flours, (modified) food starch, gelatine, mustard flour, soy proteins, milk proteins and hydrocolloids.

Biosensors Substances that detect the chemical signature that indicates a biological product is decomposing. Biosensors can be used as a safety tool for packaging systems.

Biotechnology The use of living organisms or other biological systems in the manufacture of products. Biotechnology is an umbrella term for a collection of scientific techniques or tools that use living cells and their molecules to make products or solve problems and thereby improve our lives.

Bite Textural property.

Blood protein (blood albumen) Protein derived from freshly slaughtered animals. Available in frozen liquid form and dried form. Good water- and fat-binding properties.

Blow-off Batter or breading that is released by substrate during further processing. Blow-off is the main cause of sediment in frying oil, reducing its optimum quality.

Braising A cooking method where the food is initially browned, then cooked in a small amount of liquid, tightly covered, with low heat for a long time. Primarily used for tougher cuts of beef to soften connective tissue. This tenderization can be enhanced when acidifiers are used in a pre-marinade.

Breading A baked flour product or crumb, available in many degrees of coarseness and textures, that is applied after the batter. Crumbs provide attractive texture and colour after the frying process.

Breading machine Equipment used to pre-dust free-flowing varieties of flours and or baked breading particles of specific size and shapes, providing full product coating. Crumb breakage needs to be kept to a minimum to ensure consistency. Newer features include equipment with a crumb divider allowing different breading to be applied to the top and bottom of the substrate. Optimum breading distribution is important for optimizing product characteristics.

Brine A solution of common salt (NaCl) in water. The strength of the brine is measured by the proportion of salt and water, without taking the amounts of other brine ingredients such as phosphate, sugars, non-meat proteins and starches into consideration.

Brine/marinade mixing Equipment for efficiently and rapidly dissolving dry ingredients and powders into liquids. Dry ingredients are preferably added into the vortex at a slow rate of addition or metered in automatically using a Venturi pipe system.

Broiling Cooking method using direct radiant heat. The heat source is placed above the product, and often this method is able to caramelize natural sugars into a brown appearance, creating complex sweet and savoury flavours.

Browning May be caused by Maillard reaction or caramelization. The latter usually occurs at temperatures of >148°C, during which dehydration, condensation and polymerization take place creating characteristic brown colours. The Maillard reaction begins with a carbohydrate group reacting with a nitrogen-containing amine group on an amino acid in an environment of dry, high heat.

Browning agents Ingredients that are used to create specific food colours either in uncooked or cooked state, including reducing sugars, caramel, milk powder, egg albumen and dairy whey powder.

Campylobacter The food-borne microorganism most frequently responsible for diagnosed gastrointestinal illness. Infections come from eating contaminated or undercooked poultry or meat or drinking contaminated water or milk. The illness is of particular concern for the elderly and children, and people with weakened immune systems. See also: **Pathogen**.

Capsicum A member of the red pepper family, which provide hot and spicy flavours and aromas, including jalapeno, chilli pepper and paprika.

Caramelization Caramelization is a process in which natural sugars in food are slowly heated, and then begin to brown. A non-enzymatic browning reaction caused when high temperatures react with sugar. Often used for decorative purposes on liver pâté or beef pastrami.

Carrageenan A hydrocolloid derived from seaweed of the **Rhodophyceae** group. In meat products kappa (firmer and more brittle texture) and iota (elastic cohesive gel texture that is less firm) carrageenans are used. See also: **Hydrocolloids**.

Casings Natural intestines or manufactured analogues which are used to fill or stuff meat mixtures prior to further processing. Natural (collagen) casings come from pig, sheep or cow intestines. These edible casings are fairly elastic and expandable or shrinkable, and are used for the original or classic look. Manufactured casings can be derived from cellulose, edible or inedible collagen, and can be artificial or synthetic such as plastic. Plastic casings exhibit strength, but are impermeable to smoke and moisture. Manufactured collagen casings universally are used for a wide range of smoked and cooked sausages in varying diameter and shape.

Casing-netting Mainly used to form products into natural and consistent traditional-style shapes. The casing-netting can be run on high-speed stuffer and clipping equipment. Casing-nets are also available smoke-impregnated to allow faster processing times while improving flavour.

Catalyst A substance which may either facilitate or accelerate a chemical reaction without itself being part of such a reaction.

Caustic solution Referred to as an alkaline solution for sanitation purposes, such as removal of product debris left behind during cooking.

Chargrill A marker device to imprint charcoal marks on formed meat patties to simulate outdoor grill characteristics. See also: **Griller**.

Chopper Also known as: bowlchopper or cutter. A half-bowl shaped processing unit, which has the ability to produce a very fine, consistent emulsion. Important are skill levels of the operator, cutting speed of the rotating knives, knife settings, and bowl rotating speed, knife sharpness, constant knife-to-bowl distance and bowl geometry.

CIP Clean-in-place (CIP) system that allows automation in cleaning of processing equipment.

Clipper A machine to hermetically close the ends of sausage casings. Ideally, the chopped or massaged meat product is voided from the casing where the clips are applied to ensure a tight seal. All types of casings, such as shirred fibrous, collagen, plastic and reinforced nylon, can be made into chubs, chains of chubs and stick sausages of any length, including collagen-cased ring sausages.

Coagulation Protein conversion from a liquid to solid or semi-solid state such as occurs during the cooking of an egg. Adjusting pH by adding salts and other ingredients can influence coagulation.

Coating Refers to application of pre-dust, batter and breading.
Cold pasteurization See: **Irradiation**.
Colloid A colloid is a state of matter where individual particles of a substance are uniformly distributed in the dispersion medium of another. When this medium is water, they are called hydrocolloids. See also: **Hydrocolloids**.
Column dumper Elevator-type mechanism to lift meat containers.
Compression roller Following breading application, the coated substrate passes under a roller which gently presses the breading into the batter. Adjusting roller pressure can marginally regulate product pick-up.
Concentrated soybean protein Soy flour (50%), soy concentrate (70%) or soy protein isolate (90%) (on a dry basis).
Conduction cooking Transmission of heat through solid material.
Contamination The entry of undesirable organisms that enter physically, chemically or biologically into processed meat products.
Contractile proteins Belonging to the group myofibrillar proteins. Mainly important for their salt-soluble proteins that make the meat bind and immobilize water.
Convection cooking Natural or forced heat transfer by fluid motion, such as the use of fans to create equal density or temperature resulting in controlled, uniform heating.
Cooking intensity Defined as the heat transfer capabilities in an oven determined by velocity, airflow, product load and heat energy.
Core temperature Also expressed as IT (internal temperature). Temperature of a product measured at its core or centre.
Coverage Defines the degree of coating to uniformly cover the food product with as few as possible voids. Encapsulation is another word for coverage.
Cutter See: **Chopper**.
Delta-T cooking The temperature differential from the inside of a product to the atmosphere of the thermal processing unit. This method raises the processing temperature in small steps as the core temperature increases. The differential between the core temperature and the outside temperature is kept to a minimum to allow expansion, contraction and protein setting of the processed meat product. Delta-T cooking results in the lowest yield losses, though this method requires a greater amount of time to finish the processing cycle.
Dew point The temperature at which air at a specific temperature with a specific relative humidity will release water in the air as condensation.
DFD Dark Firm Dry. High-pH meat usually dark in colour. Characterized as meat with high water-binding capacity but associated with reduced shelf life, caused by long-term stress.
Direct fired Frying equipment directly heated by electric heaters, gas burners or thermal fluids.
Dispersibility Dispersibility is the situation in which a powder can be mixed with liquid, resulting in a homogeneous product free of lumps. Proteins can be instantized to improve dispersibility.
DNA (deoxyribonucleic acid) All living cells use DNA as genetic material. Genes from different organisms can be quite similar in their basic structure. Biotechnology allows a process to design and build new genes that never previously existed in nature. This process is known as genetic engineering and is also called recombinant DNA technology. There is little doubt that (trans) genetic modification and manipulation will influence the speed with which consumers will accept these products.
Double pass Product that is battered and breaded, then re-battered and re-breaded. This system is used when pick-up greater than 35% is required.
Dry time The time needed for a coated product to be dry to the touch. Breading ingredients, type and temperature of oil regulate dry time.

Dusting drum Rotating drum mechanism through which a conveyor passes to force dry pre-dust or breading on to meat parts such as chicken tenders or bone-in products.

Dwell time The amount of time a meat product spends in a liquid for marinade absorption or moisture absorption.

Edible films and coatings Edible films can be made from several different materials including protein (with collagen casings well established throughout the world), lipids and water-soluble polysaccharides. Edible films are biodegradable and environmentally friendly; however, they exhibit poor barrier properties, especially in high humidity and are limited in many uses.

