DAIRY ANIMAL PRODUCTION

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Preface

India is known for its rich cattle and buffalo wealth. Over the last few years India remains number one in milk production in the world. However, per animal productivity is still low. Low productivity is contributed by multiple factors like poor genetic make up, insufficient feed and fodder availability, adverse climatic condition, unscientific managemental practices and many more factors. In monetary term, milk is the single largest commodity, ahead of rice and wheat among the subsectors of agriculture in India. Till date dairy sector is not getting proper support and attention, although it contributes to the health and nutrition of the people as well as employment of the large number of people in India. There is a tremendous scope for improvement of the dairy sector.

The available information related to dairy animal production and management are too descriptive and much theory orientated. Few books are available especially on dairy animal production. This book deals specifically with basic managemental aspects of dairy animal in the context of Indian subcontinent. The informations are carefully selected and presented in concise manner and to the point. The entire book has been prepared in most simple, clear and talking language for easy understanding.

In this book, an attempt has been made to introduce both the science and practice of dairy animal production for the students, teachers, progressive farmers and extension workers. Any book which attempt to cover the needs of much a wide range of people must have their limitations as far as any one group of persons is concerned. It is hoped however that all those who read these books will find some guidance and instruction which will enable them to improve their knowledge and understanding of the management and production of dairy animals. Being this first edition, there could be some shortcomings for which valuable and informative suggestions will be gratefully appreciated. Special thanks to Dr. Manoj Khuswaha for providing his immense effort and patience to draw the figures in this book. A special word of appreciation is due to the publishers for their co-operation and patience in the publication of the book

Jabalpur (Madhya Pradesh) **Biswajit Roy**
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CHAPTER - 1

Introduction to Dairy Farm Management

1.1. INTRODUCTION

Dairy animal production in the last few decades witnessed tremendous growth throughout the world. The remarkable success of the dairy animal production can be attributed to the constant efforts of researcher, planner as well as producer. At present dairy farming is becoming a commercial activity. Hi-tech dairy farms produce high quality milk for making value added milk products for competitive markets around the world. The management of the dairy farming enterprises is crucial for the sustainability and profitability of it. The effective management of dairy animals essentially emphasizes the following areas:

- Improving genetic potential of the cows
- Providing optimum environment to the animals to express their full genetic potential though the strategic application of housing, breeding, feeding, culling and preventive health care.

The sound management practices of dairy husbandry are integrated along with modern technologies for mechanization and automation in dairy farming. These farms can also be a place of research, development and extension activities.

1.2. OBJECTIVES

The objectives of this unit are to :

- Know the importance of dairy farming

- Know the world dairy scenario
- Understand the milk and milk products
- Understand the life cycle of a cow

1.3. WORLD DAIRY SCENARIO

According to an FAO report the livestock sector traditionally based on local production and consumption, which supports the livelihood of an estimated 600 million rural poor. The milk production in the developing countries has grown by 200% since the early 1980's. The population growth and higher income have both contributed to these rising demands. According to FAO estimate, by 2030 the developing world will consume almost 2/3rd of the global milk supply, compared to just 1/3rd 25 years ago. International trade in livestock products has increased from 4% of production in the early 1980's to about 13% in 2003.

Milk is an almost complete food. It is a unique product. It is liquid and containing between 82 and 88% water depending upon the kind of mammal and almost instantly perishable. The cow's milk accounts for 84% of the total world milk production. India is the top milk producing country in the world (Table 1.1). The world average for milk production amongst cattle is 2038 kg /animal/lactation. Lactation yield per animal is highest in Israel over 9000 kg, followed by 7038 kg in USA , 5462 kg in UK and 4451 kg in Australia. The low yields are reported in the countries like 1541 kg in China, 1179 kg Pakistan and 987 kg in India. The milk production throughout the world is not uniform. In some regions there is sufficient and surplus production of milk, where as in some regions milk production is in deficit (Table 1.2). There is immense scope of improvement of milk production in the deficit areas.

Table 1.1 : World top 10 milk producing countries

Rank	Country
1	India
2	United States of America
3	Germany
4	Pakistan
5	China
6	Russia

Contd...

7	Brazil
8	France
9	New Zealand
10	United Kingdom

***Source*:** Basic animal husbandry statistics, 2006. Animal Husbandry Statistics Division, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, New Delhi, India

Table 1.2 : Sufficiency level of milk

Milk Sufficiency	Region	Sufficiency level (%)
Milk Surplus	Oceania (Australia and New Zealand)	300
	Western Europe	110
Milk Sufficient	South Asia	100
	Confederation of industrial nation (CIS)	100
Milk Deficit	South America	95
	Central America	80
	Africa	65
	South East Asia	65
	Middle East	55

Source: Rabobank International

The increasing human population and urbanization is expected to expand the potential market for the dairy sector. The consumption of milk based products is growing at a faster rate than the growth in production. The world population is expected to increase by 1.5% per annum reaching between 8.1 and 8.5 billion in 2025. The projected growth of 80-90 million per year will occur primarily in the developing nations, with Asia at 54 million experiencing the most. This will increase the demand for milk which will be about 654 million tones in 2020 in the world and the developing countries will require about 60% of this amount. To meet the total demand it is estimated that a 4% annual growth of milk production is required. But the actual growth rate is low, e.g., in South Asia the actual growth between 1998 and 2003 was only 1.1%. This suggests a great opportunity of managemental interventions to achieve this goal.

1.4. INDIAN DAIRY SCENARIO

The livestock and fisheries sector contributed over 4.07 per cent of the total GDP during 2008-09 and about 26.84 per cent value of

output from total agriculture and allied activities. The Eleventh Five Year Plan envisages an overall growth of 6-7 percent per annum for the sector. In 2008-09, this sector contributed 108.5 million tonnes of milk, 55.6 billion eggs, 42.7 million kg wool and 3.8 million tonnes of meat. The 18th Livestock Census (2007) has placed the total livestock population at 529.70 million and chicken population at 556 million. India ranks first in world milk production, its production having increased from 17 million tones in 1950-51 to 133 million tonnes by 2012-13. The Annual growth rate for production of milk is about 5% in 2011-12 compared to 2010-11. Total bovine population remain almost unchanged, however, there is a clear trend of decreasing cattle population and increasing buffalo population. It is predicted that buffalo is the future dairy animal in India. The per capita availability of milk has increased from 112 grams per day in 1968-69 to 281 grams per day in 2011-12, but is still low compared to the world average of 295.89 grams per day (Table 1.3). About 80 per cent of milk produced in the country is handled in the unorganized sector and the remaining 20 per cent is equally shared by cooperatives and private dairies. Over 1.33 lakh village-level dairy cooperative societies, spread over 265 districts in the country, collect about 25.1 million litres of milk per day and market about 20 million litres. The efforts of the Government in the dairy ector are concentrated in promotion of dairy activities in non-Operation Flood areas with emphasis on building cooperative infrastructure, revitalization of sick dairy cooperatives and federations and creation of infrastructure in the States.

Table 1.3 : Production and per capita availability of milk in India

Year	Per capita (grams/day	Milk production (MT)
1990-91	176	53.9
2000-01	220	80.6
2005-06	241	97.1
2006-07	246	100.9
2007-08	260	107.9
2008-09	266	112.2
2009-10	273	116.4
2010-11	281	121.8
2011-12	291	127.9

Source **:** Department of Animal Husbandry and Dairying, Government of India.

1.5. IMPORTANCE OF DAIRY FARMING

Dairy farming in developing countries helps directly in agriculture by making available drought power, manure and cash income on day to day basis. It provides socio-economic security to the farmers especially to the small and marginal farmers. Dairying is crucial for providing employment and supplementary income to the bulk of rural families. The various livestock products like milk and milk products are a good source of income for cattle owners. The cattle manure can be used for organic agricultural production. The dung is complete manure having all the major elements required by crops.

1.6. IMPORTANCE OF DAIRY FARM MANAGEMENT

The dairy animal is considered biological machine producing milk. The input is given in the form of feed, care and management and the output is milk. The profit can be maximized by minimizing the cost of input and maximizing the output. Not withstanding the genetic ability of the dairy cattle and nutritive value of the feed, the factor that makes a difference to profitability of the dairy farming is care and management of the animals. In spite of selecting the best breeds of high producing cows, feeding them with best of feeds and fodders, preferably a mixture of leguminous and non-leguminous fodder and protecting them against common diseases yet milk yield will vary from high to low. The critical factors that makes all the difference is 'management'. Scientific dairy management helps to channelise the limited resources to maximize returns from the dairy farm. The cost of feed and good dairy animal as well as milk prices depends on the external factors, but the volume of milk production depends largely on the application of sound management practices in the farm.

An efficient dairy animal is the result of better breeding, but its productivity depends on care and management including feeding. The rising cost of high yielding dairy animals enable the farmer to give importance to care and management for maximizing the profit from the dairy animals. Feed is the largest input into commercial milk production and roughly accounts for 50-70 % of the total production cost depending on dairy farming practices. The judicious use of feed and fodder can bring down this expense. Many new types of cattle feed have been developed to meet the nutritional demand of the dairy animals like by-pass feed (protein, fat), urea molasses block (UMB), complete feed block, total mixed ration (TMR) etc. These may help in higher growth rate, proper health condition and higher economic return from dairy animals.

The efficient day to day management activities of a farm must be routinised, like cleaning the shed with disinfectants, spraying with insecticides, grooming and brushing the animals, milking, feeding, watering, chaffing the fodder, cleaning utensils etc. Other periodical operations include vaccination, deworming, testing cows for sub-clinical mastitis etc.

The maintenance of proper health condition of the animals is essential for optimum production and reproduction. The animals should be vaccinated according to a particular schedule based on the prevalence of diseases in a particular area or farm. Paying appropriate attention to the animal health care would minimize the economic losses caused by major cattle diseases like mastitis, FMD, anthrax, B.Q. etc.

1.7. HYGIENIC QUALITY OF RAW MILK

The hygienic quality of raw milk is essential to produce milk products of highest standards. Shelf life of milk and milk products depends on the level of microbes in the raw milk which in turn depends on the management of the animals.

1.8. LIFE CYCLE OF DAIRY CATTLE

The life of a dairy animal starts with the birth of a calf (Fig. 1.1). Major portion of the calf mortality occurs during the first 24-48 hours of life, as at this time, they are very much prone to diseases. Poor care and management of calves can cause mortality as high as 20-25% in the first 3 months. In the calves some important farm operations are performed like identification, dehorning, castration, removal of extra teats etc. Next important phase of life is heifer stage. Growth is the prime prerequisite in this phase of cattle's life. If proper growth fails, the animals will not attain puberty and subsequently sexual maturity will be delayed. This will cause increase unproductive life of a cattle and decrease profitability of the farm. When, heifer sexually mature, it is bred with the good quality semen obtained from the sexually mature males. After breeding it is essential to check the animal for pregnancy as early as possible. About 45-60 days after breeding the females are diagnosed for pregnancy. If the animal shows positive sign of pregnancy then it will be considered as pregnant stock which needs special care and management and if not then it will be rebred. The animals which after repeated rebreeding fail to become pregnant would be culled immediately. The pregnant animals needs special care for the foetal growth inside her womb. Calving occurs after about 280

days in cattle and 310 days in buffaloes after conception. Regular grooming and clipping of the animals are performed to keep them clean.

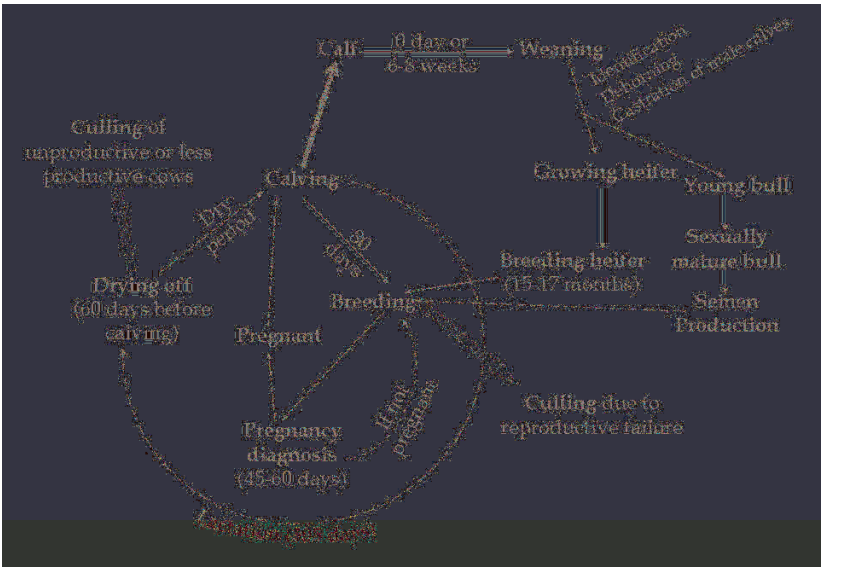

Fig. 1.1 : Life cycle of a cow

Lactation length about 305 days. Daily milk yield reaches its peak at around 6-8 weeks, persist for another 2-3 months and then begins to decline. Normally, a milch animal is capable of giving on an average 8 lactation. To get continuous milk supply and generate maximum profit from a dairy farm, the dairy cows are required to give birth one calf every year. This target will only be achieved by milking the cows for a period of ten months along with cow become pregnant about 80 days after parturition, and stop milking 2 months before next parturition.