Emulsification The process in which two normally immiscible liquids are intimately mixed, one liquid becoming dispersed in the form of small droplets or globules in the other. The stabilization of the suspension of one liquid in another. In meat products fat-in-water emulsions are used, with fat or oil dispersed in a continuous oil–water phase (o/w). Pre-emulsion is a technology used to pre-stabilize fat or oil in a bowl-chopper. This allows greater use or variety of fats and oils which are stabilized in water with the help of a functional protein such as sodium caseinate or soy protein isolate. The fat:water:protein ratio depends on the fat or oil properties, but is usually 5:5:1.

Emulsifier Machine to size-reduce meat batter or meat dough to extra-fine emulsions at 3000–4000 rpm, delivering several million cutting actions per minute, preferably without increasing temperatures. From the emulsifier, the meat is transferred to the stuffing equipment for filling and further processing.

Encapsulation A coating system for an active ingredient or acidulates which will be time- or temperature-released. For example: encapsulated salt, or lactic acid. Direct acidification, the most common type of encapsulation, prevents the growth of pathogenic bacteria. When an encapsulated ingredient is released from its lipid shell, it lowers pH levels, increasing acidity in the meat product such as a fermented sausage. Future developments will allow slow-release acidulation of, for example, a 24 h period at certain temperature ranges.

Erythorbate The salt of erythorbic acid, which accelerates the nitrite reduction reaction to nitric oxide gas, which in turn acts on the myoglobin and the haemoglobin to produce nitrosomyoglobin and nitrosohaemoglobin respectively. Results in the typical colour of cured meat. On applying heat at less than 60°C, the cured colour is fixed, which changes the compounds into nitrosomyochromogen and nitrosochaemochromogen. Chemically closely related to ascorbates (vitamin C). However, erythorbate is less expensive and almost as useful for curing and colour fixation purposes. Erythorbate may inhibit the formation of nitrosamines. Also inhibits formation of peroxide radicals and thus prevents decomposition of pigments, contributing to long-lasting stable colour in the presence of ultraviolet light and oxygen. See also: sodium ascorbate and sodium erythorbate.

Fat absorption The ability to hold and retain fat. This is important because fat is a natural component of meat and is required for the overall flavour, taste and appearance as well as for achieving high cook yields.

Fattening out A term used to describe the presence of fat on the surface of a sausage after thermal processing. Also known as fat capping. The major causes are: excess or incorrect grinding, chopping or emulsifying leading to weak emulsions; insufficient addition or selection of non-protein ingredients to reinforce the emulsion structure; loosely stuffed products; (excessive) heat transfer during thermalization.

Fermentation Inoculation of lactic acid bacteria, such as active *Lactobacillus bavaricus*, in a meat mixture prior to stuffing of a dry or semi-dry sausage. This can be done by traditional direct fermentation by concentrated freeze-dried lactic acid starter cultures consisting of microorganisms, or indirect acidification by using fat-coated encapsulated lactic or citric acids. Encapsulated acidulants control the acid level (pH) during cooking, resulting in sausages with a higher margin of microbiological safety. Additionally, the acidulants produce end results that are significantly faster than using starter cultures. The acidulants can be mixed into the meat without protein reactions, and the acids can be released by a combination of moisture, heat and/or time. See also: back slopping and starter cultures.

Flake ice Shaved ice particles made by an ice-generator to control temperature of a sausage mix during emulsion preparation to avoid premature breakdown of fat and protein.

Flash frying See: **Pre-frying**.

Flavouring agents Ingredients intended to increase, decrease or modify flavour profile in processed meat products. For example, (liquid) smoke, bacterial starter cultures, sweeteners such as sugar, dextrose, sorbitol, maize syrup and flavour modifiers such as monosodium glutamate (MSG).

Fleischermeister German-educated and degree-qualified sausagemaker and meat technology specialist.

Foaming Air entrapment occurring when using sub-optimal methods and ingredients to prepare a brine or marinade, or as these liquids are being transferred into the tanks. Adding marinade ingredients directly into the vortex, reducing the amount of splashing and maintaining tight control of circulation pumps to/from the multi-needle injector all reduce foaming.

Footprint Defines the floor space needed for specific equipment. A lower footprint usually allows improved manufacturing efficiency.

Forming cups Device made from plastic or metal that exactly matches the contours of the forming plate to allow perfect knock-out properties of the meat-filled cavities of the forming plate.

Forming machine To produce perfectly formed and portioned products in a variety of shapes and sizes while maintaining the highest levels of product texture, structure, integrity, and maintaining organoleptical properties. Important are parameters such as fast-forming plate exchange, low plate leakage and waste, and high capability of strokes per minute with a minimum of downtime. Recent developments allow features such as a memory bank, which adapts to changing conditions, such as pressure in the forming plate, and adjusts temperatures in the press chamber accordingly.

Forming plate Device made from plastic or metal which is inserted into the forming machine providing exact product shape or contour and product weight.

Free fatty acids (FFAs) FFAs are caused by undesirable conditions of the frying oil, which generates fumes and odours creating off-flavours and darker end products. FFAs significantly reduce optimum performance of the frying oil.

Freezing Equipment for blast or cryogenic freezing. The most common equipment includes spiral blast freezing and cryogenic freezing. Spiral blast freezing uses temperatures as low as –35°C using air velocities and cross-flow air patterns, compared with cryogenic freezing, which uses either carbon dioxide or nitrogen at temperatures as low as –79°C and –129°C, respectively. Rapid temperature reduction results in small ice crystals and causes limited separation of solutes and water. It also retards the growth of psychotrophic or cold-loving microorganisms that grow at less than –18°C.

Fry tolerance The amount of time needed in the oil fryer to develop specified colour.

Fryer A thermal oil, gas or electrical heated unit filled with oil to cook coated foods. Conveyorized fryers are used for in-line manufacturing processes.

Frying A method to cook foods by submerging the substrate into hot oil or fat. Frying creates a crispy texture that can be changed with the use of various coatings, batters and breading. Frying creates a rich and fatty mouth feel.

Full fried Full cook. Product which is fried to such a degree that all harmful pathogens have been eliminated, for example to a core temperature of 72°C.

Functional foods (nutraceutical) Any food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains.

Functional soy protein concentrate (FSPC) Functional soy protein concentrate is a technologically improved version of soy protein concentrate (SPC). Compared to SPC, FSPC has superior gelling and emulsification properties and often can be used to replace soy protein isolate (SPI) in emulsified meat products on a weight-for-weight basis.

GDL Glucono delta lactone enhances meat preservation by reducing pH level and accelerating the curing or fermentation process.

Gelatine Derived from collagen and is present in animal skin, bone and connective tissue. Partial hydrolysis transforms the collagen into a product with varying gel strength or bloom. High-bloom values indicate greater firmness. For meat applications, bloom numbers generally range from 90 (low) to 260 (high). Gelatine is relatively insoluble in cold water and solubilization increases at higher temperatures. Gelatine is thermoreversible and absorbs at 5–10 times its weight.

Gelation Gelation is the process which transforms fluid materials into semisolid forms. The process of gelation creates the structural characteristics of a large variety of food products, including emulsified meat products. Many different kinds of polymeric ingredients gel under specific conditions. Proteins normally require higher concentrations to gel than other common gelling ingredients. Enzymes, acids, divalent cations and/or heat are utilized to induce gelation of proteins.

Gelling agents Thickening agents in food and meat systems such as alginates, carrageenans, locust bean gum, guar gum and xanthan gum. See also: **Hydrocolloids**.

Glycogen Sugar compound that functions as an energy reserve in muscle tissue. In normal slaughtering, glycogen reduction and ATP reduction will cause lactic acid formation and thus lowering of the pH. Under the influence of low pH, water-binding capacity decreases.

Granulation Refers to the particle size of ground meat, ground fat or gelled (intermediate) ingredients. Also refers to the particle size of breading.

Greening The presence of lactobacilli, leuconostocs or acid-forming micrococci of a processed sausage or ham, creating ‘green rings’ (non-contagious contamination of raw material or equipment existing before processing), ‘green cores’ (contagious due to insufficient heat processing) and ‘surface greening’ (very contagious contamination after processing).

Green weight The weight of the meat before processing or injection.

Griller An oven using conductive heating to further process grill foods to simultaneously brown, cook, char-mark meat patties, chicken breasts and strips, etc. See also: **Chargrill**.

Grilling A direct heat method of cooking that uses hot or heated coals, wood or gas flames as the dominant heat source, which is located below the food. The food is usually placed on a metal grill and this system can create unique smoking flavours.