Therefore, for effective discussion and understanding of the dairy farm management practices, total matter is divided into various units. The various managemental practices are discussed in details in each unit. Each units takes care the especially the particular stage of the animals life.

Management of every stages of the cow's life is very crucial. If any stage of life is disturbed it would ultimately hamper the productivity and thus, development of the uneconomical enterprises.

1.9. SUMMARY

The importance of dairy farming has increased throughout the world in the last few decades. Dairy farming has become a commercial enterprise. India is the largest producer of the milk in the world. Dairy farming provides a source of sustainable income to the poor farmers. Whatever may be the genetic potential of the animal, its production is largely depending on the care and management provide to it. After birth, the calf needs proper care and management which will be reflected in its body growth and health condition required to attain sexual maturity at earliest. Heifers are bred as early as possible to reduce the generation interval. The care and management of the lactating cow is necessary for increased and hygienic milk production.

1.10. CHECK YOUR PROGRESS

(a) Which is the largest milk producing country in the world?

(b) Which country has the highest per animal milk production per lactation?

(c) What component of the cost contribute most of the expenses in the dairy farm?

(d) What is the lactation length of the cow?

1.11. ANSWERS TO 'CHECK YOUR PROGRESS'

(a) India

(b) Israel

(c) Feed is the largest input into commercial milk production and roughly accounts for 50-70 % of the total production cost depending on dairy farming practices.

(d) 305 days

1.12. EXERCISES AND QUESTIONS

(a) Discuss world dairy scenario.

(b) Write the importance of dairy farming in the present condition.

(c) Discuss in brief about the life cycle of a dairy cow.

(d) How management contributes to the successful dairy farming.

1.13. FURTHER READING

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CHAPTER - 2

Animal Housing

2.1. INTRODUCTION

A system of housing is more or less synonymous to the system of management of dairy cattle. Housing is essential to protect the animals from extreme climatic conditions, wild animals and theft. Housing also helps to maintain normal health of the animal by proper feeding, watering and reducing environmental stresses. An efficient housing system ultimately leads to an efficient management and reduce labour requirements to the minimum.

2.2. OBJECTIVES

The objectives of providing housing to the dairy animals are:

i. **Protection :** Housing protects the animals from hot, cold and other adverse climatic conditions like rain, chilly and hot winds. It also protects cattle from wild animals and theft.

ii. **Feeding :** Housing is necessary for proper and economic feeding of the animals. The feeding trough should be of proper dimension and must be so designed that all the animals in the lot have easy access to it at the same time, can be filled easily from outside without disturbing the animals and minimize feed wastage.

iii. **Watering :** Animals generally drink small amount water several times in a day. So, housing must have necessary drinking trough to allow the animals to drink as much and as often as they want.

iv. **Isolation :** Housing provides a sort of isolation where animals are protected from cohabitation with human and other farm animals like poultry, pig and small ruminants etc. Further within animal houses separation of different classes like calves, heifers, pregnant animals, milch animals etc. are necessary for proper management and prevention from aggressive behavior, fighting, climbing etc.

v. **Comfort :** Housing allows the animals for proper rest, moderate exercise, provide suitable micro-environment, proper ventilation which is essential for comfort of the animals.

vi. **Hygienic condition :** Removal and disposal of excreta, cleaning and disinfection of animal houses provide a hygienic condition important for well-being of the animals.

2.3. SELECTION OF SITE FOR ESTABLISHMENT OF A DAIRY FARM

The site for the establishment of a dairy farm should be selected considering the following points.

i. **Topography**: The topography should be high and somewhat level with no abrupt slopes.

ii. **Soil**: The soil should be fertile and sandy loamy. This will help in keeping surroundings clean and dry without water logging. Fertile soil is important for fodder crop cultivation.

iii. **Nearby market**: The marketing of farm produces and by products are important for viability and profitability of a farm. Nearby market will reduce transportation cost, spoilage of animal products during storage and transport. Further quick marketing of animal products (milk and milk products) is important as they are perishable items.

iv. **Labour**: Availability of skilled and unskilled, reliable, honest, laborious and cheap labour is essential for smooth running of a dairy farm.

v. **Accessibility**: The farm should be located near the main road with good connectivity. This will reduce transportation cost and helps in quick purchasing and disposal of materials.

vi. **Electricity**: There is need of enough and continuous supply of electricity for speedy work.

vii. **Water supply**: Good quality water should be available abundantly. It is required for feeding animals, washing and cleaning of animals and equipments, irrigation etc.

viii. **Sun exposure and wind protection**: The farmstead should be located to get maximum sun exposure in the north and minimum sun exposure in the south. Further, protection of the animals from direct wind is required to prevent sudden change in environmental temperature, and ill effect on the animals. A site with many trees around is ideal which will act as windbreak and also provide shade to the animals.

ix. **Surroundings**: The farm should be located nearer to the towns, but not within human habitations. The surroundings should be safe and clean.

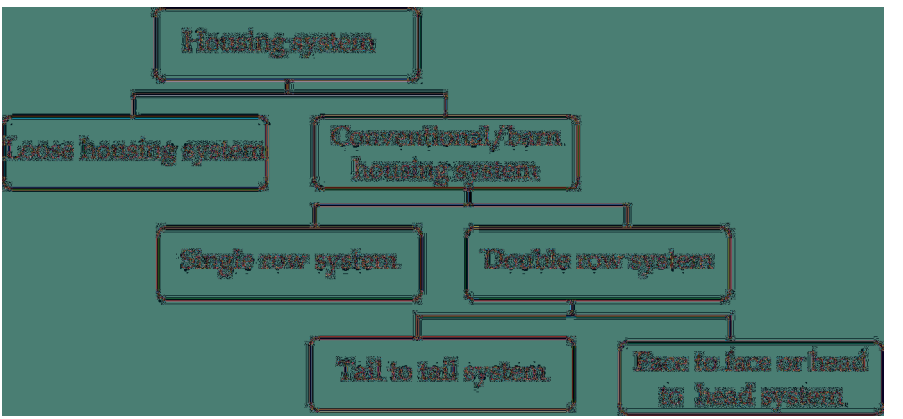
x. **Miscellaneous**: Facilities like bank, post offices, shopping centres, schools etc. are needed to provide proper working environment to the staffs and connectivity.

2.4. SYSTEMS OF HOUSING

There are broadly two types of housing systems for housing cattle.

A. Loose housing system

B. Conventional housing system



2.4.1. Loose Housing System

This system comprises of an open paddock with a covered area along one side. The animals are kept free so that they can move freely,

feed and drink water at their will. The animals can take shelter in the covered area during cold, hot or rain, or at night. The covered area consists generally of asbestos shed with 4.6 m height at the centre and 2.4 m at the sides, from the floor. The shed is supported by pillars (cement concrete or iron or wood) or wall upto a height of 1.5 m can be made and rest 0.9 m can be supported by pillars.

There is provision of common feeding trough (manger) and watering tank. There are also other buildings like a separate milking barn (for milking the animals), calf pens, heifer shed, dry animal shed, milch animal shed etc. Other ancillary structures like stores for feed and fodders, milk room, office etc are constructed according to the necessity.

The open paddock is enclosed by half walls or fence of convenient height. However, slight modifications of structures or extra fittings may be necessary to protect the animals during extreme climatic conditions (Fig. 2.1).

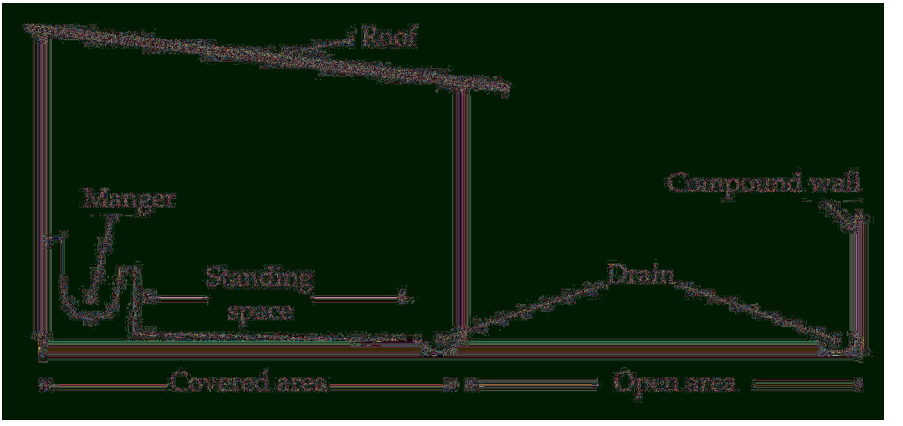


Fig. 2.1 : Loose Housing System

Advantages

1. Cheaper to construct as initial building cost is less. Since, there are not much elaborate buildings to repair the maintenance cost is also less.
2. Easier to expand when need arises without much changes
3. Flexible in utility
4. The system requires less roofed area per animals housed
5. Animals feel free and comfortable
6. Animals get adequate exercise

7. Facilitates heat detection
8. Improves labour efficiency and less numbers of labour required compared to conventional system.
9. About 10-15% more stock than the standard can be accommodated in each loose house shed for shorter period without unduly affecting their performance.

Disadvantages

1. Requires more space compared to conventional system.
2. Animals are more exposed to macroclimatic conditions
3. Chance of disease transmission is more than in conventional system
4. Animals are less cleaner than conventional system
5. If animal the animals are not grouped properly there may be chance of fighting and injury.

2.4.2. Conventional Housing System/Stanchion Barn

In this system of housing the animals are confined to allotted space by tying with ropes or chains or built in stanchions (special type of metallic device constructed in the sheds to fasten the animals). In this system the animals are not allowed to move freely. The animals are fed as well as milked in the barn. The barns are completely roofed. The height of the barn is generally 4.6 m at the centre, 2.4 m in the sides with a fall/extension of roof about 0.75 m beyond the wall (Fig. 2.2). The side walls may be complete with windows or ventilators or may not be complete with large open spaces in the side walls at suitable places for ventilation and sunlight.

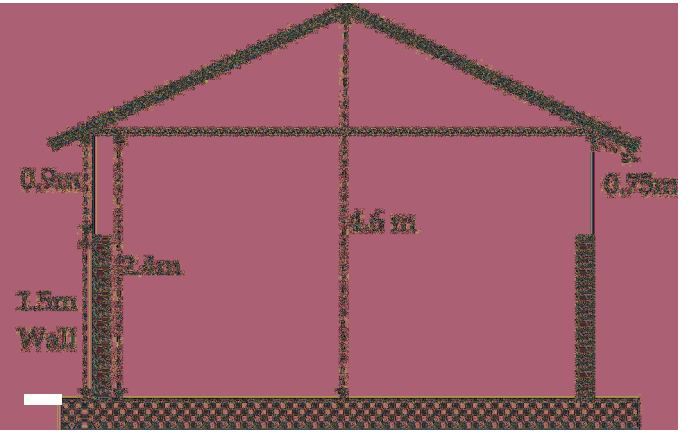


Fig. 2.2 : Dimensions of cattle shed

Advantage

1. Require less space compared to loose housing system
2. Animals are less exposed to harsh weather conditions
3. Animals can be kept cleaner
4. Disease control is better compared to loose housing system
5. Less chance of injury due to fighting

Disadvantages

1. High cost of construction compared to the loose housing system
2. Animals do not get optimum exercise and will not feel comfortable as their freedom of movement is restricted.
3. Heat detection is difficult
4. Labour requirement is more than the loose housing system.

2.4.2.1. Types of conventional system of housing

2.4.2.1.1. Single row system

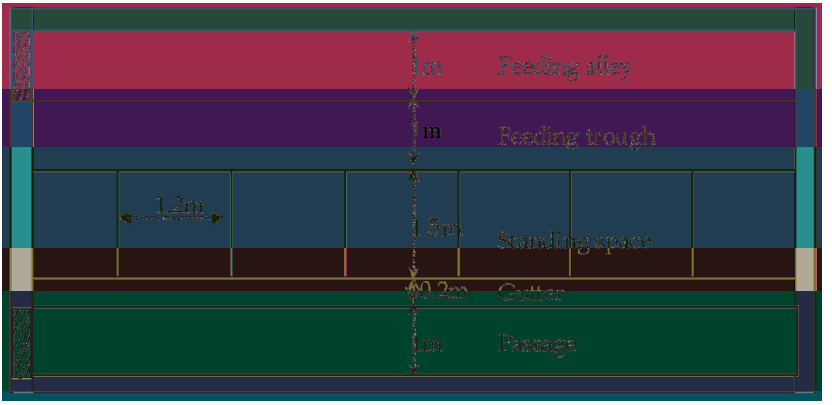


Fig. 2.3 : Top view of single row system of housing

Single row housing (Fig. 2.3) is suitable when the number of animals is less than 10. Single row housing can be constructed in a linear, circular or rectangular fashion. The floor of the shed should have following facilities:

(a) **Feeding passage (feeding alley) :** This is a passage of roughly 1m wide in front of the manger for the purpose of carrying feeding trolley for filling the manger.

(b) **Manger (feeding trough) :** This is the place for feeding the animals. It can be made of stone slabs, wooden planks, bricks lined with cement mortar or cement concrete. The floor of the manger is raised by 10-15 cm above the floor of the house to facilitate adequate feeding, drainage and cleaning of the manger. The height of the outer wall (A) is 100 cm, inner wall from outside (B) is 50 cm, inner wall from inside (C) is 40 cm and the width (D) is 60 cm (Fig. 2.4). A long pipe of suitable diameter is fitted all along the length of the manger just above and parallel to the inner wall to prevent animals from getting into the manger. The corners of the manger are rounded for efficient cleaning and minimizing wastage of feeds.

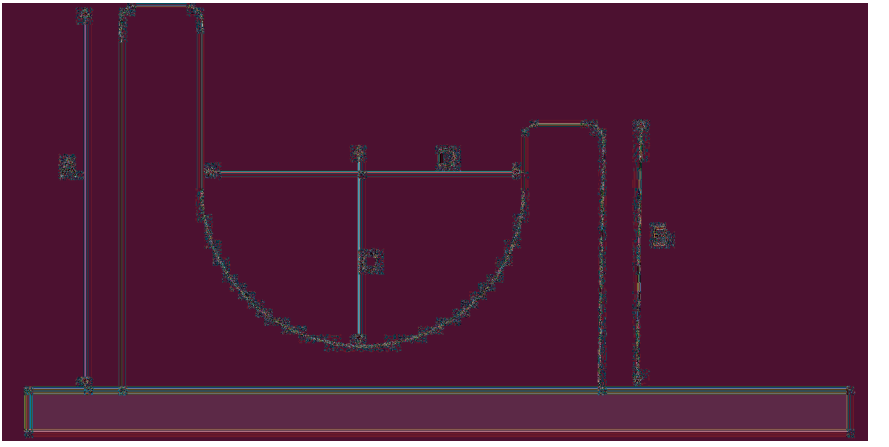


Fig. 2.4 : Manger (A =height of the outer wall, B= height of inner wall from outside, C= height of inner wall from inside and D= width)

(c) **Standing space**: This is the place where the animals stand. The dimension of the standing space varies according to the size of the animals but generally 1.5 to 1.8 m in length and 1.2 m in width. The floor should have a slope of 1 in 40 towards the drain. Partitions separating the animals can be given which protect udder of one cow from being damaged by the other and also prevents defaecation to other animals place.

(d) **Drain (gutter)**: A shallow 'U' shaped drain of 20 cm wide and 10-15 cm deep with a slope of 2.5 cm for every 3 m length

is constructed just behind the standing space (figure-2.3). It helps to keep the animal shed clean by removing urine, dung and wash water. The inside drain is connected with outside drain.

(e) **Passage**: This is the passage for milking, inspection and cleaning dung, bedding materials etc. Generally it is 1 m wide for easy movement of trolleys, milking machines etc.

2.4.2.1.2. Double row housing system

In double row housing system the animals are managed in two rows in the same barn. This is suitable when the animal number is more than 10 and a maximum of 50 animals can be housed in a barn. Floor space requirements and dimensions are same in single row system and two single rows will be there side by side, except a central passage of 1.8 m in width in the middle with slope from centre to outwards i.e., towards the drain.

Double row housing can be of two types

(a) Tail to tail system

(b) Head to head or face to face system

(a) Tail to tail system

In tail to tail system the animals are housed in two rows with their head facing outward (Fig. 2.5).

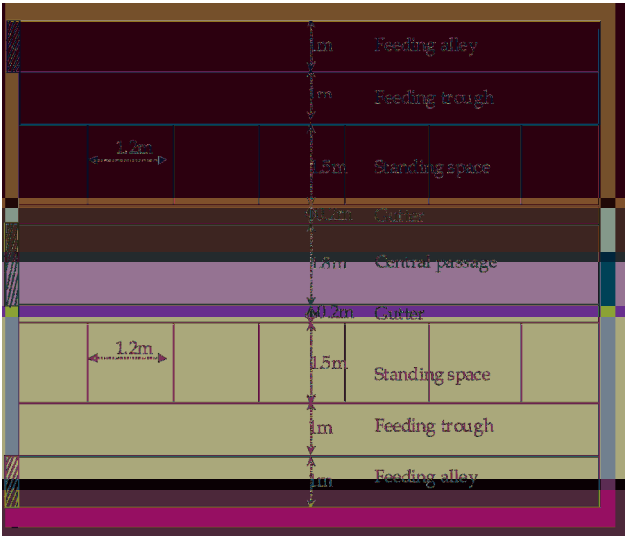


Fig. 2.5 : Top view of tail to tail system of housing

Advantages

1. Easy access to the back region of the cow which is important as time spent at the back of cows is four times more than the time spent in front of them.
2. Less chance of spread of diseases among the animals.
3. Animals can get fresh air.
4. Inspection during milking is more efficient.
5. Any injury or disease in the hind quarters of the animals can be detected quickly.
6. Cleaning of drain, dung removal, milking, heat detection is easier compared to face to face system.

(b) Face to face system

In this system the animals are housed in two rows with their head facing each other (Fig. 2.6).

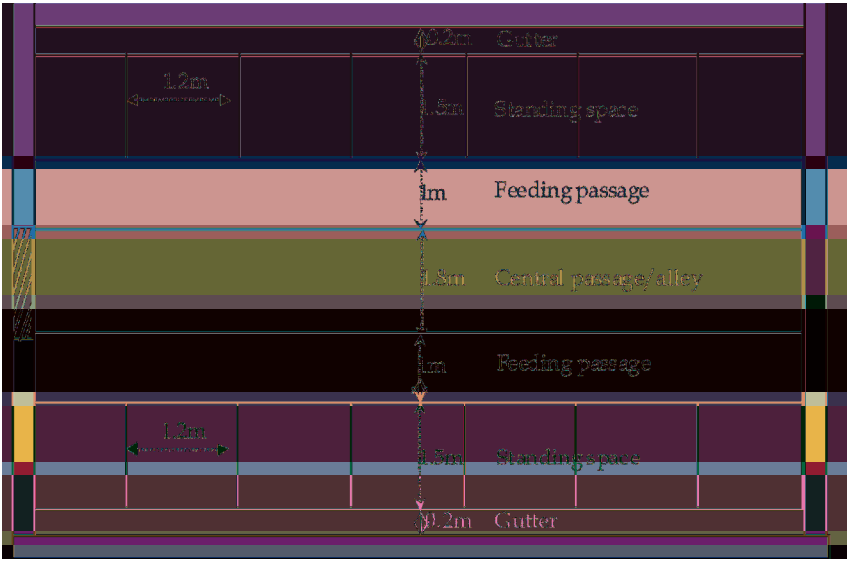


Fig. 2.6 : Top view of face to face system of housing

Advantages

1. Requires less space compared to tail to tail system.
2. Feed distribution is easier.

3. Direct sunlight can reach the drain.
4. Easier for the cows to get into the stall.
5. Cows make better show for visitors.

2.5. SPACE REQUIREMENT

The animal should be given optimum floor, feeding and watering space. The optimum floor space is required to maintain growth, production and prevention of diseases. Overcrowding should be avoided to prevent undue stress to the animals which ultimately affect their performance and make them prone to diseases. The optimum feeding and watering spaces are also required to enable the animals to feed and drink properly at their will without being disturbed by fellow animals. The provision of space to the animals beyond their requirement will require more land and increase construction cost of housing. The water trough space requirement is about 10% of the manger space requirement. This is because all the animals tend to feed at a time, but they drink water in small amount several times in a day. The optimum floor (Table 2.1), feeding and watering space (Table 2.2) are given below:

Table 2.1 : Floor space requirement for dairy cattle

Type of animal	Floor space requirement (m^2)		Maximum number of animals per shed
	Covered area	Open area	
Bulls	12.0	120.0	1
Cows	3.5	7.0	50
Buffalo	4.0	8.0	50
Down calves	12.0	12.0	1
Heifers	2.0	4.0	30
Young calves	1.0	2.0	30

Source : ISI bulletin, 1970

Table 2.2 : Manger and water trough space requirements of dairy cattle

Type of animal	Space/animal (cm)	Total manger length[1] (cm)	Water trough length[1] (cm)	Manger/water trough dimension (cm)		
				Width	Depth	Height[2]
Adult cattle	60-75	6000-7500	600-750	60	40	50
Calves	40-50	4000-5000	400-500	40	15	20

[1] Total length in a pen for 100 animals

[2] Height of inner wall from outside, i.e., height at throat of the animal

2.6. BUILDINGS REQUIRED IN A DAIRY FARM

The dairy farm consists of buildings for different classes of cattle and ancillary structures like offices, stores etc. which are discussed as follows:

2.6.1. Milking Parlour/Milking Barn

This is the place where milking is done. A separate milking parlour is required in a loose housing, but in conventional system a separate milking parlour may not be necessary. The purpose of milking parlour is to ensure clean milk production and efficient milking operation. There shall be individual standings or stalls or stanchions in single or double (tail to tail or head to head) rows. The size of the parlour depends upon the number of animals to be milked at a time. In case when hand milking is practiced each standing can be used for 2 or 3 cows and the number of standings required in a farm are thus equal to 1/2 to $1/3^{rd}$ of the number of milch animals.

2.6.2. Milch/Dry Cow Shed

There should be provision of housing for milch or dry cows separately. In a small farm a separation can be raised within a shed to keep them separately. The sheds can be constructed according to loose housing system or conventional housing system.

2.6.3. Maternity (Calving) Pens

The pregnant animals are transferred to the maternity pens 2-3 weeks before the expected date of calving. The maternity pens consist of individual partitioned stalls called calving boxes for housing pregnant animals separately. The number of calving boxes required is about 5% of the number of breedable female stock in the farm. The maternity pens should be located near the house of farmer, office or milking barn so that the pregnant animals remain in constant observation. Each calving box should be 3X4 m^2 in dimension for covered area and another 3X4 m^2 in dimension for open area. The floor should be non-slippery and well bedded. There is need for good ventilation in the calving pen.

2.6.4. Calf Shed

Calves should be housed separately from the adult animals. The calf shed should be near the milking barn. This facilitates taking calves

to their dams quickly at milking time if weaning is not practiced and feeding of milk to the calves if weaning is practiced. The newborn calves should be kept in individual boxes with an attached paddock upto 6-8 weeks of age and then should be kept in groups. Maximum of 10 calves in a group should be kept with enough feeding, watering, and floor space. The male and female calves can be kept together upto 6 months of age and after that they should be separated. If there are large numbers of calves, they should be housed separately according to different age groups i.e., 2-4 months, 4-6 months and so on. Each calf shed is attached with paddock and should have provision of manger and water trough as per specification. The floor of the covered area shall be preferably of cement concrete and open area of brick-on-edge for efficient cleaning.

2.6.5. Heifer Shed

Older female calves above 6 months of age till breeding are housed separately. Heifers can be grouped according to their age i.e., 6 months to 1 year, 1 year to breeding age and so on when the number is large and housed separately. The construction details of this shed are same as for adult cow shed except for the difference in dimensions.

2.6.6. Bull Shed

The bull shed should be constructed at one end of the farm and away from the breedable females. The bulls are kept in separate pens with adjacent paddock for exercise.

2.6.7. Sick Animal Shed (Isolation Box)

This shed is for keeping sick animals in isolation and should be located well away from other animal sheds. In construction they are more or less similar to maternity pens.

2.6.8. Ancillary Structures

Along with animal sheds certain other buildings are required in a dairy farm like stores for keeping feed material, equipments, milk house, silo, generator room, pump houses, AI centres, dispensaries, workers retiring room, office etc. for efficient running of a dairy farm.

2.7. CONSTRUCTIONAL DETAILS OF FLOOR, WALL AND ROOF

2.7.1. Floor

The floor shall be laid on a solid and compact foundation, and should be 2.5 to 5.0 cm above the outside ground for easy drainage. The floor should be impervious and non-slippery. The floor inside the shed can be made up of cement concrete, brick-on-edge, stone slab or moorum. The moorum floor is generally not preferred as it is difficult to keep clean. The cement concrete floor is best and shall be made in milking barns, stores, calf pens and other buildings where cleanliness is important. If the floor inside the cattle shed is made of cement concrete its surface must be roughened by imprinting the impression of wire or metal when the concrete is moist to prevent sleeping of animals. The open areas are generally made of brick-on-edge or moorum or kankar floor. Wooden floors can be used in temperate regions, as wood is act as insulator. The floor should have a gradient towards the drain of 1 in 40 in the covered area and 1 in 60 in the open area for easy drainage of urine and wash water towards the drain.

2.7.2. Wall

The walls of the animal houses protect the animals from adverse climatic conditions like rain, hot and cold winds and act as roof supporting structures. The shed may have full walls, half walls, or no wall at all where it is being supported by pillars, depending on the climatic conditions and type of housing. The walls are generally made upto a height of 1.5 m with an open space of 0.9 m supported by pillars for ventilation and sunlight. In conventional housing system the open spaces are covered with wire mesh to prevent entry of birds, which can spread diseases directly or indirectly by contaminating feed and water.

The walls may be constructed of brick, stone, mud, wood, bamboo or any other material available in the locality and suitable to the climate. The pillars may be made up of stones, bricks, cast iron pipes or wood. The thickness of side walls shall not exceed 35 cm, and the partition walls and the walls lining the open area shall be 22.5 cm. It is better to plaster and paint the inner surface of the walls as it will not allow lodgment of dust and moisture, and is easy to clean.

2.7.3. Roof

The roof should be light, strong, durable, a bad conductor of heat and free from tendency to condense moisture inside. The roof is generally made of asbestos, tiles, aluminium or iron sheets, wood, thatch, bamboo etc. depending on the availability and feasibility. The sloping roofs are better as they make allowance for air space and light along with roof ventilation. The height of the roof at the centre is 4.6 m and 2.4 m on the sides. There should be a fall/extension of 0.75 m beyond the wall to prevent heating of the walls by direct sunlight (Fig. 2.2).