Grinder Equipment with multiple-plate assemblies to size-reduce fresh, chilled or frozen meat. The system should be self-feeding and collect bone fragments.

Guar A hydrocolloid obtained from the seeds of the *Cyanobris tetragonoloba* plant. Used in some processed meat products as a thickening agent.

HACCP Hazard Analysis and Critical Control Point. A systematic and effective method to analyze a process and identify potential biological, chemical and physical hazards that can occur in food. HACCP is also called the ‘hurdle method’, which assembles multiple scientific barriers against food product deterioration to act simultaneously, minimizing food-safety risks. A limitation of HACCP is that it only addresses known food safety problems.

HACCP definitions:

- *CCP decision tree* A sequence of questions to determine whether a control point is a CCP.
- *Continuous monitoring* Uninterrupted collection and recording of data such as temperature on a strip chart.
- *Control* To manage the conditions of an operation to maintain compliance with established criteria. The stated correct procedures are being followed and criteria are being met.
- *Control point* Any point, step or procedure at which biological, physical or chemical factors can be controlled.
- *Corrective action* The action taken when monitoring at a CCP indicates a potential loss of control or when a critical limit is not being met.
- *Criterion* A requirement on which a judgement or decision can be based.
- *Critical control point (CCP)* Any location or procedure in food production at which control can be applied and a food safety hazard can be prevented, eliminated or reduced to acceptable levels.
- *Critical defect* A deviation at a CCP which may result in a hazard.
- *Critical limit* A value which separates acceptability from unacceptability.
- *Deviation* Failure to meet a critical limit.
- *HACCP plan* The written document that is based upon the principles of HACCP and that delineates the procedures to be followed to assure the control of a specific process or procedure.
- *HACCP plan revalidation* One aspect of verification in which documented periodic review of the HACCP plan is done by the HACCP team with the purpose of modifying the HACCP plan as necessary.
- *HACCP plan validation* The initial review by the HACCP team to ensure that all elements of the HACCP plan are accurate.
- *HACCP system* The result of the implementation of the HACCP plan.
- *HACCP team* The group of people who are responsible for developing a HACCP plan.
- *Hazard* A biological, chemical or physical property that may cause a food to be unsafe for consumption.
- *Hazard analysis* The process of collecting and interpreting information to assess the risk and severity of potential hazards.
- *Monitor* To conduct a planned sequence of observations or measurements to assess whether a CCP is under control and to produce an accurate record for future use in verification.
- *Operational procedure* Routine procedures that are critical to protecting the health of customers. These practices include personal hygiene, hygienic food handling and sanitation, and procedures that minimize chemical and physical dangers.
- *Preventive measure* Physical, chemical or other factors that can be used to control an identified health hazard.
- *Random checks* Observations or measurements that are performed to supplement the scheduled evaluations, required by the HACCP plan.
- *Risk* An estimate of the likely occurrence of a hazard.
- *Sensitive ingredient* An ingredient known to have been associated with a hazard and for which there is reason for concern.
- *Severity* The seriousness of a hazard.
- *Target levels* Values that are used to assure that critical limits are met.
- *Verification* The use of methods, procedures or tests in addition to those used in monitoring to determine if the HACCP system is in compliance with the HACCP plan and/or whether the HACCP plan needs modification and revalidation.

Ham press rack Designed to form whole muscle meat products into consistently repeatable shapes and sizes during cooking and/or smoking. The proper amount of compression allows for uniform pressure to ensure gentle and thorough cooking and cooling.

High pressure cold pasteurizer High processing method by which food or meat products are subjected to a high level of hydrostatic pressure which inactivates the majority of microorganisms without the loss of organoleptic quality. It is designed to extend the shelf life of pre-packed heat-sensitive meat products.

HMR (home meal replacement) Ready-to-eat, ready-to-heat or ready-to-assemble hot or cold meals or entrées prepared or packaged outside the home that are brought or delivered to the home. A more narrow definition of HMR is meal occasions when the meal provider does not have the time or talent to cook from scratch and subsequently the meal is prepared by a supermarket, deli or specialized (franchised) fast-food company.

Hydration The ability to take up and hold water.

Hydrocolloids Water-soluble macromolecules of high molecular weight that, by binding a large amount of water, modify the rheology of aqueous systems to which they have been added. Hydrocolloids are more closely defined as macromolecular hydrophilic, water-soluble substances which, when dispersed in water, form viscous solutions, gels or pseudo-gels. See also: **Carrageenan**.

Hydrolysed vegetable protein (HVP) HVP is manufactured by acid hydrolysis of high protein fractions from plant sources such as soy, maize and wheat, which provides peptides, nucleotides and free glutamates for flavour enhancement.

Impermeable casing No moisture or smoke can penetrate into the meat product inside the casing.

Impingement cooking A method of accelerated heat transfer to quickly penetrate the insulating layer of air surrounding the food product (conveyor transferred) in the oven. Faster method of forced convection cooking.

Impingement freezing A method using high-speed jets of air to penetrate the boundary layer around the product; freezing it quickly gives improved yields compared with cryogenic systems.

Indirect cooking Defines a method where heat is introduced into the oven from an external source, thereby effectively eliminating combustion contact of the food.

Indirect fired Equipment set up where the frying oil is heated outside the frying tunnel. Pumps circulate the oil.

Injection The process of brine, pickle or marinating injection by multi-needles directly into whole muscle sections in order to manipulate product characteristics such as flavour distribution. Preferably each needle is individually activated when it penetrates the meat, thus optimizing brine economics. For bone-in product, needles need to retract and stop injecting when touching a bone, subsequently eliminating brine or jelly pockets. Injection is also used as a mechanism to stabilize water in a whole muscle meat system.

Inulin (fibre) A naturally occurring plant polysaccharide extract mainly made from chicory that improves texture by replacing the mouthfeel of fat and sugar in food, beverages, vegetarian preparations and certain processed meat systems. The low-molecular fraction of inulin, with a chain length between 2 and 10 monomer units, is referred to as oligofructose or fructo-oligosaccharides (FOS), prepared by a partial enzymatic hydrolysis of inulin. Inulin is a soluble dietary fibre that also serves as a prebiotic. It stimulates the growth of bifidobacteria and thus promotes enhanced gastrointestinal health (colon) and can provide improved bioavailability such as mineral absorption and help maintain a healthy cholesterol level.

Irradiation (also known as electronic or cold pasteurization) Efficient method to reduce pathogens such as *Escherichia coli*, salmonella, listeria and campylobacter in meat and meat products to a safe level. The potential for consumer illness from pathogens is virtually eliminated. There are three types of irradiation systems used: gamma irradiation using Cobalt 60 or Caesium 137; electron beam irradiation; and X-ray (a flexible combination of gamma and electron-beam irradiation). While electron-beam irradiation is the most viable option for in-line processing and quicker than gamma irradiation, it only penetrates 4 cm into the meat. Higher dosages will increase penetration, but meat flavours and aromas might be affected negatively. Also, the centre of a stack of products might not be fully irradiated.

Konjac flour A hydrocolloid made from the amorphosphallus root. Basically there are two types: *Rivierii oncophallus*, which grows in China and Japan, and the Burud roots which are cultivated in Myanmar, Thailand and Indonesia. Konjac flour has a water-holding capacity of approximately 200 times its own weight and it is often used in emulsified low fat meat products in combination with starch to create a gel that can be chopped or ground into white particles to mimic animal fat.

Lactose Milk sugar that is often used as a low-dextrose equivalent type of sugar in brines for ham curing to boost dry solid content. Lactose is often used as an ingredient to absorb off-flavours.

Least-cost formulation A computer-generated mathematical model that first satisfies all required product standards and then does so with the least expensive mix of meat selections and ingredients. Least-cost formulation programs are a valuable tool for all manufacturing segments in optimizing profitability. It also offers R&D benefits to answer 'what if' questions to find alternative ingredient solutions.

Leavened batter Typically baking powder (sodium bicarbonate) or other additives such as sodium aluminium phosphate added to dry batter mixtures to raise or aerate the liquid batter during mixing and frying or baking to increase product volume and create certain open and light structural properties. An example: **Tempura batter**.

Lecithin A complex mixture of phospholipids, triglycerides, fatty acids and other compounds that occur naturally in soybean oil. Lecithin is a natural ingredient with inherent nutritional value, providing emulsification properties. The molecules of the phospholipid components are both polar hydrophilic (water loving) and non-polar lipophilic (oil loving). Lecithin is often used for instantizing powders and as a release agent for encapsulated ingredients such as salt, and serves often as a belt release agent for products that have been formed, coated, fried and cooked.

Linker A machine that automatically forms or links sausage with natural casings, plastic casings, collagen casings of equal length, weight, diameter and shape and directly feeding into loops for smoking and cooking.

Maceration Multiple incisions deep inside the raw muscle meat sections to cut connective tissue and membrane layers and/or improve upon salt and phosphate accessibility to enhance release of salt-solubilized proteins.

Maillard reaction The interaction of sugar and protein amino acids – first described by French chemist Louis Maillard in 1912. The interactions create pleasing flavours, aromas and colours often characteristic of certain foods and meat products.

Marinate Method to diffuse liquids into muscle parts to create flavour sensations and influence textural properties. Spray injection allows brine or marinades to evenly distribute without dead zones and with minimal drip loss.

Meat analyser An instrument to accurately and rapidly analyse for fat, moisture and protein in a raw meat mixture. For large manufacturing lines continuous fat analysers are used for on-line compositional testing. Methods used are near-infrared spectroscopy (NIR) and near-infrared transmission (NIT), whereas guided microwave spectrometry (GMS) has been developed for on-line non-destructive measurement of fat, moisture and protein in meat mixtures.

Meat–bone separation Equipment to manufacture mechanically deboned meat. Meat–bone separators are used for separating meat from sinews and bones for poultry, pork, beef and lamb. Usually no pre-breaking is necessary, but the machines should operate at very low temperatures, preferably with minimum pressure and low rotation speed of the auger to ensure minimal temperature increase to maintain fibrous meat texture.

Meat emulsion The term meat emulsion is often mingled with the terms meat batter, meat matrix, meat comminute and meat dough. A meat emulsion can best be described as a multi-phase system that contains a true solution, gel solution, emulsion, suspension and some entrapped air or foam. Meat emulsions are distinguished from classical emulsions because the continuous phase of the meat emulsion is a colloidal matrix of protein and salt rather than a simple liquid. Quite a number of viewpoints exist among meat scientists, but generally a meat emulsion can be seen as a substance in which discrete particles of meat cannot be distinguished.

Meat protein There are three groups: contractile proteins (or myofibrillar protein), plasma protein (or sarcoplasmic proteins) and connective tissue (mainly collagen protein). Myofibrillar proteins such as actin and myosin are salt soluble, while the sarcoplasmic proteins such as myoglobin are water soluble. For emulsification and binding, the salt-soluble proteins are most important. The typical meat colour is the result of the haem portion of the myoglobin reacting with the curing compounds such as nitrite.

Microbial spoilage Toxic metabolites causing food poisoning, infection and/or disease. Microorganisms are well distributed throughout the emulsion, but most are killed when the internal temperature (IT) reaches 59°C. Ideally the core temperature (IT) of a processed meat product should reach 71°C. There is also inhibition by the presence of salt, nitrite and sodium or potassium lactate. Micrococci and yeast can cause a slimy layer to form on frankfurter-type sausages.

Mixer/grinder Equipment that has both mixing and grinding capabilities.

Mixers and blenders Equipment that usually is fitted with overlapping paddles, Z-arms or ribbon devices for quick and homogeneous mixing of meat systems. Equipment can be jacketed for heat-exchange, including steam injection, or fitted with CO_2 or liquid N_2 chilling systems. Machines can be fitted with bottom- or side-discharge and load-cell mounting for automatic meat and ingredient metering.

Modified atmosphere packaging (MAP) An inert gas purges and replaces the oxygen in the package before it is sealed. The barrier film overwrap resists the escape of the inert gas from the package. Nitrogen and CO_2 are the most common gases used. Usually CO_2 and N_2 are mixed. The objective is to prevent oxidative deterioration of a product.

Moisture barrier Protective film to prevent weight loss of meat products due to dehydration if left in open air.

Moisture retention Ability of a food or meat product to hold on to its own juices or added liquids.

Monosodium glutamate (MSG) MSG is derived from naturally fermented ingredients that have naturally occurring sources of glutamic acid such as found in meats, peas and maize. MSG provides a desirable flavour also known as 'unami'.

Multi-needle injector A mechanical device for brine or marinade injection into the meat prior to mechanical massaging or tumbling.

Multiple pass line A further processing line configuration for pre-dust, batter, breading, batter and breading to achieve high pick-up levels and/or achieve specific organoleptical properties.

Myofibrillar protein Group of proteins that are classified as actin and myosin and are partly salt soluble. See also: **Contractile proteins**.

Myoglobin Pigment in muscle that forms a stable curing colour when nitrite is present.

Nitrate Crystalline salts containing, along with metallic constituents, the chemical radical NO_3. Also called saltpetre. In curing, nitrate ($NaNO_3$) must first be converted into nitrite ($NaNO_2$) to become effective.

Nitric oxide The active part of nitrites that combines with myoglobin to form nitrosyl myoglobin in the uncooked product. Nitric oxide turns into di-nitrosochromes when the product is cooked, helping to form a stable curing colour.

Nitrite In meat curing, sodium nitrite ($NaNO_2$) and potassium nitrite (KNO_2) are used. Nitrite is a very poisonous compound. Nitrite itself does not react with meat, but needs to be reduced to nitrous oxide. Once the highly reactive nitrous oxide is formed, it partially reacts with myoglobin and haemoglobin to form nitrosomyoglobin. This pigment ultimately is responsible for typical end-product colour. Nitrite has the potential ability to deplete antioxidative properties, and therefore care should be observed adding the various ingredients in the right sequence.

Oil migration Unstable oil or fat can cause problems within an emulsion or meat matrix (batter). It can deteriorate texture, speed-up oxidation and promote microbial spoilage.

Oil pick-up The amount of oil absorbed by the coating (the batter and breading) during frying. Oil absorption typically ranges from 15% to 20%. Most manufacturers calculate with an equal exchange of water loss caused by cooking for oil pick-up and do not take moisture loss into consideration when calculating pick-up. Quite often added non-meat proteins offer yield advantages in this respect.

Organic The term organic refers not to the food or meat itself, but how the food or meat is produced. Organic produce and meat are grown using land management practices obtaining a harmony of environment without the use of synthetic fertilizers, herbicides, pesticides, growth regulators, antibiotics, hormone stimulants or other forms of intensive livestock systems. Organic foods and meats are minimally processed to maintain the integrity of the food without the use of artificial ingredients, preservatives and irradiation. Increasing consumer concerns about hormones, antibiotics and genetically modified organisms (GMOs) are fuelling demand for organic meat and free-range chicken and veal.

Organoleptical Observations of food quality and impressions as a result of taste, smell and colour visualization.

Oxidation Taste deterioration when fat and oil turn rancid. A chemical reaction resulting in the loss of an electron.

Oxidation of frying oil Phenomenon describing the reaction of oil with oxygen, ultimately causing development of free fatty acids (FFAs) leading to product flaws such as darkening of coated foods, off-flavours.

Oxygen barrier Film protection on surface of meat product to retard spoilage and mould caused by bacteria which grow only in the presence of oxygen.

Pale soft exudate (PSE) Pale soft exudative muscle with a rapid post-mortem glycolysis and rapid pH decline. Usually light in colour. Low water binding, though with longer shelf life. PSE can be caused by short-time stress prior to slaughtering. Many pigs that yield PSE pork are genetically prone to porcine stress syndrome which can cause PSE meat.

Pathogen An organism or bacterium capable of producing disease. Pathogen identification such as campylobacter, salmonella, *Listeria monocytogenes* and *E. coli* O157:H7 can be done using the enzyme-linked immunosorbent assay (ELISA).

pH value A measurement on a scale of 14 to 0, reflecting the alkalinity or acidity of the product. All values above pH 7 are alkaline and those under pH 7 are acidic. A pH of 7 is considered neutral. The further from neutral pH 7, the greater the intensity of the alkalinity or acidity. Meat with higher pH values can bind more water than meat with lower pH values.

Phosphates A functional ingredient that is responsible for increasing (or decreasing) the water-holding capacity in meat and for reducing the viscosity of the meat batter prior to cooking. Phosphates prevent flavour loss because they contribute to some antioxidant functions by binding heavy metals. This appears to be of more significance in poultry.

Phytochemicals Encompass essentially all plant-produced chemical components such as found in soybeans. A select group of these components has received considerable attention due to their possible health-enhancing effects, such as soy genistein and soy daidzein.

Pickle See: **Brine**.

Pick-up The weight of coating materials adhering to the substrate (or base). Calculated as a percentage from the base weight by dividing the difference by the total weight.

Pinking A term used in uncured meat product to describe the formation of pink discoloration in cooked whole muscle meat products or emulsion products. Pinking can be caused by the presence of nitrites in drinking water prior to slaughter, ingestion of nitrogen compounds, traffic pollution during pre-slaughtering transport, nitrite contamination from processing equipment and direct heated or combustion ovens. Also ingredients such as direct-heated proteins and starches can promote or cause pinking.