2.8. SUMMARY

Housing is an essential part of dairy cattle management. Housing protects the animals from adverse climatic conditions. It enables the animals to feed and drink at their will without any disturbance which ultimately leads to better production. It also helps to keep the animals healthy by preventing occurrence of diseases by providing hygienic environment to them. While selecting a site for establishment of a dairy farm some points should be considered regarding topography, soil, nearby market, availability of labour, electricity, water etc. The housing system can be divided into two types viz., loose housing system and conventional/barn housing system. The conventional system may be single row or double row (tail to tail or head to head) depending on the number of animals. The animal should be given proper floor, feeding and watering space. The dairy farm consists of various buildings for different classes of cattle like milking barn, milch/dry cow shed, maternity pen, calf shed, heifer shed etc. and ancillary structures like stores, offices, silo, milk house etc.

2.9. CHECK YOUR PROGRESS

(a) What is isolation box?

(b) How many extra animals can be accommodated to a loose house pen?

(c) How many numbers of maternity pens is required in a dairy farm?

(d) What are the ancilliary structures of a dairy farm?

(e) What is the fall of the roof of animal house?

2.10. ANSWERS TO 'CHECK YOUR PROGRESS'

(a) This shed is for keeping sick animals in isolation and should be located well away from other animal sheds. In construction they are more or less similar to maternity pens.

(b) About 10-15%.

(c) 5% of the breedable female in the herd.

(d) The ancilliary structures of a dairy farm are stores for keeping feed material, equipments, milk house, silo, generator room, pump houses, AI centres, dispensaries, workers retiring room, office etc.

(e) About 0.75 m.

2.11. EXERCISES AND QUESTIONS

(a) Write about the selection of site for the establishment of a dairy farm.

(b) What are the advantages and disadvantages of loose housing system?

(c) Draw a diagram of face to face conventional barn with dimensions.

(d) Describe the constructional detail of the floor, roof and wall of the animal houses.

2.12. FURTHER READING

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CHAPTER - 3

Care and Management of Calves

3.1. INTRODUCTION

Calves are the future replacement stock of dairy farm. The raising of calves, an important operation of the dairy farm requires a great deal of managemental skill, application and constant attention. Any negligency results in increased calf mortality, poor growth and development of the calves. So, care of the calves is important for success of the dairy farm.

3.2. OBJECTIVES

The objective of calf raising is to:

- check calf mortality
- ensure proper growth of the calves for early maturity
- avoid risk of infection in the calves
- building a good dairy herd
- proper feeding and management

3.3. CARE AND MANAGEMENT PRACTICES FOR CALVES

The scientific managemental practices and care for calf rearing are described as follows:

3.3.1. Pre-partum Care

The raising of a calf begins even before it is born. The pregnant cows should be provided with additional feed beyond maintenance

requirement during the last 2-3 months of pregnancy. Otherwise, it may give birth to weak, deformed, immature and under-nourished calf. Additional feed provides extra nutrient required for foetal growth, prepare the cow for production of sufficient colostrum and develops ample reserve of nutrients to stand the stress of parturition and early lactation. This extra feeding is called challenge feeding.

3.3.2. Care Just after Birth

(a) **Cleaning mucous :** Soon after birth, mucous membrane from nostrils and mouth has to be removed to allow the calf to breath. The mucous from the body is cleaned either naturally by allowing the dam to lick the calf or manually by a clean and soft towel or smooth dry straw. This will stimulate cutaneous blood circulation of the calf.

(b) **Stimulation of breathing :** Normally calf starts breathing after birth, if this does not occur stimulating the calf for breathing can be done by i) alternate compressing and relaxing the chest, ii) tickling nose of calf with a piece of straw or grass, the calf will sneeze and expel the mucous, iii) hanging the calf by holding in the rear legs and keeping the head downward, mucous may flow off.

(c) **Navel treatment :** The black tarry material inside the navel cord should be squeezed out and tied 2.5 cm away from the navel with a thick clean thread or rubber tube. The cord should be cut 1 cm below the tied position with sterilized scissors or new razor blade dipped in any antiseptic. The exposed part is then disinfected with 7 % iodine solution to prevent bacterial invasion before the navel is sealed. Under normal condition the navel will dry, shrivel and the opening will seal in 1-2 days.

3.3.3. Colostrum Feeding

Colostrum is the secretion from the mammary gland of cow in the first 24 hours after parturition. It differs markedly from normal (whole) milk in composition, physical properties, and function. Transition milk is the secretion from the mammary gland from 24 to 72 hours after calving and it differs from colostrum in composition. Colostrum is important for providing passive immunity to the calves.

i. **Composition of colostrum:** Colostrum contains two times more dry matter, three times more minerals, and five times

more protein than whole milk (Table 3.1). It is also higher in energy and vitamins like A, D, and E. In addition, relatively low lactose content of colostrum reduces the occurrence of diarrhoea. Colostrum is also rich in immunoglobulins (antibodies) which provide passive immunity to the calves.

Table 3.1 : Composition of colostrum, transitional and whole milk of Holstein cow

Item	1st day milk (colostrum)	2nd day milk (transition	3rd day milk (transition)	4th day onwards (Whole milk)
Solids (%)	23.9	17.9	14.1	12.9
Protein (%)	14.0	8.4	5.1	3.1
Solids (%)	23.9	17.9	14.1	12.9
Protein (%)	14.0	8.4	5.1	3.1
IgG (mg/ml)	48.0	2.05	15.0	0.6
Fat (%)	6.7	5.4	3.9	4.0
Lactose (%)	2.7	3.9	4.4	5.0
Minerals (%)	1.1	1.0	0.8	0.7
Vitamin A (ug/dl)	295.0	190.0	113.0	34.0

Source : Journal of Dairy Science, 1978, 61:1033-1060.

ii. **Colostral immunoglobulins :** There are three types of immunoglobulins present in the colostrum of cattle viz., IgG (with two isotypes IgG_1 and IgG_2), IgM and IgA in the amount (%) of 70-80, 10-15 and 10-15, respectively. The primary role of IgG is to identify and help to destroy the invading pathogen. Because of the smaller size of IgG, it can move out of the blood stream into other body pools where it helps to identify the pathogens. IgM is larger molecule and remains in the blood and serves as the first line of defense in cases of septicemia. IgA protects mucosal surfaces such as it attaches to the intestinal lining and prevents pathogen from attaching and causing disease.

iii. **Importance of colostrum feeding** :

(a) **Passive immunity :** The newborn calves are born without immunoglobulins (antibodies) in blood which are critical for defense against pathogen in their early life because the immunoglobulins are unable to pass from the maternal blood to the foetus through placenta. Also the immune

system of the calf not starts functioning at birth. Therefore, feeding of colostrum rich in immunoglobulins is essential to provide passive immunity to the calves to fight against pathogens until its own immune system starts functioning at about 3 weeks of age.

(b) Rich in nutrients: Colostrum is rich in dry matter (DM), energy, protein, minerals and vitamins than the whole milk. High fat and vitamins in colostrum provides instant energy to the calves and protein is important for body growth.

(c) Low lactose content: Low lactose content of colostrum reduces the incidence of diarrhoea.

(d) Laxative property: Colostrum has laxative property and helps in the removal of the meconium (first faeces of calf)

(e) Hormones and growth factors: Colostrum also contains various hormones and growth factors that are necessary for the growth and development of digestive tract of calf.

iv. Time and reason of early colostrum feeding : The new born calves must get first dose of colostrum within 15-30 minutes of birth to get maximum antibodies, followed by a second dose in approximately 10-12 hours later. The amount of antibody absorption depends on the time of colostrum feeding after birth. The antibody absorption through gut decreases to about 30% within 6 hours and about 10% within 24 hours after birth.

The reasons behind the early feeding of colostrum are as follows:

(a) Loss of absorptive sites in the intestine : At the time of birth the intestinal cells are immature and they can absorb the antibodies present in the colostrum as intact macromolecule. The maturation of intestine begins shortly after birth and within 24 hours of birth the intestinal cells become mature enough and lose their ability to absorb intact macromolecules.

(b) Secretion of digestive enzymes : The secretion of digestive enzymes in the abomasum and intestine becomes marked by about 12 hours after birth. This causes breakdown of the antibodies (protein in nature) into amino acids, which have no antibody function.

(c) **Bacterial colonization in intestine :** The intestinal tract of new born is sterile at birth. The bacteria from environment begin to colonise in the intestine within a few hours of birth and this will hamper the colostum absorption. Further, if the intestinal cells are not saturated by colostral proteins this may favour colonization of pathogenic bacteria in this site.

(d) **Enzyme inhibitors:** Colostrum contains enzyme inhibitor (trypsin inhibitor) that allows antibodies to escape intestinal digestion and absorb intact. The concentration and activity of trypsin inhibitor is closely related to the concentration of IgG in the colostrum and it decreases with gradual drop of IgG concentration.

v. **Factors affecting the quality of colostrum :** The quality of colostrum depends upon the following factors :

(a) **Age of cow:** Colostrum of older cows contains more amount and greater variety of immunoglobulins than younger cows because older cows are comparatively more exposed to pathogens.

(b) **Pathogen exposure of dam:** If the dam is exposed to many pathogens she will have high level of antibodies.

(c) **Vaccination of the dam:** A good dry cow vaccination programme can improve colostrum quality as vaccines stimulate increased maternal antibody production.

(d) **Length of dry period:** A 3-4 weeks dry period is needed to allow antibodies from the blood to be concentrated in colostrum.

(e) **Dry cow nutrition:** Providing adequate nutrition (like protein, energy) to the dry cow produce good quality colostrum than the cows not fed adequately.

(f) **Prenating:** Milking before calving or leaking milk pre-partum reduces antibody levels in the colostrum.

g) **Breed:** Jersey has the highest level and Holstein has the lowest level of antibodies in colostrum.

(h) **Season:** The quality of the colostrum is reduced due to stress during severe summer in tropical regions and severe winter in temperate regions, associated with variation in the quality of feed and fodder.

vi. **Storage of colostrum :** Excess colostrum can efficiently be stored and used later when necessity arises in conditions like (i) death of the dam just after parturition, ii) non-availability of colostrum, iii) pathogen contaminated colostrum, and iv) poor quality colostrum.

(a) Freezing of colostrum : Excess colostrum can be stored by freezing in 2 litres double bagged freezer bags or 2 litres plastic containers. These can be kept on a flat surface in non-frost-free freezer for upto one year. The freezer temperature should be -20°C.

Thawing colostrum : At the time of necessity, the frozen colostrum can be thawed in warm water (not hot water) or in a microwave on low power for shorter periods and immediately fed to the calves.

(b) Fermented/soured colostrum : Colostrum ferments when it is stored at a temperature between 60°F and 80°F (in absence of direct sunlight) by the action of fermenting microorganisms present in the colostrum. It is to be stirred daily to prevent separation. The colostrum takes approximately 10-14 days to ferment and can be stored for an additional 14-30 days. The production of lactic acids lower pH of colostrum (4.5 or less) favouring its preservation. The addition of small amount of acid preservatives can extend the life of the fermented colostrum and decrease undesirable fermentation.

Milk from antibiotic treated cows can not be used for preparation of fermenting colostrum, since the antibiotics will kill the fermenting organisms. Milk from such cows can be used two weeks after antibiotic withdrawal.

Fermented colostrum should be diluted with warm water (not hot water) @ 1 part warm water to 2 parts fermented colostrum and the reconstituted mixture can be fed to the calves approximately 10 % of their body weight at 4 days of age instead of whole milk or milk replacer. It can be not be used as substitute of colostrum in the first 3 days of calf's life.

vii. **Colostrum substitutes :** Substitute of colostrum may be required when colostrum is not available from any source. It can be prepared with the use of following ingredients

Ingredients	Amount
Whipped up fresh egg	1 piece
Cod liver oil	5 ml
Castor oil	15 ml
Warm water	300 ml

The total amount constitutes single meal and it should be prepared freshly just before feeding. Castor oil in the mixture is used as laxative. Therefore, after defaecation of meconium castor oil should be omitted from the mixture. The rest ingredients should be mixed and fed thrice daily for 3-4 days.

Other colostrum supplements are available commercially for use such as bovine serum, cheese whey etc.

3.3.4. System of Raising Calves

The calves are generally raised in two systems :

1. **Keeping calf with its dam (mother)**-In this system the calf stays along with its mother. Calves are allowed to suckle dam's udder a little before and after milking. Suckle before milking helps milk ejection and suckle after milking provides milk to the calf. After initial suckling as milk let down starts, the calf is held by a person or tied in front of the cow. After completion of milking, the calf is allowed to suckle for last 5-10 minutes. In this system, it is very difficult to predict whether calf is overfed or underfed.
2. **Weaning system:** In this system the calf is permanently separated from its dam immediately or few days (usually 3 days when the colostrum feeding period is over) after birth.

Weaning time

The calf may be weaned either of the following time:-

(i) Just after birth

(ii) After allowing calf to get nursing once as first feeding.

(iii) Allowing calf to remain with its dam for 2 to 3 days and then separate.

(iv) Keeping calf with dam until milk becomes suitable to put in the regular supply.

(v) At 3-4 months of age when rumen of the calf is fully developed.