Poaching Poaching is slow cooking by simmering in water and this method uses moist heat to prepare foods. It is distinguished from 'broiling' by keeping the water temperature slightly below the boiling point.

Pop-up timer A disposable or reusable thermometer to accurately gauge the proper readiness of processed meat products such as whole muscle ham and beef.

Prebiotics Stimulates the growth of microorganisms such as bifidobacteria and therefore promotes enhanced gastrointestinal health. See also: **Inulin**.

Pre-dust Dry blend of finely ground starch, flour and seasoning or fine breading, applied to meat products, often prior to adding batter and breading. Pre-dust improves adhesion, delivers additional flavour and increases yield.

Pre-frying Also known as par-frying. Short-duration oil cooking to set the coating and colour.

Pre-rigor meat After slaughter the bloodstream can no longer transport glucose to the muscle cell, hence only through breakdown of glycogen can muscle cells manufacture adenosine triphosphate (ATP). Meat products made from pre-rigor meat have excellent water-binding capacity, firmer texture, brighter curing colour and longer shelf life in fresh sausage.

Probiotics Most simply defined as health-enhancing microorganisms consumed as a food component or dietary supplement. Probiotics are friendly or healthy bacteria present in for example *Lactobacillus acidophilus* and *L. casei*. Health effects of certain strains promote natural improvement in such areas as the immune system, hypertension, vaginitis, diarrhoea, small bowel bacterial overgrowth and lactose intolerance. See also: **Prebiotics**.

Product cook yield The percentage of initial product weight remaining after partial or full cooking.

Pro-oxidant An ingredient or additive that accelerates oxidation, especially the oxidation of fat and oil that results in rancidity, e.g. sodium chloride (salt), copper, trace elements. Salt-triggered oxidation might be caused by meat pigment and/or may serve as a catalyst for oxidation reactions such as salt-induced changes in antioxidant enzyme activity.

Protein Originally a Greek word meaning 'first' or 'primary'. Proteins are complex combinations of various amino acids with different molecular weights, different structures and different reactions to water and salt solutions. In meat there are water-soluble proteins, salt-soluble proteins and collagen proteins.

Protein denaturation Alteration of protein due to heat, acid or drying. The best example of protein denaturation, the cooking of an egg, turning from a fluid to a solid when heated.

Puff batter A cake-type texture batter, mostly sweet and highly leavened. Product characterized by its golden brown appearance, crisp yet tender to the bite.

Purge Separation of moisture upon contraction or shrinkage of a meat gel. Purge is a major quality flaw and an issue of consumer complaint.

Purge controllers Functional ingredients such as soy protein isolate, caseinate, modified food starch and carrageenan, which reduce or eliminate moisture separation upon contraction or shrinkage following final processing.

Radiation cooking Defines the transmission of heat energy without using airflow or direct contact.

Reconstitution Describes a second cooking or frying process before final consumption of the food product.

Relative humidity (RH) The ratio of the amount of water vapour in the air at a specific temperature to the maximum capacity of the air at that temperature. The percentage of moisture in the air compared to the maximum it can hold.

Rework Finished processed meat product which failed to meet QA specifications. It is generally accepted practice to reuse or rework a small percentage of these products in a new production batch.

Rheological Originates from the famous expression *panta rhei* 'everything flows'. In processed meat products rheological expresses deformation and flow of variables such as viscosity, elasticity, shear stress and fluid properties.

Roast cooking Cooking method using dry heat after coating food lightly with fat. The food should be uncovered to promote browning which gives a characteristic flavour.

RTE (ready-to-eat) Processed meat that has been pre-cooked and is ready for immediate consumption.

Rusk English term for breadcrumbs.

Salometer Also called brine tester. A salometer is a scaled hydrometer that shows the degree of saturation of salt brines. A saturated brine solution reads 100, whereas pure water reads 0 (zero). Standard temperature for readings is +4°C.

Salt Common salt, also known as normal, ordinary, table or kitchen salt (NaCl). Technologically, salt is responsible for reacting with myofibrillar protein to optimize swelling and solubilization. The latter two properties are important to increase the water-holding capacity and to allow the separate muscle pieces to 'glue' or bind together and realign. Salt also imparts a distinctive flavour and acts as a suppressor of water activity and aids in bacterial control and shelf life.

Sarcoplasmic protein A group of meat proteins that are classified as water-soluble and hold most of the myoglobin proteins (which affect colour formation in meat products after cooking). Sarcoplasmic proteins are part of the fluid mass that bathes the myofibrillar proteins.

Sautéing Sautéing is a method of briefly cooking food or meat in a shallow pan or skillet in a small amount of fat over high heat. Sautéing often creates a seared crust on food while keeping the interior moist.

Seasoning A specific blend of ingredients such as spices, herbs and flavours to provide distinct organoleptical properties to a food or meat product.

Sediment Unused debris and ingredients collected at the bottom of the brine tank, batter reservoir or oil basin. Increases cost of manufacturing and contributes to formula inefficiency.

Sensory Often used intermingled with 'organoleptic'. Observations of specific food parameters by taste panels.

Shock cooling A term used to describe the practice of adding ice to a pre-emulsion following emulsification in order to cool down the emulsion temperature quickly to avoid microbial spoilage, save on cooling energy of cooling space and to quickly use the pre-emulsion for further processing.

Single pass line Typical processing line configurations for one pass through pre-dust, batter and breading. Pick-up usually is <30%.

Skinless sausage A technology in which an emulsion is stuffed into cellulose casings into the desired size and shape. Once the processing has been completed the casing is peeled off by a knife slit, and can be discarded. In order to allow smoke and vapour moisture penetration, the casing must have permeability, and elasticity to maintain mechanical stress during stuffing and cooking (expanding).

Smearing Also known as greasing. Occurs when excessive friction is used during the stuffing or filling process of an emulsion or coarse meat mixture such as salami. The result is the deposit of fat on the surface just beneath the cellulose or fibrous casing, inhibiting peeling and/or proper thermalization.

Smoke-cooking parameters A process integration of time, temperature, velocity (airflow speed and direction), extraction (air replacement) and relative humidity.

Smoke flavours Concentrated ingredients in three base forms: oil-based, aqueous and powder. Distinctive smoke flavours and aromas can be created using atomization equipment to distribute in smokehouses, or blending in marinades and meat mixtures.

Smokehouse Thermal processing equipment to apply smoke to a wide variation of sausage and whole muscle meats. Smoking provides colour and flavour characteristics before or during cooking. Smoke colours and flavours can be generated from wood chips or liquid smoke.

Smoking A slow, low heat cooking method using chips of hardwood on top of coals to create natural smoke, which permeates the meat and creates unique and complex flavours. Smoking can also be accomplished using liquid smoke flavours which are sprayed on top of the meat or alternatively mixed with the meat emulsion.

Sodium ascorbate (see also sodium erythorbate) Accelerates the conversion of sodium nitrite to nitric oxide, which reacts with the muscle pigment myoglobin to produce the characteristic pink-cured colour.

Sodium caseinate (milk protein derivative) A milk derivative that has been solubilized following the treatment of the raw casein with hydrochloric acid (HCl) or sulphuric acid (H_2SO_4). Caseinates are used as fat binders in emulsified meat products. Bland taste profile.

Sodium erythorbate The sodium salt of erythorbic acid. It is an epimer (structural mirror image) of sodium ascorbate. Erythorbate, like ascorbate, is an antioxidant. It enhances flavour, colour and above all safety of cured meat and poultry products.

Sodium lactate The sodium salt of lactic acid. Functions as bacteriostat by increasing the lag or dormant phase of microorganisms. Interferes with bacterial metabolism and lowers water activity. Controls the growth of food-borne pathogenic bacteria including *Clostridium botulinum*, *E. coli* and *L. monocytogenes*. An effective ingredient that extends product shelf life and improves flavour in both fresh and processed meat. Also useful in reducing the sodium content in processed meat products. Lactate is also available as potassium lactate.

Solubility Solubility is a measure of how much of a solute (dissolved substance) will dissolve in a given volume of solvent (the substance in which the solute is dissolved). Solutes can range from highly soluble to insoluble, depending on the requirement of the food system. Time, temperature, type of mixing action, presence of other salts and ingredients competing for water and the physical properties of the solute all influence solubility.

Soy protein concentrate (SPC) Less pure form of soy protein containing approximately 70% protein on a dry basis. The balance is mostly soy fibre, which can contribute to texture and additional stability in the finished product. For meat emulsion systems usually functional soy protein concentrate (FSPC) is used. Soy protein concentrate can also be extruded, forming firm, fibrous textured particles with a texture resembling meat. Also known as TSPC.

Soy protein isolates (SPI) The purest form of soy protein containing 90% protein on a dry basis. The powder is virtually free of fat and carbohydrates. During processing, soluble and insoluble carbohydrate fractions from defatted soy flakes are removed through a series of protein precipitations and multiple washings, ideally by distilled water or reverse osmosis processes. SPI has excellent water- and fat-binding properties, and in concentrated form can granulate, which under certain conditions mimics meat-like textural properties. SPI can have a very bland flavour profile. Certain types of SPI are lecithinated to improve dispersibility in brine systems.

Spices and herbs Flavourings derived from botanical sources such as plants and trees. For example: the herb leaves basil, oregano, thyme, parsley, sage, dill, tarragon; berries or fruits, such as pepper, cloves, paprika and allspice; bark compounds such as cinnamon; roots like ginger and turmeric; seed spices such as fennel, caraway, coriander, dill and anise.

Starch Native and modified food starches are nearly always used in high-yielding whole muscle meats. Modified food starch is frequently used in conjunction with functional non-meat protein to retain water in thermalized processed meat products, including no- or low-fat sausage and marinated poultry products. The most commonly used starches are derived from potato, rice, maize, wheat and tapioca. The gelatinizations of these various native starches have different temperatures.

Starter culture Bacteria to 'jump start' the fermentation process in fermented sausage. These freeze-dried cultures are defined mixtures of organisms selected from *Lactobacillus*, *Staphylococcus* and *Pediococcus* not only lower the pH because of sugar conversion to lactic acid, but also form compounds that influence flavour, while maintaining a consistent fermentation and ripening process. Often used in combination with small amounts of dextrose.

Steam cooking An oven exclusively cooking with injected steam as the only source of energy. Steaming can help retain flavour, shape and texture while safeguarding the presence of nutrients.

Stripe markings Also defined as tiger stripes. Occur in whole muscle meat that has been injected with high yielding brine. Usually the result of too high injection pressures, insufficient tumbling, presence of carrageenan and brine injection through the fat sections adhering to the lean muscle mass.

Stroma protein A group of meat protein that is classified as connective tissue protein such as collagen and elastin.

Stuffer Equipment to accurately and smear-free fill or stuff natural or manufactured casings with deaerated, delicate and/or viscous emulsions, ground meats and whole muscles of large diameter while maintaining muscle integrity and morphology.

Stuffing horn Attachment for fast, efficient loading of marinated whole muscle meats into food packaging bags and/or mesh netting. After the plastic bag or net is placed on the horn, the prepared meats are pushed through the front end and if necessary closed with a clip.

Submerger conveyor A double design conveyor which allows the substrate to travel below the surface of the batter.

Sugar Saccharose (sucrose), lactose, dextrose, including glucose syrup, have a wide range of inclusion levels because of varying sweetness profiles. The main reasons for sugar addition to processed meat products are flavour and to depress water activity.

Syneresis Is the separation of liquid from a gel that is caused by contraction or by natural or intended destroying crosslinking of, for example, starch or hydrocolloid molecules in processed meat products.

Tempering cooking zone Defined as a low-intensity cooking chamber to precondition the processed meat products prior to entering the main cooking zone.

Tempura batter Highly leavened, rich, smooth batter that immediately puffs or expands when in contact with cooking oil during frying.

Tempura line Special design applicators for tempura batter mixing and application to avoid breaking down the leavening agents of the batter. See also: **Puff batter** or **Tempura batter**.

Tenderizer Equipment to soften or tenderize both bone-in and boneless beef, pork, lamb, poultry and seafood, to sever sinew, connective tissue and muscle fibre and thus improve upon textural properties and increase consumer value.

Texture enhancement The ability to maintain or improve the structural integrity of processed meat products by using functional ingredients and/or mechanical processes.

Textured soy flour (TSF) (also known as TSP or TVP) Produced by thermoplastic extrusion of defatted soy protein flour with a protein content of 50%.

Textured soy protein concentrate (TSPC) Produced by thermoplastic extrusion of soy protein concentrate, with a final structure that provides good hydration and fat absorption.

Textured vegetable protein crumbles (TVPC) Contain other functional ingredients such as wheat protein, lupine protein and modified food starches to fine-tune specific end-product characteristics.

Textured soy protein isolate (TSPI) Produced by thermoplastic extrusion of soy protein isolate providing a three-dimensional particulate structure which is very stable during processing, cooking and reconstitution. These functional ingredients provide superior nutritive properties while enhancing or mimicking meat texture and improving machinability when formed and further processed.

Thermalization The process in which meat products are converted from their fresh state to a final usable state by applying heat transfer such as steaming, cooking and roasting.

Tofu A bean curd or cheese-like food made from soybeans. Fresh soy milk is curdled with calcium sulphate or magnesium chloride. The curds are pressed into cakes and the liquid is expelled. The amount of liquid removed determines the consistency and texture. Extra-firm tofu is concentrated and has the highest protein content. Tofu is a very versatile food for a diversity of cooking styles.

Transglutaminase Naturally occurring substance present in the organs and tissues of mammals, fish and plants. It is produced by a specific fermentation process and because of its ability to cross-link and polymerize protein molecules, it can improve physical properties such as gelation, visco-elasticity, thermo-stability and emulsifying and binding support. Can be used as a partial substitute for phosphate and caseinates.

Tumbling The process of rotating muscle meat in a drum to evenly distribute brine, pickle or marinade in order to extract protein and to diffuse flavours. Temperature (<5°C) and tumbling time, usually expressed as RPM (rounds per minute), is more important than revolutions of the drum and rest. Tumbling ideally should be done under osmotic pressure or vacuum.

Vacuum packaging The procedure whereby air is removed from the package with less than 1% retained oxygen. The content clings closely to the package and is almost like a second skin.

Vegetable protein Family of proteins of vegetable origin such as extractions from soy, wheat, lupine, rice, maize, mustard and potato. Soybean is the most popular source and is made into many powdered concentrations and texturized forms.

Viscosity Viscosity is the resistance of a liquid or a semi-solid to flow and is an important physical property of liquid and semi-solid foods. Viscosity is described in terms of shear, or the force required to move a product, and is measured in centipoise.

Warmed-over flavour The development of rancid flavours caused by oxidative deterioration. These flavours are most common in uncured meat products.

Water activity (A_w) Water activity is a measure of the vapour pressure or humidity given off by a product at equilibrium. It is an indicator of the amount of moisture available in a product for microbial growth or chemical reactions. The measurement of A_w is on a scale from 1 (maximum) to 0 (minimum) to determine microbial activity. A_w is lowered when ingredients such as salts, fats, sugar, non-meat proteins and other water-binding substances are mixed into the product. The quantity of these ingredients will determine how much the A_w has been lowered. A_w will also be lowered when a product loses moisture during processing or storage. If the A_w value in a finished meat product is too high, shelf life will be drastically affected, resulting in spoilage, rancidity and possibly mould formation.

Water binding The terms water binding and water absorption refer to the tendency of water to associate with hydrophilic, or water-loving, substances, including proteins, gums, starches and sugars. The absorption of water occurs in several phases and is influenced by various physical and process factors.

Water-holding capacity (WHC) The ability of meat or a meat product to immobilize water. Pre-rigor meat has higher bind properties than rigor meat. pH and WHC will both decrease after rigor sets in. Increasing WHC is basically altering the myofibrillar proteins under the influence of salt, phosphates, chopping or mixing at a temperature ideally between –2°C and +4°C.

Wet bulb Cooking parameter indicating the temperature at which moisture evaporates.

Wetting out Moisture absorption by a collagen casing after stuffing. If too much moisture is absorbed, the sausage will have machinability problems such as linking, hanging and casing breaking.

Yeast and mould These spores are often associated with the fermentation, ripening and storage of fermented products, despite good manufacturing practices. Mechanical removal is often ineffective, since invisible mycelium threads that penetrate deep into the product are not washed out. Also, these mycelium threads produce metabolites, some of which are toxic. To prevent yeast and mould occurrence and contamination, active natamycin is sprayed, dipped or otherwise incorporated in casings.

Yield The percentage derived by dividing the finished product weight by the raw product weight.

Appendices

Preferred pH values of pre-processed meat

Product	pH	Observation
Cooked sausage (scalded) (frankfurter/hot dogs)	5.8–6.3	The higher the pH, the higher the water binding. However, the higher the pH the lower the colour intensity and microbial stability.
Cold smoked, dry and semi-dry fermented sausages (salami)	5.4–5.8	Lower pH values suppress the growth of unwanted microorganisms. Allows the removal of moisture during the processing cycles.
Cooked whole muscle meat (pork ham)	5.8–6.3	High pH values increase yield. However, too high pH values might affect colour stability and textural properties.