Advantages of weaning

- Cow continues to give milk whether or not the calf is alive. When calf is reared along with its dam, strong bonding develops. If the calf dies, some cows may stop giving milk.
- Calf can be raised artificially even if the dam dies
- Calf can be culled at an early age
- Milk can be fed to the calves in accordance with their requirement. Therefore, it is economical as well as healthy managemental practice.
- Actual milk yield of the cow can be recorded and it facilitates feeding her according to the requirement.
- Overfeeding of milk to the claves may lead to several calfhood diseases like diarrohoea, scours etc. Underfed calves are prone to weakness, poor growth and decreased disease resistance.
- Hygienic and sanitary milk production can be assured when there is no suckling.
- Cows become regular breeder with the calving interval of 12-13 months. Continuous suckling stimulates the release of prolactin hormone, which prevents early post partum oestrus.
- Injury to teat is avoided.

3.3.5. Calf feeding

The feeding management of the calves is discussed as follows:

(a) **Colostrum**: The feeding of the newborn calves begins with colostrum in 15-30 minutes after birth again fed 12 hours later. The total amount of colostrum fed to the calves should be @ 10 % of the body weight per day.

(b) **Transition milk**: The transition milk is produced in the transition phase (2^{nd} and 3^{rd} day of milking) as colostrum (first day milk) is gradually changed to normal milk (4^{th} day). This milk is fed in 2^{nd} and 3^{rd} days of calf's life @ 10 % of the body weight daily divided into two parts at 12 hours interval.

(c) **Milk** : From 4 days of age milk or other acceptable liquid feeds can be fed to the calves;

1. **Whole milk**: Whole milk can be fed to the calves from 4th day onwards @ approximately 10 % of body weight at divided doses twice daily for a maximum of 2 weeks.
2. **Skim milk**: After 2 weeks of age, whole milk can be replaced gradually by skim milk.
3. **Milk replacer**: Milk replacer can be used from 4th day onwards instead of whole milk to make calf raising economical. Milk replacer powder contains proteins derived from dairy products (like dried skim milk or whey products) or other sources (fish protein, cereal flours, or meat protein).
4. **Fermented colostrum**: Discussed earlier in this unit.

Milk replacer should have following qualities :

- Palatable
- Easy to use and economical
- Supply sufficient energy, high quality protein, vitamins and minerals
- Contain minimum of 20 % crude protein (CP), 20 % fat and less than 0.5 % crude fibre on dry matter basis
- Mixing of ingredients form a homogenous mixture
- Atleast 2/3rd protein from milk source.

Table 3.2 : Composition of a milk replacer

Compound	Parts
Spray dried milk powder	50
Dried whey	10
Non-milk source	40

Source **:** Journal of dairy science, 32: 986

Table 3.3 : Milk feeding schedule for calves

Calf age (days)	Colostrum (litres)	Whole milk (litres)	Skim milk (litres)
Upto 3	1/10th of BW	-	-
4-20	-	1/10th of BW	-
21-30	-	1/15th of BW	1/20th of BW
31-60	-	1/20th of BW	1/25th of BW
61-100	-	1/25th of BW	1/25th of BW

(BW= Body weight)

The ingredients should be mixed with water and fed according to the manufacturers' direction, generally at a ratio of 1: 8 (milk replacer powder: water).

(d) **Calf starter** : Calf starter is the first dry concentrate mixture fed to the calves. It should be given to the calves at 4 days of age and at first they will nibble the calf starter. At birth, calves behave like simple stomach (monogastric) animal with functional abomasum and non-functional rumen. When calf consume milk, it directly passes from oesophagus to omasum and finally to the abomasum by- passing the rumen through a groove called 'esophageal groove', formed by the muscular folds of the reticulum. This groove is formed due to the neural stimulation from suckling and milk proteins. It remains functional if only milk feeding continues. The feeding of calf starter helps in the development of functional rumen as the esophageal groove does not function when the calf eats dry feeds which enter the rumen and are digested by microbes. The reflex closure of the groove to form a channel can be stimulated even in adults, particularly if they are allowed to drink from a teat.

Calf starter is a mixture of grains, protein source, mineral and vitamins with 75 % total digestible nutrient (TDN) and 16-18 % digestible crude protein (DCP). It should be highly palatable to the calves. A coccidiostat or coccidiocide should be included in the calf starter.

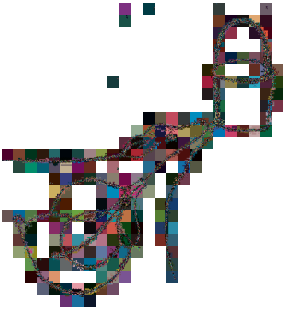

Fig. 3.1 : Esophageal groove direct milk from esophagus to abomasum

Calf starter may be fed on free choice basis and for the first 2 weeks of life, the calves will just nibble calf starter. The amount may be restricted when the calf starts consuming 1-1.5 kg of the starter mix a day. Milk feeding can be discontinued when the calf is consuming 0.4-0.5 kg concentrate per day. Calf starters should be fed until calves are about 12 weeks of age.

Table 3.4 : Nutrient composition of a calf starter

Component	Amount
Crude protein	16-20%
Calcium	0.70%
Phosphorus	0.45 %
Potassium	0.65 %
Copper	10 ppm
Zinc	40 ppm
Manganese	40 ppm
Cobalt	0.10 ppm
Selenium	0.30 ppm
Vitamin A/lb dry matter	1818 IU
Vitamin D/lb dry matter	270 IU
Vitamin E/lb dry matter	12 IU

Source : Nutrient Requirements for Dairy Cattle-2001

Table 3.5 : Composition of a calf starter

Ingredients	Quantity
Maize	35 kg
Barley	15 kg
Ground nut cake	30 kg
Wheat bran	10 kg
Fish meal	07 kg
Mineral mixture	02 kg
Common salt	01 kg
Antibiotics	100 g
Vitamins (A, B and D)	15 g

Source : Mishra and Singh, 1992. Indian Dairyman, XLIV: 526-529.

(e) Grains : Calves are fed grain mixes containing 18% crude protein (CP) from 2-3 months age assuming early cut alfalfa/ grass hay is fed containing 18% CP and 35 % acid detergent fibre (ADF).

(f) Forage : Feeding good quality fodder and hay can be started from 5-7 days of age on a free choice basis and this will encourage early rumen development. Calves start nibbling at first and gradually start consuming. Silages as the sole forage should be given to the calves after 4 months of age.

(g) **Water :** Fresh and clean water should be provided free choice starting at 4 days of age. Water along with calf starter helps to convert a calf from a simple stomach animal to one with a functional rumen that can utilize forages and grains. Water consumed as plain water enters the rumen and becomes available for the microbes' use. However, water consumed along with other feeds, including milk or milk replacer, is not readily available to rumen microbes as it is funneled through the esophageal groove to the abomasum and not to the rumen. Absence of either milk or water added to the milk to the rumen limit rumen microbial growth. Thus, water should be provided separately to the calves starting at the early life. Precaution should be taken that water should not be fed immediately just after milk feeding as the esophageal groove remains active.

3.3.6. Teaching Calves to Drink

1. **Hand feeding :** Colostrum or milk is poured into a clean pail. The calf is brought to the pail and its nose in contact with the milk. The husbandry person should insert two fingers of right hand (after cleaning) into the mouth of the calf, while holding the milk at left hand at a convenient height for the calf. As the calf starts suckling the fingers, the muzzle is gradually dipped into the pail and the fingers are gradually removed when the calf starts suckling milk. This procedure may be repeated whenever the calf stops drinking and lifts its head.

Fig. 3.2 : Hand feeding of calf

2. **Nipple feeding :** The calf can be fed from rubber nipples attached to the pails or bottles, placed at a convenient height from which the calf suckles milk. This stimulates the natural suckling process of the calf keeping mouth and neck stretch upward. The nipples should be removed, washed thoroughly and sterililsed once a day.

3.3.7. Housing

Housing is important to protect the calves from harsh environmental conditions. Calves are kept in individual stalls upto the age of about 8 weeks to prevent licking each other and for better care. Then they should be kept in small groups of 6-10 calves so that they can adjust to group feeding and to minimize competition among them for feed. Details are discussed in the section 2.6.4.

3.3.8. Identification

Identification of calf is important for keeping records, proper feeding, better care and management. Identification of new born calf can be done with an ear tag or tattoo and/or sketch or photograph.

3.3.9. Extra (Supernumerary) Teat Removal

An ideal udder contains four teats and if any calf is born with extra teats (more than four), it should be removed as soon as possible after birth to ensure a quick recovery. Extra teats can interfere with milking and may leak which increases the chance of mastitis. Extra teat is removed (Fig. 3.3) by clipping off with a pair of sterilized scissors and a disinfectant such as tincture iodine is applied.

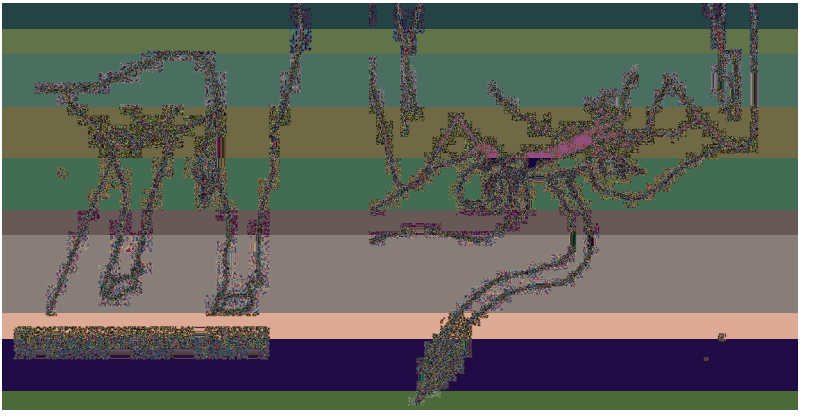

Fig. 3.3 : Removal of supernumerary teats

3.3.10. Dehorning

Dehorning the calves is important to avoid injury to personnel or other animals, reduce space requirement and increase handling ease. Dehorning should be performed when the calves are 2-3 weeks of age by any of the three methods e.g., electrical, chemical or mechanical.

3.3.11. Castration

Castration of male calves is done at 2-3 months of age to make the animals more docile, produce more desirable edible meat and prevent uncontrolled breeding. However, the age of castratopm shoud be 1.5 to 2 yrs if male calf reared to produce bullock. This can be done by different methods viz., open and bloodless methods.

3.3.12. Record Keeping

Record should be kept regarding birth date, sire and dam of each calf, vaccination, dystokia at birth etc. for efficient management.

3.3.13. Prevention of Diseases

The prevention of diseases in the calves is very important for the production of healthy calves. The following points should be taken into consideration to prevent disease occurrence in the calves.

(i) **Vaccination** : Calves should be vaccinated to prevent occurrence of diseases. The vaccination programme should depend on the disease problem prevalent in a given area and herd. The common diseases of calves are generally associated with respiratory and digestive tract. For better prevention of calf from diseases the dry cow can be vaccinated and the calf will get protection by consuming colostrum. At birth the calves can be given oral vaccine to prevent scours. After that vaccines against different diseases (eg., black quarter, foot and mouth disease, haemorrahgic secpticaemia, rinder pest etc.,) are given to the calves according to the disease occurrence in the area.

(ii) **Deworming:** Regular deworming of the calves from 5 days of age is necessary to protect them from internal parasites like roundworms, flukes and tapeworms.

(iii) **Control of ecto-parasistes:** Regular grooming, clean surroundings and use of insecticides are important to control the ectoparasite infestation in the calves.

3.4. SUMMARY

The first step in raising healthy and productive replacement stocks for the milking herd is proper feeding, care and management of young calves. Feeding of colostrum within 15-30 minutes of birth is essential to provide antibodies and required nutrients to the calves. From 4 days of age liquid feed (whole milk/skim milk/milk replacer), calf starter and water should be provided. Green fodder and hay should be provided to the calves from 5-7 days of age on a free choice basis. The other important managemental factors to the considered are proper housing, castration, removal of supernumerary teats, dehorning etc. Regular vaccination, deworming and ectoparasite control are also important to raise healthy calves. Proper record keeping of the calves is also important for efficient management of the calves and its future use in the dairy herd.

3.5. CHECK YOUR PROGRESS

(a) What is colostrum?

(b) What is transition milk?

(c) What is weaning?

(d) What is the age of castration of male calves?

(e) What is 'oesophageal groove'?

3.6. ANSWERS TO 'CHECK YOUR PROGRESS'

(a) Colostrum is the secretion from the mammary gland of cow in the first 24 hours after parturition

(b) Transition milk is the secretion from the mammary gland from 24 to 72 hours after calving.

(c) Calf is permanently separated from its dam immediately or few days (usually 3 days when the colostrum feeding period is over) after birth is called weaning.

(d) About 2-3 months of age male calves are castrated

(e) When calf consume milk, it directly passes from oesophagus to omasum and finally to the abomasum by- passing the rumen through a groove called 'esophageal groove', formed by the muscular folds of the reticulum.

3.7. EXERCISES AND QUESTIONS

(a) What is the purpose of colostrums feeding in calf?

(b) What are factors affecting the quality of colostrums?

(c) What is the purpose of weaning?

(d) How to teach a calf to drink milk?

(e) Write in detail about the feeding schedule of calf.