Processing variables that affect microorganisms

Meat processing equipment	Cause of microbial contamination.
Operation personnel	Cause of microbial contamination.
Meat emulsion	Distributes microflora throughout product.
Thermalization	Prevents growth of pathogens, retards spoilage. 60°C (IT) – destroys yeast, mould and most bacteria. 74°C (IT) – destroys everything except bacterial spores.
Salt	At low levels (<1.0%), retards growth of most bacteria. High levels (>3.0%), prevents bacterial growth.
Nitrite	Retards growth of undesirable bacteria in pasteurized products, prevents growth of spores surviving more severe thermalization.
Sugar	Ideal medium to provide substrate for production of lactic acid.
Smoke	Provides nitrogen oxides and other antimicrobial support.
pH	Starts to restrict growth of undesirable bacteria below pH 6.0. Retards all pathogens below pH 4.8.
Water activity (A_w)	0.96 – prevents growth of most spoilage bacteria. 0.94 – prevents growth of *Clostridium botulinum.* 0.86 – prevents growth of all pathogenic bacteria. 0.60 – prevents growth of all microorganisms.
Vacuum packaging	Prevents growth of moulds and aerobic bacteria. Retards growth of yeast.
Ingredients and additives	Carries specific microflora as well as certain antimicrobial properties.

Basic meat spices

Basil	Pungently aromatic, sweet, spicy flavour.
Celery seed	Warm, slightly bitter celery taste. Hint of nutmeg and parsley. Used in emulsions.
Chilli pepper	A sweet, pungent, slightly burnt flavour associated with Asian and Tex-Mex cooking.
Cloves	Spicy, fruity, warm astringent, slightly bitter flavour. Used in pâté and emulsions.
Coriander	A sweet, aromatic, rose-like flavour and used as an alternative to nutmeg in frankfurters.
Cumin	A strong, musty flavour associated with chilli and curry products.
Fennel	A sweet liquorice-like flavour often used in Italian sausage and pepperoni.
Garlic	A strong odour, pungent flavour used in hot dogs and Polish sausage.
Mustard	A slightly bitter and acrid (sulphurous) flavour often used in emulsified meat products.
Nutmeg (mace)	Spicy, warm, sweet, pungent.
Oregano	Bitter, warm, pungent flavour. Used in Italian dishes such as pizza.
Paprika	A sweet flavour, though it will not flavour meat products by itself. Used for red colour.
Parsley	Grassy, herbaceous. Used for decorations.
Pepper	Black pepper: a hot, pungent flavour used for its mouth sensation. White pepper: less pungent flavour.
Pimento (allspice)	An aromatic flavour used in emulsified sausage.
Red pepper	A pungent flavour, used for its throat sensation. A small amount will give 'heat' to meat products.
Saffron	Earthy, bitter, herbaceous flavour. Yellow.
Sage	A bitter, balsamic, aromatic flavour used in fresh sausage.
Thyme	Sharp, biting, spicy, herbaceous.

Vocabulary of taste-descriptive names

Acid	Taste of acetic, citric acids like lemon. Irritating and sharp taste, often sour like vinegar or fermented dairy products.
Acrid	Harsh, sharp. Irritating, pungent, burning, choking like burnt fat and oil.
Aftertaste	Taste–odour stimulus appearing after elimination of the product and differing from the sensations perceived when the product was in the mouth when being eaten.
Aged	Ripened, over-ripe, mature.
Aggressive	Strong and unbalanced unequilibrated taste. (See: Harsh.)
Alcoholic	Strong association with ethanol. May be associated with fermented products and liquor, wine, beer.
Aldehydic	Green, soap (floral), waxy.
Alliaceous	Characteristic note of garlic and onion.
Ammoniacal	Ammonia or certain amines.
Animallic	Characteristic of wild animals and cattle or strong fermented cheeses.
Aromatic	Fragrant, full, sweet like spicy notes of cinnamon, nutmeg and clove.
Astringent	Drying and tightening of the palate like tannins in tea and red wine. Potassium aluminium tartrate.
Balanced	Round and equilibrated. Right harmony between the different components of a flavour and absence of predominant or individual notes.
Barbecued	Charcoal grilled note. Flavour of food cooked over hot coals and burning fat.
Beery	Fermented effect of beer.
Bright	Fresh, clean, more character.
Camphoraceous	Camphor.
Cardboard	Damp cardboard or paper.

Catty	Typical sulphury note of blackcurrant, guava. Unpleasant, strong animal note.
Cheesy	Acid, fermented, sour notes such as cheese, old yoghurt.
Chemical	Unnatural, artificial, synthetic.
Churned	Associated with some stirred dairy products such as cream, butter.
Citrus	Characteristic acid, fruity notes of citrus fruits like lemon, lime, orange.
Clean	Absence of foreign, non-characteristic odours and tastes. No lingering off-notes.
Cloying	Taste stimulation beyond the point of satiation. Frequently used to describe overly sweet products.
Cooked	Heat-processed product as distinguished from the raw product.
Cool	Chemical–thermal stimulus which gives a fresh sensation in the mouth like eucalyptus or menthol.
Cowy	Reminiscent of a stable, barny note such as caseinate or whey.
Creamy	Characteristic rich note of butter or cream. Also describes mouthfeel for fatty, especially aerated foods such as ice cream, cordials and fat toppings.
Dairy	A pleasant smooth creamy note that is characteristic in dairy products.
Delicate	Exquisite choice flavour that is appreciated by the discerning.
Dirty	Presence of atypical odours or tastes and off-notes. Sometimes associated with mouldy, unpleasant earthy aftertaste.
Distillate	Fruity–alcohol–aromatic taste developed in the liquid product resulting through distillation of the fermented juices of some fruits and plants.
Dried	Associated with dried wood, herbs or fruits.
Dry	Lack of moisture, characteristic of the texture of a product. Associated with astringent.
Earthy	Characteristic odour of freshly turned soil or compost. Smell of a forest or, for example, mushroom or potato.
Equilibrated	See: Balanced.
Essential oil	Distinctive characteristic of odour or taste given by the oil components of a plant, flower or fruit.
Estery	Fruity, berry-like, grapey. Relates usually to non-citrus fruit flavours. Volatile.
Ether	Characteristic strong alcohol odour, especially sensitive to nose and instant release of flavour at first bite and chew.
Etheral	Light, volatile aliphatic esters.
Faecal	Faeces, complex protein decomposition with indole and skatole.
Fantasy	Creative, imaginary version of a taste or odour not occurring naturally.
Fatty	Greasy taste and texture due to animal or vegetable fats.
Fermented	Characteristic acid note of a processed or natural product following yeast or enzymatic fermentation such as yoghurt or dried sausage.
Fibrous	Fresh, green, juicy notes associated with a characteristic texture found in fresh exotic fruits such as mango.
Fishy	Characteristic odour of fish and seafood. Very fresh fish has a slightly milky odour. More pronounced and sometimes unpleasant ‘fishy’ notes are developed through exposure to heat and air. Often associated with a metallic taste.
Flat	Lacking impact and top note.
Fleshy	Juicy and texture characteristic of a fruit such as peach or cherry.
Floral	Aromatic, flowery notes such as rose, violet, jasmine and orange flower.
Floury	Powdery or fine granular texture. Sensation in the mouth similar to that due to the presence of uncooked flour in food.
Foxy	Characteristic of Concord and Lambrusca grapes. Musty, dirty.
Fresh	Optimum tastes, clean, free from off-tastes. Characteristic of freshly prepared or recently harvested foods such as bread, fruits and vegetables.
Fried	Note developed in a product through cooking in oil or fat.
Fruity	Pleasant and aromatic characteristic of fresh fruit.
Full	See: Rich.
Glutamate	Considered as an elementary taste. Together with the ribonucleotides, inosinate and guanylate represents the characteristic note of ‘Unami’. Slightly salty and mouth-watering. Provides richness in savoury products.
Grassy	See: Green.