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CHAPTER - 4

Care and Management of Heifers

4.1. INTRODUCTION

Heifers are young female cattle from 12 months of age to first calving. Heifer management is important as they are future cow of the herd. Proper growth and body condition of the heifers are associated with their early sexual maturity and age at first breeding, and their later productive and reproductive performances, when they become cow. Thus, proper care and management of the heifers is necessary to establish a good dairy herd.

4.2. OBJECTIVES

The objective of heifer management is to :

- attain adequate growth for reaching sexual maturity at earlier age
- reduce age at first calving and better reproductive performance
- obtain good milk production in her first and subsequent lactations
- reduce the culling of heifer for failure to conceive or poor production
- produce superior heifers to replace culled lactating cows
- maximize the genetic potential
- raise heifer at a minimum cost and getting early return on the investment

4.3. TARGETS OF HEIFER MANAGEMENT

The heifer management should have the following targets :

(a) **Daily body weight gain:** Optimum daily body weight gain is necessary for early sexual maturity, which is about 0.8 -0.9 kg per day for larger breeds (like Holstein) and 0.6 kg per day for smaller breeds (like Jersey).

b) **Breeding age:** The breeding of the heifer should be done at 15-18 months of age when they become sexually mature. This will increase the lifetime milk production, number of calves obtained and reduce the unproductive life of a cow. Too early breeding will affect proper growth and development of the heifer which in turn will affect her lifetime production. Too late breeding increases the generation interval as well as the unproductive life.

c) **Breeding weight:** Puberty as well as sexual maturity of heifers is more related to the body weight rather than age. The heifer should reach 65 % of her mature weight at breeding time i.e., about 330-370 kg for larger breeds like Holstein and 230-280 kg for smaller breeds like Jersey.

d) **Age at first calving:** When the heifers become pregnant at early age (around 15-18 months), after completion of pregnancy (280 days), the calving will occur at about 25-28 months of age. Therefore, target age at first calving should be 25-28 months.

e) **Weight at first calving:** The heifer should attain 85 percent of her mature weight at the time of calving that is about 550-600 kg for larger breeds and 400-450 kg smaller breeds. This will help to withstand the strain of calving and also minimize the calving problems.

f) **Body condition score:** Too lean and too obese heifers are not suitable for breeding. The body condition score of heifers should be between 2.5 to 3.0 from 12 months upto breeding age and 3.25 to 3.5 (on 5 point scale) from breeding to freshening.

g) **Replacement rate**: About 80-85% of the heifers reared should reach the lactating herd.

4.4. MANAGEMENTAL STEPS

The mangemental steps for successful heifer rearing are discussed as follows :

4.4.1. Feeding

Feeding of the heifers should be monitored closely at different stages of heiferhood which are discussed as follows:

4.4.1.1. Growing and breeding heifers

Proper feeding of heifers is important to attain the target weight at proper age and prepare them for breeding and calving. The heifers can be fed high quality forages and fibrous agricultural byproducts which can meet their growth requirements. Some grain and other feed additive supplementation are necessary to fulfill the nutrient requirement (Table-4.1) necessary to attain desired growth rate per day.

If the heifers are managed in pasture, it can be an excellent source of feed for growing dairy heifers. However, it is important to manage the pasture properly considering desirable plant species, stage of growth, parts of plants, digestibility etc. to provide sufficient nutrients to the heifers. Heifers should be fed grains and other feed supplements additionally according to necessity to attain the desired growth rate.

Table 4.1 : Nutritive value of diet for heifers (growth rate 0.7 kg/day)

Parameters	6-12 months	Above 12 months
Live weight (kg)	254	400
DM intake (kg/day)	5.7	8.8
Metabolisable energy (MJ/kg DM)	10.3	9.5
Crude protein (%)	12.0	12.0
Calcium (%)	0.41	0.29
Phosphorus (%)	0.30	0.23

Source : NRC (1989)

4.4.1.2. Pregnant heifers

Pregnant heifers are usually given high forage diets until a few weeks prior to calving. The body weight goal must be reached at calving age (65% of their mature weight), body condition of 3.25-3.75 (5 point

scale). Herds having history of udder oedema, can be corrected by withdrawing salt from the heifers, reaching near parturition.

Steaming up : Extra feeding heifers during late pregnancy (about 2 weeks before expected date of calving) are called steaming up. It is important for the following reason.

(a) Heifer continues to grow during their first pregnancy and it requires extra feeds.

(b) Maintaining body reserve at the time of calving to withstand the strain of parturition.

(c) It is having a growing foetus and maximum growth occurs during the last trimester of pregnancy.

(d) Preparing for production of colostrum and milk after calving.

(e) Conditioning her digestive system for the increased amount of concentrate feeding at early lactation.

For steaming up the heifers may be fed 1.5 kg concentrate daily during the last fortnight of gestation. The amount of concentrate should gradually be increased daily by 300-400g until the heifers starts consuming 1.5kg concentrate daily. The gradual increase of concentrate is important to acclimate the rumen and, to prevent acidosis and other digestive problems.

4.4.2. Housing

Heifers do not require elaborate housing facilities. They are required to be housed in groups according to age (details in section 2.6.5)

4.4.3. Exercise

If the heifers are allowed to graze on pasture or kept in loose housing system with open paddock, extra exercise is not required. If the heifers are kept indoor, an open area (run out) may be provided so that the heifers can get sufficient exercise. Exercise will remove stiffness in their limbs, keep them thrifty, growing, not obese and maintain normal appetite. Obesity may results in accumulation fat around ovary which may hamper normal reproductive function.

4.4.4. Breeding

Early breeding of heifers is important for early calving. The time of breeding heifers is generally when it reaches about 65 percent of

her mature weight i.e., about 330-370 kg for larger breeds like Holstein and 230-280 kg for smaller breeds like Jersey at an age of 15 months. Before breeding, per-rectal examination of the reproductive tract for soundness is necessary. Suitable methods should be applied for oestrus (heat) detection in heifers. Special care should be taken regarding visibility of the identification of the heifers. Oestrus synchronization techniques can be applied to avoid heat detection problems and helps group breeding and calving.

Breeding heifers is to be done with bulls with known or predicted low calving difficulty. The breeding of heifers to large framed bulls should be avoided as calving difficulty increases with increasing size of calf at birth, which is directly related to the mature weight of sires.

After breeding, pregnancy is checked at about 60 days. The open heifers should be bred again, if not conceive they should be culled to increase the calving percentage in the herd.

4.4.5. Training

The heifers should be handled gently. They should be trained to be lead with halter from an early age which will help to make them docile cows with good temperament.

4.4.6. Breaking-in Heifer

The pregnant heifers should be housed in a shed along with the milking cows about a month prior to calving to accustom them to their place in barn. This will help in co-mingling with older socially dominant cows, become accustom to increased handling by human and adjust to the milking routine. They should be accustomed with the process of milking by washing udder with warm water, mopping of udder to feel the hands in this region and getting teats pulled as though in the process of milking. After calving, such heifers would not get excited to cause difficulty in milking, otherwise she may develop a nervous disposition, habit of kicking and become a problem cow.

4.4.7. Selection and Culling of Heifer

Selection of heifers should be done time to time till they become pregnant. The following points may be taken into consideration for selection and culling of heifers.

(a) Select heifers that are structurally large, physically sound, in good health and have a good growth potential because they will reach puberty earliest.

(b) Select heifer having large skeletal size or frame as indicated by height at hip and length of body.

(c) Select replacement heifers with appropriate pelvic measurements to prevent dystokia. Heifers with pelvic openings below a certain standard (160 cm^2 at 12 months of age) can be culled.

(d) Do not select heifers that are very fat because of the tendency for a reduced milk producing ability.

(e) Select heifers that have the potential for long productive life by choosing those with structural soundness in feet and legs and with a straight strong back.

(f) Select heifers with well developed sex organs, and avoid those with excessive fat or waste in the brisket

(g) Select a heifer based on her dam's and sire's performance records. The sires need to have good maternal traits.

(h) Heifers with genetic defects can be culled

(i) Heifers having functional defects due to injuries may be culled

(j) Heifers having anatomical defects, bad disposition and poor in growth and late maturing should be culled.

(k) Cull the repeat breeding heifers.

(l) Avoid heifers with abnormally heavy muscling, an indication of lack of feminity.

4.4.8. Identification

Individual identification of heifers can be done with ear tags or branding.

4.4.9. Record Keeping

Proper records should be kept regarding body weight, average daily live-weight gain, breeding dates, sire and dam performance records, pregnancy diagnosis results, body condition scores, disease occurrence, vaccination etc.

4.4.10. Health Management

1. **Vaccination**: Vaccination programme of the heifers should be done to protect against the diseases prevalent in the area

and specific diseases of individual farms. Following is the list of typical vaccination protocol, but this can vary depending on disease prevalence in a particular area or in the farm.

Age (months)	Vaccine
5-6	Vaccinate for Brucellosis, Infectious Bovine Rhinotracheitis (IBR), Bovine Viral Diarrhoea (BVD), Bovine Respiratory Syncytical Virus (BRSV), Para Influenza type-3 (PI3)
13	Repeat IBR, PI3, BVD and BRSVVaccinate for leptospirosisVaccinate for vibrio in case of natural service
18-20(Pregnant heifers)	Vaccinate against leptospirosis
60 days prior to calving	Vaccinate with E-Coli, Rota and corona virus

2. **Deworming** : Regular deworming at 4-6 months interval is needed to keep the heifers free from internal worms and for maintaining proper growth and health condition. A coccidiostat should be fed as a supplement at about 6 months of age and to the pregnant heifers. Ionophores (monensin or lasalocid) act as coccidiostat and may increase feed efficiency and weight gain.

3. **Control of ectoparasites and fly** : Heifers which are allowed to graze on pasture are commonly infested with ectoparasites like tick, lice etc. These can be controlled by spraying with insecticides like 1% melathion spray. Spraying grounds nearby and around sheds with approved insecticides will control ectoparasites and flies. The shed and nearby area should be kept dry without accumulated beddings or manure to prevent fly breeding. Keeping farm neat and clean and proper disposal of manure can help reduce fly numbers. Further, regular grooming of heifers is helpful not only in detection of ectoparasites but also in making them docile.

4.5. SUMMARY

The care and management of heifers is important for establishment of a good dairy herd. The heifers should have adequate growth rate to reach sexual maturity at an early age. This is important for early age at first breeding and age at first calving which will reduce the generation interval and increase the profitability of the dairy farm. They should preferably be bred at 15-18 months of age attaining about

65% of her mature body weight and calved at 24-27 months of age attaining about 85% of her mature body weight. Proper feeding is important to reach these goals. At about 2 weeks before the expected date of calving, steaming up the heifers is essential. Training and breaking-in of heifers is necessary to avoid any behavioural nuisance during milking. Selection of the heifers should be done from time to time till they become pregnant. Proper housing, exercise, identification, record keeping and health management are also important for successful rearing and management of heifers.

4.6. CHECK YOUR PROGRESS

(a) What is heifer?

(b) What is the breeding age of heifer?

(c) What will be the desirable body condition of pregnant heifer at their last stage of pregnancy?

(d) What is steaming up?

(e) What is the age of calving of heifer?

4.7. ANSWERS TO 'CHECK YOUR PROGRESS'

(a) Heifers are young female cattle from 6 months of age to first calving.

(b) About 15-18 months

(c) 3.25-3.75 in 5 point scale

(d) Extra feeding heifers during late pregnancy (about 2 weeks before expected date of calving) are called steaming up.

(e) About 25-28 months

4.8. EXERCISES AND QUESTIONS

(a) What are the targets of heifer management?

(b) Write in brief about the feeding management of heifer.

(c) What is breaking-in heifer?

(d) How would you select heifer as replacement stock of a dairy farm?

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CHAPTER - 5

Care and Management of Dry Cows

5.1. INTRODUCTION

A dry cow is a cow that is not producing milk. Usually cow remains in-milk for about 305 days (average lactation length), after that it remains for a period of about 60 days in dry condition (not giving milk) called dry period. Dry period is critical for a cow for regeneration of her udder and reserve nutrients for the next lactation, otherwise, milk production will not be upto the mark and the cow may suffer from several metabolic diseases after parturition. A dry cow is just as valuable as a lactating cow, therefore should be not neglected. A dry cow management programme includes nutrition, general management and health control programme.

5.2. OBJECTIVES

The objectives of dry cow management are to:

- allow for involution and regeneration of milk secretory tissue in the udder
- increase milk production in the subsequent lactation
- increase production of colostrum, as the transfer of immunoglobulins from the cow's blood to the milk starts about one month before calving and reaches its peak just before parturition
- develop optimum body reserve to withstand the strain of calving

- provide nutrition for the growing foetus as maximum growth occurs during last trimester of pregnancy
- avoid nutritional deficiency diseases like milk fever etc. after calving
- allow the cow to prepare for next lactation

5.3. LENGTH OF THE DRY PERIOD

The optimum dry period is 50-70 days. A longer dry period increases production in the following lactation, but lifetime milk production is less and also contributes to obesity at calving. A shorter or absent dry period decreases the milk production in the following lactation as the cow does not get sufficient rest period to rejuvenate and prepare her udder as well as body.

5.4. MANAGEMENT OF DRY COWS

5.4.1. Phases of Dry Period

Dry period can be divided into three phases for efficient management of the dry cows.

(a) Drying off period (first 4-10 days)

(b) Dry or "far-off" period (next 30-40 days)

(c) Transition or "close-up" period (last 21 days before calving)

5.4.1.1. Management during drying off period

5.4.1.1.1. Drying off

Drying off usually means stopping of milk secretion in the udder. The drying off process usually takes 4-10 days. It occurs at the condition when milk pressure in the udder equals the blood pressure and thus cessation of milk secretion. Drying off can be achieved by the following methods:

(a) Complete cessation: It means complete stoppage of milking. The milk will remain within the udder and thereby increases milk pressure within the udder. The milk pressure has a negative impact on the secretary tissues and reduces milk secretion. Milk secretion gradually decline and ultimately stop. The remaining milk in the udder is gradually reabsorbed. It is the fasted and best method of drying off.

(b) Intermittent milking : It refers to the milking the cows once in a day for about a week and then stop milking completely. The increase in milking interval has negative impact on milk secretory tissues, resulting in gradual decline and finally stoppage of milk secretion.

(c) Incomplete milking: It means milking is done regularly, but incompletely so that more amount of residual milk remains within the udder. The residual milk will have a negative impact on the secretory tissues. Thus, the milk synthesis gradually decline and ultimately stop after sometime. This process is time consuming.

The complete cessation of milking is the best method of drying off as intermittent or incomplete methods increases the incidence of mastitis flare-ups. Whatever the method is followed for drying off, feed and water restriction is important to facilitate the drying off process. Concentrate should be eliminated from cow's ration about 2 weeks before drying off, as this will reduce cow's milk production. Water intake should also be reduced 3-4 days prior to drying off. Cow should be observed for two weeks after drying off, whether udder is involuting (not swollen or inflamed) properly. Cow developed hard and swollen quarters should be milked as this will help remove the bacteria and toxins responsible for the inflammation. They should again be infused with antibiotics and teats dipped, after normal dry cow therapy.

5.4.1.1.2. Dry cow therapy

Dry cow therapy, the intramammary infusion of antibiotics is an important managemetal tool to prevent mastitis. During dry period, there is a great chance of getting subclinical mastitis infection specially the high yielding animals. About half of all new mastitis infections occur in the early dry period. During the early dry period tremendous stress is exerted on the udder, because the gland must breakdown and absorbs retained milk as well as millions of dead milk secreting cells. Therefore, dry cow mastitis treatment is adopted to eliminate bacterial infections occurred during the lactation and to prevent entry of new infections during the dry period. Dry cow therapy can reduce the number of new infections during this period by around 30%.

Procedure of dry cow therapy: The dry cow therapy should be adopted with the following steps:

i. Milk out the udder completely

ii. Clean and dry the teats with clean paper towel or cloth

iii. Dip teats in an effective germicidal solution for 30 seconds and then wipe teats with paper towel or clean cloth

iv. Clean and disinfect each teat, starting with the teats on the far side of the udder (in respect of herdsman), thoroughly by scrubbing with a separate piece of cotton (for each teat) soaked in 70% alcohol.

v. Starting with the teats on the close side of the udder, insert the cannula (Fig. 5.1) only 6 mm (1/4 inch) into the teat end and infused each quarter with recommended treatment with single dose syringe.

vi. Immediately following treatment dip all teats in an effective germicidal solution

vii. If possible, teat dips all treated cows atleast once a day for two weeks after drying off and two weeks before calving.

Fig. 5.1 : Dry cow therapy

5.4.1.2. Management during far-off dry period

The dry matter intake of early (far-off) dry cows should be 1.8-2.1% of body weight. The forage should form the basis of the diet with minimum level of 60% of the total ration dry matter depending on the body condition score. The concentrate portion added to compensate for the inadequacies of the forage for meeting the other nutrient needs of the dry cows. Cows entering the dry period in proper body condition (BCS of about 3.5) should be fed only roughages such as hay, pasture, green fodder and silage until about three weeks before calving. Mineral supplementation may be necessary. Thin dry cows (BCS below 2.5)

should be fed a higher energy ration to allow them to regain optimal body condition. Obese cows (BCS score of 4 or above) should be fed low quality forages with protein supplementation separately to prevent from calving and other health problems. All the cows should be fed diet with CP level of atleast 15% of dry matter.

Feeding good quality forage to the dry cows keeps rumen functioning properly by maximising rumen fill and volume, maintaining rumen muscle tone, promoting salivation and aiding in restoring and healing of the rumen wall lining damaged by high grain ration during lactation. The silage intake should be limited to 50% of the forage dry matter.

Mineral and vitamin supplementation: Providing adequate amount of minerals and vitamins to the dry cows help to minimize health problems at calving. Adequate amount of selenium, copper, iodine, calcium, and vitamin A and E to prevent problems of retain placenta. Copper, zinc, selenium, and vitamin A and E improve cows' immune response. Calcium and phosphorus is the most important mineral to be considered in dry cow ration. Ration containing less than 100 g of calcium and 40 g of phosphorus reduces the incidence of milk fever. Salt can be added @ 0.25% of total ration dry matter in early dry cows. Salt should be withheld in the close-up period to prevent udder oedema. Provide a trace mineral package to all the dry cows containing specially iodine and selenium. Magnesium and sulphur should also be supplemented to the dry cows. Anionic salts may be fed to dry cows to decrease incidence of metabolic disorders for atleast two but not more than three weeks prior to freshening.

5.4.1.3. Management during close-up dry period

The feeding during close-up period is called steaming-up or transition feeding or challenge feeding. The DM intake of the close-up dry cow should be 1.5 -1.75% of the body weight. Due to lower DM intake because of the growing calf and hormonal changes associated with the calving process, the diet nutrient density must be adjusted during this period to maintain nutrient intake to about 1.70 Mcal/kg. Compared with early dry cow ration, close-up dry cow ration usually involves increasing the concentrate portion and decreasing the forage portion of the diet. This is important for preparing the rumen for more concentrate dense ration that will be fed after calving. The increase level of concentrate increases the development of rumen papillae that functions to absorb the fatty acids produced during fermentation and

helps to prevent reduction of rumen pH and prevent rumen acidosis. This practice also allows the rumen microorganisms a chance to adjust to the diet before calving. The cow's hormonal system gets adapted to the higher levels glucose and energy due to high concentrate feeding and reduces the incidence of metabolic disorders. All these factors may help to prevent the cows from going off-fed after calving. If the cows go off-fed shortly after calving, they lose a lot of weight through mobilization of body fat, which can increase the incidence of metabolic disorders like ketosis, fatty liver etc. The fat is supplemented to the transition ration to increase the energy density of the ration that allows the cow to acclimate to the presence of fat in the lactation ration. The amount of concentrate should be increased gradually from 1 kg per day containing 250-300 g digestible undegradable protein (DUP) reaching upto 2 kg of concentrate before calving. Sources of DUP include protected soybean or fish meal. The concentrate having about 14-15% CP is required during this period as the developing calf has a large nutrient demand for protein.

Mineral and vitamin supplementation : The close-up dry cow diets should be supplemented with proper macro-minerals like sodium, potassium, chloride and sulphur. High Ca supplementation (over 100-125g/cow/day) to the close-up dry cows is not required as it tends to increase the problem of milk fever, because high Ca depresses the activity of the parathyroid hormone (PTH) and its gland. PTH maintains blood Ca level. Conversely, feeding low Ca (8-10g/cow/day) and high P feeding during this period stimulate PTH activity and condition the gland for increased activity required at and after parturition for mobilization of Ca from body reserves like bone. Vitamin supplementation is also vital during late pregnancy particularly A, D and E along with selenium. Vitamin-A helps in preventing premature and still born claves and retain placenta while vitamin-E and Se helps to enhance the body defense against infection.

5.4.2. General Management of Dry Cows

5.4.2.1. Body condition score (BCS)

Achieving and/or maintaining proper body condition of dry cows is an important aspect of dry cow management. Proper BCS is critical to reduce the chance of post parturient metabolic diseases and for better milk production in the next lactation body condition is a method of evaluating fatness or thinness of cows in a five point scale; a scale of '0' denotes a very thin cow, while '5' denotes an excessively fat

(obese) cow. The dry cow should have a body condition score of 3.0-3.5 and it should be maintained upto parturition. At the time of parturition the cow should have sufficient nutrient reserve to cope up the strain of parturition. After calving, early lactating cows are unable to consume enough feed to meet their energy need for milk production and maintenance, and they use their stores of body fat to supply additional energy needed to support milk production.

Under conditioned or thinned (less than score 2.5) dry cows have lower milk production, reduced persistency of lactation and reduced protein content of milk because of insufficient energy and protein reserves. Thin cows often do not show heat or conceive until they start to regain or at least maintain body weight and therefore increases open period. In contrast, the over-conditioned (>3.7 score) dry cows have difficulty at calving, more susceptibility to metabolic disorders and infections.

Proper body condition score can be maintained by providing adequate nutrition (feed and energy intake) according to the body condition.

5.4.2.2. Housing and sanitation

Dry cows should be housed separately from the milking herd and they are usually housed in groups. The environment should be clean and dry as these cows are most susceptible during the first two weeks after they are dried off and again two weeks before calving. This is because the udder is not milked during the dry period, pathogens are not flushed out of the lower portion of teat canal leading to new intra-mammary infection. Therefore, exercise lots, loafing areas, stalls and maternity pens should be clean and dry. If the cows are allowed to graze on pasture, proper pasture management techniques should be followed and the cows should not be allowed to ponds and muddy areas.

The pregnant close-up cows 2-3 weeks before the expected date of calving are shifted to the maternity pens. The maternity pens should be well ventilated, clean and dry with clean bedding, preferably straw or inorganic bedding. Depending on the weather condition, a clean grassy paddock is an ideal calving area.

5.4.2.3. Exercise

Dry cows reared in pasture or loose housing system need no extra exercise. However, cow housed in conventional system should be

turned out of the barn into an adjoining exercise lot. Exercise is needed to maintain better appetite, and little more thrifty and to remove stiffness of limbs.

5.4.2.4. Health management

5.4.2.4.1. Vaccination

The dry cows need to be vaccinated late in the far-off period. The vaccination during this period has several advantages

(a) This is a period of low stress and milk production will not be affected

(b) Production of antibodies that protect the calves through colostrum (passive immunity)

(c) Production of protective antibodies for calving time and early lactation.

The important vaccines for dry period are i) against respiratory viruses such as IBR, BVD etc., ii) against scour virus such as rota virus (provide colostral protection for calves).

5.4.2.4.2. Parasite control

The far-off dry cow is an excellent time to treat for internal and external parasites. If lactating cow is given anthelminthic treatment, the milk should be withheld from the market and this causes milk losses. The external parasites such as tick, lice, ringworm etc. cause discomfort and disease to the animals, so their elimination is desirable.

5.5. SUMMARY

A dry period of about 50-70 days should be given to the cows for a number reasons like; regeneration of udder, reserving nutrients for the next lactation, adequate foetal growth, withstand the strain of parturition, optimum milk production in the coming lactation, preventing cows from a number of metabolic diseases, colostrum secretion containing adequate level of antibodies and other nutrients. The cows can be dried off by any of the three methods i.e., complete cessation, incomplete and intermittent milking. Complete cessation method is the best and quickest method of drying off. Drying off usually takes 4-10 days. After drying off, dry cow therapy with suitable antibiotics is essential to control existing infection or to prevent any

new infection of mammary gland. The maintenance of proper body condition score (3.0-3.5 in 5 point scale) of the dry cow is essential and depending on this feeding programme of the cow should be undertaken. Extra concentrate feeding called challenge feeding or transition feeding or steaming up should be provided to the dry cows during the close-up dry period (last 21 days before parturition). Other managemetal steps like proper housing and sanitation, exercise and health management should be ensured. Vaccination during dry period is essential to provide adequate amount of antibodies to the calves through colostrum.

5.6. CHECK YOUR PROGRESS

(a) What is dry cow?

(b) What is the optimum dry period?

(c) Drying-off process takes how many days?

(d) When will you shift the pregnant dry cows to the maternity pen?

(e) Write the name of diseases against which vaccination is done during dry period.

5.7. ANSWERS TO 'CHECK YOUR PROGRESS'

(a) A dry cow is a cow that is not producing milk.

(b) About 50-70 days.

(c) 4-10 days

(d) 2-3 weeks before the expected date of calving.

(e) IBR, BVD

5.8. EXERCISES AND QUESTIONS

(a) What is dry cow therapy?

(b) What are the managemental steps you will consider for close-up dry cows?

(c) What are the methods of drying off?

(d) Write about the body condition score of the dry cow.

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CHAPTER - 6

Care of Cows at and After Parturition

6.1. INTRODUCTION

Care of cows at and after calving is vital for successful birth and maintaining the cow and calf in proper health condition. Calving is a high risk event in terms of both cow and calf health, and is associated with most of the health problems. New born calves are born sterile and it gets infection from the surroundings which depends on the maintenance of hygienic environment and care of the just after birth. The fresh cows are susceptible to a number of metabolic diseases and infections due decrease immune status of the cow. Preparation and care during this period will minimize sickness and death of the cow and calf.

6.2. OBJECTIVES

The objectives of care of cows at and after calving are to

(a) maintain cow and its calf health, as calving is a high risk event

(b) prevent cows from most of the disease problems particularly metabolic diseases

(c) minimize sickness and death of the cow and calf

(d) minimize stress to both cow and calf

(e) minimize calving related difficulties

(f) properly initiate lactation.

6.3. CARE AT CALVING

The following points need to be considered for proper care of cows at calving.