Vocabulary of taste-descriptive names (*continued*)

Greasy	See: Fatty.
Green	Characteristic of freshly cut grass. Fresh note of an unripe fruit or vegetable like cucumber, skin of an unripe banana, green lettuce or green apple.
Grilled	Characteristic slightly burnt note developed in some food products through cooking in radiant heat. For example, grilled beef or pork patties.
Harsh	Unpleasant, sharp, rough, irritating, lacking harmony or smoothness. Sometimes bitter.
Hay	Dried mixed grasses and other plants.
Heavy	Strong, lingering. Cloying.
Herbaceous	Associated with aromatic herbs, sometimes green, leafy notes such as basil, parsley, thyme, rosemary, oregano.
Honey	Heavily sweet, slightly aromatic–floral. Syrupy fragrance with a waxy background.
HVP	Meaty, broth, vegetable. Typical of hydrolysed vegetable proteins.
Impact	Associated with 'high', indicates brightness of a flavour. Associated with 'low' or 'weak', indicates flatness of a flavour.
Insipid	Absence of taste. Lacking character, tasteless.
Intense	Strong, acute.
Jammy	Characteristic of a fruit cooked with sugar. Sweet, cooked, caramelized such as strawberry jam.
Juicy	Fresh, aromatic, mouth-watering characteristic of a flavour. Associated with juicy fruits such as peach and orange.
Kernel	Slightly bitter-almond note of some fruit-stones (pits) like cherry, apricot and peach.
Leafy	Green characteristic of leaves of some plants, e.g. raspberry, strawberry.
Leathery	Typical odour of leather.
Liqueur-like	Fruity, sweet, fermented alcoholic syrupy note.
Liquorice	Sweet characteristic note: reglisse, e.g. fennel, aniseed.
Malty	Malt syrup or sugar, sweet, slightly fermented and acid.
Matured	Optimal state for a food or drink to be consumed. Aged, balanced for products such as wine, cheese or brandy.
Meaty	Savoury, cooked or roast note of meat. Sometimes associated with a pleasant texture characteristic.
Medicinal	Typical odour of a pharmaceutical. Somewhat astringent, disinfectant-like.
Melted	Characteristic of molten butter or cheese.
Metallic	Odour or taste of metals. Characteristic sometimes associated with phosphate-containing processed meat products, canned vegetables and fruits. In some cases cool, astringent 'electrical' sensation in the mouth.
Mild	Light, soft, pleasant to the palate.
Milky	Note associated with raw milk, slightly creamy.
Minty	Fresh, herbal characteristic of peppermint and spearmint.
Mouldy	See: Musty.
Mouthfeel	'Good' or 'bad' mouthfeel of a flavour: tactile sensation in the mouth of a rich and full flavour or the opposed characteristic.
Musky	Of various musks, natural and artificial.
Musty	Not fresh, mouldy, e.g. reminiscent of the atmosphere in a damp and unventilated cellar, old books.
Nutty	Distinctive, slightly woody oily notes such as walnut, peanut, chestnut, hazelnut, coconut and almond.
Off-note	Undesirable, foreign, non-characteristic note.
Oily	Characteristic taste and texture notes of vegetable oils.
Overripe	Acid-fermented notes of a strongly ripe fruit or vegetable.
Oxidized	Usually used to characterize off-notes in oxidized essential oils like citrus. Sometimes used for oxidized (rancid) fats and oils.
Peely	Characteristic slightly bitter note of citrus fruit peel like orange, lemon and grapefruit.

Peppery	Characteristic aroma of freshly ground white or black pepper, aromatic. Tickling sensation in the nose.
Perfumery	Pleasant odour, floral, fragrant. Can be a disturbing note in a flavour. Normally a negative feature in food products.
Phenolic	Phenol or substituted phenols.
Piquant	Spicy, pungent note like curry, pimento. Sometimes used to define a sour note.
Plastic	Off-note, sometimes due to the contamination of a product by its polymer-derived packaging.
Powdery	Tactile, texture, odorous stimulus or sensation of a ground product such as cocoa.
Processed	Cooked.
Pulpy	Texture, taste characteristic given by the soft juicy or fleshy part of a fruit or vegetable such as tomato.
Pungent	Sharp somewhat painful sensation producing a recoil response. See: Harsh, Tactile, Irritating. Stinging sensation such as certain spices, mustard, hot chilli.
Putrid	Decomposition of animal and vegetable products.
Rancid	Unpleasant smell or taste, oxidized. Bitter, acid taste such as oxidized fats or oils, old potato chips.
Raw	Non-cooked food, e.g. raw milk, raw meat, raw vegetables.
Refreshing	Sensation of freshness and lightness given by a fresh fruit or vegetable-containing food. Opposite of cloying.
Resinous	Odour or taste usually associated with conifer wood exudate, tree sap such as pine oils.
Rich	Full-bodied taste.
Rindy	Characteristic note of the hard or tough outer layer (skin) of some foods such as cheese and bacon.
Ripe	Characteristic of the sweetness of mature fruits.
Roasted	Cooked, caramelized notes developed in some foods through cooking in an oven. For example: coffee beans, roasted cured meats.
Rooty	Slightly earthy, somewhat sweet note of roots such as carrots.
Rotten	Unpleasant fermented notes of spoiled foods, decayed. For example: fruits, banana, strawberry, meat (putrid).
Round	See: Unbalanced.
Rubbery	Odour or taste of rubber. Can also describe an elastic and chewy texture.
Salty	Elementary taste, slight or excessive amount of salt notes.
Savoury	Characteristic note of a very appetizing and succulent meat, fish and vegetables. The taste is usually enhanced through addition of salt and spices. See: Unami. Normally used as the opposite of sweet.
Seedy	Tactile–taste sensation when biting into a seed. Slightly bitter. Desirable characteristic of some red fruits such as strawberry and raspberry.
Sharp	Strong, penetrating.
Sickening	Disgusting, unpleasant. Characteristic of a food sweetened and flavoured in excess.
Skinny	Peely, rindy. Somewhat green, fruity note of the skin of a vegetable or fruit. Also used for non-citrus fruits like apple, peach and pear.
Smoked	Taste of smoke. Taste of foods processed with various burning materials such as wood chips to flavour-penetrate cured meat, bacon, salmon.
Smooth	Mellow, round. Characteristic given the concept of a well-balanced product. Can also be used as a texture characteristic.
Soapy	Associated with rancidity in fats, taste of soap. In meat products can be created by excessive phosphate addition.
Sour	Complex sensation due to acidic organic substances. Taste of green, unripe fruits. Taste of over-fermented dairy products, e.g. unripe grape and citrus, yoghurt.
Spicy	Note associated with aromatic herbs and spices. Aromatic, pungent and piquant with somewhat sharp topnotes, e.g. cinnamon, cloves, ginger, thyme, curry.
Stale	Flat from age. Old, not fresh, e.g. stale bread, stale beer.
Stewed	Characteristic note of a food cooked in its own juice, e.g. meat, fruits, vegetables.
Stinking	Foul and offensive odours (sulphur compounds and protein decomposition products).

Vocabulary of taste-descriptive names (*continued*)

Strong	Heavy, overdosed.
Succulent	Having juicy tissues, such as cooked ham in natural juices, or fruits such as melons.
Sulphur	Elemental sulphur or combinations thereof.
Sweaty	Offensive note, goaty, muttony (dirty sweaty socks).
Sweet	Elementary taste e.g. sugar cane or sugar substitutes. Vanilla, vanillin, honey.
Synthetic	See: Chemical.
Syrupy	Sweet, slightly caramelized, somewhat aromatic. Sometimes sticky or viscous texture.
Tallowy	Waxy–fatty.
Tangy	Sharp. Tart.
Tenacious	Residual taste, odour sensation similar to that perceived when the product was in the mouth.
Terpenic	As in dipentene-like turpentine, oxidized, waxy, soapy.
Thin	Not balanced, not full. Lacking substance, richness, strength.
Toasted	Caramelized notes and crispness developed through direct cooking of some foods and raw materials, e.g. bread.
Unami	Elementary taste. Slightly salty. Characteristic savoury note resulting from the synergism between monosodium glutamate, inosinate and guanylate. (See: Glutamate.)
Unbalanced	Non-equilibrated. Absence of harmony between the different notes of a flavour.
Warm	Characteristic of some spices giving a rich and full sensation in the mouth e.g. cinnamon, thyme.
Watery	Diluted, flat, weak, thin. Absence of impact and strength. Also used to describe a tactile sensation in addition to juicy, e.g. gooseberry, peach.
Waxy	Paraffin. Candle wax, beeswax, mineral wax.
Weak	Flat, low impact. Lack of brightness and intensity. Can also describe texture.
Wild	Characteristic of some fruits and plants. Herbaceous note, e.g. fennel, fruits of the forest.
Winey	Reminiscent of wine, somewhat fermented alcoholic – fruity – woody note, astringent.
Woody	Aroma of freshly cut wood, green or seasoned. Associated with a mouth-drying character.
Yeasty	Characteristic note of some yeast-fermented food products, e.g. bread, beer.
Young	As opposed to a ripe fruit or vegetable. Usually used only for cheese and wine.
Zest	Piquant, appealing flavour.

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Note: page numbers in *italics* refer to figures and tables