6.3.1. Proper Handling

The expected date of calving can be determined from the breeding records and proper care can be given accordingly. Care should be taken to prevent the advance pregnant cows from being injured by slipping on floors, crowding through doors, mounting cows that in heat, fighting etc. At 2-3 weeks before calving they are to be shifted to the individual calving pens. The calving pen should be well-ventilated, clean, well-bedded and free of unnecessary disturbances. Clean straw, sand, saw dust, husks, dry leaves and various inorganic substances (like rubber mats, sand, gravels etc.) can be used as bedding material. The udder becomes large and swollen just before calving. Special care should be taken to prevent injury to the udder by nails, stones, loose glass pieces etc.

6.3.2. Prenating

The milking before calving is called prenating. Some cows, especially heifers and high milk producers, are prone to severe swelling of udder before parturition which is uncomfortable and painful to the cow. In extreme cases it might be necessary to milk the dam before the birth of the calf to relieve some of the discomfort. In such cases, the colostrum should be kept store to feed the calf after birth. This is because pre-partum milking will remove some colostrum and dilute the immunoglobulin level in the colostrum secreted after birth.

6.3.3. Observe Symptoms of Calving

Symptoms that a cow is about to calf include swelling of vulva, dropping of ligaments around tail head, enlargement of mammary gland, thick mucuous discharge from vulva etc. Birth usually occurs in one or two hours. The calving takes place in a calving pen or well grassed clean pasture depending on the climatic and mangemetal condition.

Cows close to calving should not be disturbed as this may delay calving, such as strangers nearby or exposure to abnormal environmental conditions. Sanitation in the calving area is essential to minimize disease and stress to both cow and calf.

6.3.4. Observe for Parturition Process

In case of normal presentation of calf, parturition occurs normally within 4 hours after onset of labour pain. The normal presentation of the calf includes forelimbs extended and calf head lies between the knees, straight body and hind limbs. At the first sign of calving, the front feet of the calf should appear first, then the nose. In such case, there is no need of much attention. But, if the labour prolongs for more than 4 hours and abnormal presentation of calf occurs, the help of expert veterinarian should be taken.

After a cow gives birth, she should be examined to ascertain whether she has a second calf which is not yet been born. Cows having twins or require assistance during calving, are more likely to retain the placenta and/or develop a uterine infection. These cows should be examined closely than cows that had normal, unassisted calving. The cows having assisted birth and retained placenta are prone to metritis which significantly delay early post partum heat and conception. Along with treatment of the cows proper hygiene should be maintained. The problems identified early mean more live calves and fewer cows suffering from obturator paralysis.

6.4. CARE AFTER CALVING

(a) After parturition a good antiseptic wash should be given with warm water containing some crystals of potassium permanganate to the exterior of genitalia, flanks down the hocks as well as along the tail.

(b) The calving pen is cleaned, wet bedding removed and floor is washed with good disinfectant solution. The udder of the cow should be washed with chlorine solution to prevent any infectious organisms from entering into the calf while suckling colostrum.

(c) The cow should be given luke warm water to drink. This practice stimulates appetite and helps promote expulsion of placenta.

(d) Normally the placenta is expelled in an average period of 4-5 hours after parturition and maximum of 12 hours. If the placenta is not expelled that is retained, it is better not to try and remove it forcibly. If long pieces of placenta is hanging, it should be cut at the level of the hocks to prevent trampled

on by the cow. Daily treatment with pessaries will prevent infections and the cow can be left for 3-4 days to eject the placenta in her own, or allow the placenta to loosen before steps are taken to remove it. When pessaries are placed into the uterus, placenta can be lightly pulled avoiding tearing. With difficult calving or retain placenta, treatment for the prevention of uterine infections must be applied. Uterine pessaries can be put into the uterus until the cervical opening closes, after which a pipette is used to deposit disinfectants in the uterus.

Care is needed to prevent the cow from licking or ingesting placenta as this may result in digestive disorder and drop in milk production due to excessive intake of biological protein. After expulsion, the placenta should be buried in ground or burnt.

(e) The cow should not be milked completely dry for 72 hours after parturition to prevent the chance of milk fever.

(f) After parturition the feed given to the cow should have laxative effect. Generally a mix of bran mash moistened in warm water and molasses given containing 2 kg bran to 1 kg molasses for first 3 days. After 3 days a concentrate mixture containing wheat bran, oats and linseed meal in equal parts can be fed. The DCP and TDN of the ration must be 16-18% and 70%, respectively. The amount of concentrate is increased gradually by 0.5 kg per day till the desired maximum level depending on production is reached. Mineral mixture should be fed containing 40-60g sterilized bone meal and 40 g common salt. Succulent, green palatable fodder containing minimum 50-60% legume are suitable.

(g) The cow should be prevented from extreme climatic condition like cold in winter, hot in summer and rain.

(h) Protection against infections: Cows become more sensitive to infections after parturition. The parturient cow should be kept in hygienic environment to reduce the incidence of infections. After parturition the discharges, beddings etc are to be removed from the calving pen and the calving pen should be disinfected.

There is normal vaginal discharge in cows after parturition for about 2-3 weeks due to regeneration of reproductive organs. Such

discharge is called as lochia. This is blood stained during first 3 days after parturition and then becomes yellowish in colour. It is again mixed with blood between day 7 and 14 and then become clear and stops by 3rd week. The lochial discharge should be observed carefully. In even most hygienic calving areas, there are millions of microorganisms which will contaminate the cows' reproductive tract and the calf. Most cows and calves are able to overcome the contamination with no clinical problems. The infected cows should properly be identified, separated from healthy ones and treated. The lochial discharge of the infected cows will be foul smelling which indicates genital infection and pus in the uterus. The treatment protocol should be designed to combat microbial infection avoiding any milk and milk residues. To avoid possible infections, suitable antibiotics (like 1g tetracycline) may be introduced into the uterus just after expulsion of placenta for atleast 5 days.

6.5. RECORD KEEPING

Record should be maintained to ascertain the expected date of calving so that proper care can be taken. The records are also important for efficient management especially before and after parturition. The records include date of service, date of conception, related breeding parameters, date of pregnancy examination and results, normal or abnormal presentation of calf, assistance required during parturition, any abnormalities of parturition, date of parturition, sex and weight of newborn calf, medicines used etc.

6.6. SUMMARY

Proper attention is needed to manage the cows at and after parturition as it is the most critical phase of life for both cow and calf. About 2-3 weeks before the expected date of calving the pregnant cows are transferred to the calving pen. Maintenance of proper hygienic condition and bedding is necessary to prevent any infections and to provide comfort to the cow at the time of calving. Normally, the calving occurs after about 4 hours of onset of labour pain without any assistance in most of the cases. Difficulty if any, assistance should be provided by veterinarian. Normally, the placenta is expelled within 4-5 hours after calving. The cow should not be allowed to lick or ingest the placenta. After birth, proper feeding and protection from extreme climatic conditions are necessary for better health of the cow. Maintenance of hygienic condition and close observation of cow is

required to prevent her from any further infection. All the calving related data should properly be recorded for better management and future use.

6.7. CHECK YOUR PROGRESS

(a) What is prenating?

(b) Is prepartum milking is recommended in cows?

(c) What is calving?

(d) How much time is required for the expulsion of placenta after parturition?

(e) What will be consequence after ingestion placenta by the cows?

6.8. ANSWERS TO 'CHECK YOUR PROGRESS'

(a) Milking before calving is called prenating

(b) No

(c) Act of parturition in cow is called calving.

(d) 4-5 hours

(e) Ingestion of placenta may results in digestive disorder and drops in milk production due to excessive intake of biological protein.

6.9. EXERCISES AND QUESTIONS

(a) What are the symptoms of calving?

(b) How would you handle cows around parturion?

(c) Write about the process of calving.

(d) What will be the managemental steps for cows after parturition?

6.10. FURTHER READING

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CHAPTER - 7

Care of Lactating Cows

7.1. INTRODUCTION

The lactating cows are important assets of a dairy farm. The profitability and viability of the dairy farm mainly depend on the overall milk production. The lactation cycle of the cow can be divided into different phases for efficient management as milk production, DM intake and body weight vary considerably during the different phases. In the early lactation, lactating animals loose body weight drastically and they are prone to various metabolic disorders. Efficient nutritional management during lactation is required to support the high milk production, persistency of lactation and health of the cows. Another most important event is the post partum oestrus and subsequent conception, which depends on the care and management of the cows during this period. Therefore, proper care and management of the lactating cows are essential to harvest maximum amount of milk from healthy cows in a sustainable way.

7.2. OBJECTIVES

The objectives of the care and management of lactating cows are to :

(a) get maximum milk from the cow

(b) increase persistency of lactation

(c) obtain good quality milk

(d) ensure involution of reproductive tract

(e) prepare her for early postpartum oestrus and next pregnancy

(f) ensure optimum nutrient intake

(g) maintain proper body condition

(h) prevent from metabolic diseases like milk fever, ketosis

(i) prevent from udder diseases like mastitis.

7.3. PHASES OF LACTATION

As milk production, body weight and dry matter intake vary throughout the lactation period, the period can be divided into different phases for efficient management of lactating cows. The milk production of a cow reaches its peak at about 6-8 weeks after calving, remains for sometime at peak, starts declining and ultimately stops after the completion of lactation period. The dry matter (DM) intake of the cow reaches peak at around mid lactation. The body weight of the cow starts declining after parturition as animals mobilizes nutrients to maintain milk production and starts increasing at the end of early lactation phase (Fig. 7.1).

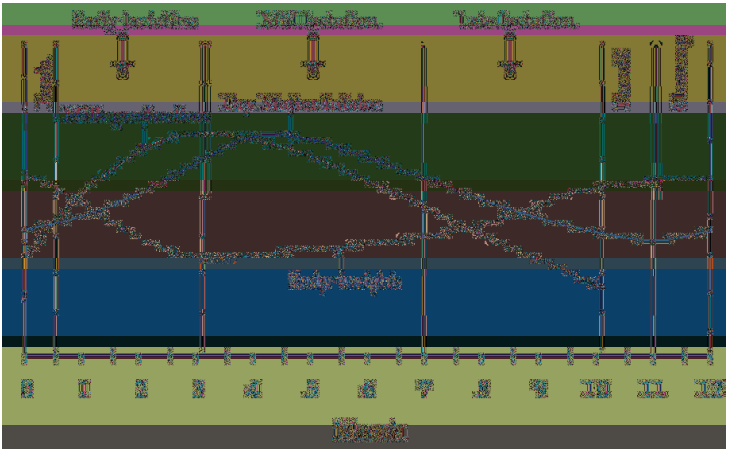

Fig. 7.1 : Pattern of changes of dry matter intake, body weight and milk production of different phases of a cow

The lactation period of a cow can be divided into following phases (Fig. 7.2) :

i. Fresh cow (0-14 days)

ii. Early lactation (14-100 days)

iii. Mid lactation (100-200 days)

iv. Late lactation (200-305 days)

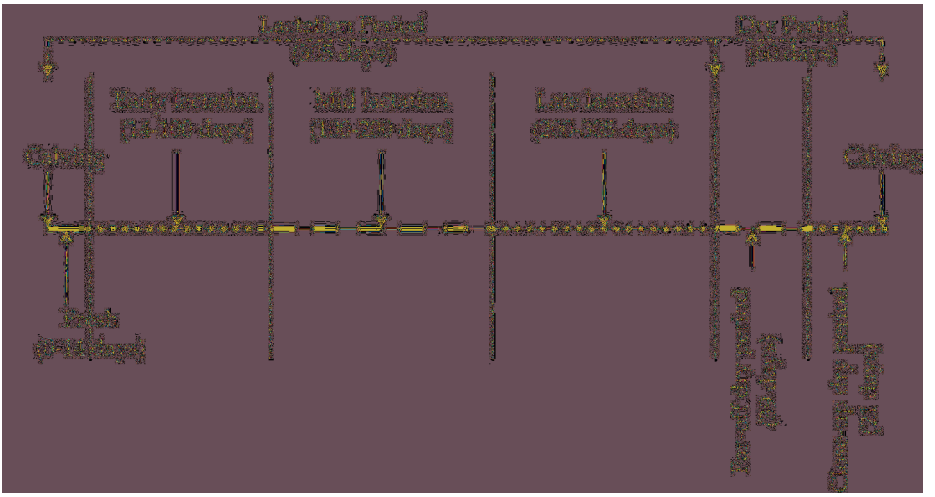

Fig. 7.2 : Lactation cycle of a cow

7.3.1. Fresh Cow (0-14 days)

The cow is called fresh cow in first 14 days after parturition. The sound fresh cow programme is required to optimize cow health, milk production and subsequent reproduction. It is vital in making transition from dry to lactating cow. This will reduce strain on the dairy cow, and the rumen microorganisms by moving gradually and smoothly from close-up dry ration to early lactation ration. The stress of calving, increased nutrient demands for milk production and decreased DM intake are major metabolic and physical characteristics that impact energy balance during this period. This leads to alternations in nutrient metabolism and body fat mobilization. The main reason for the tissue mobilization of nutrients is requirement of nutrients (glucose, protein, fat etc.) by the mammary gland to produce colostrum and milk, in addition to requirement for normal bodily function. This leads to lower body weight as the increased nutrient demand can not be met by feed intake alone. Therefore, special attention to the management and diet of fresh cows is necessary to avoid metabolic problems and for maintenance of lactation.

7.3.1.1. Feeding

The amount of concentrate in the diet of close-up dry cow is increased to acclimatize the cow to the concentrate dense ration to be fed to the cows after parturition. This may prevent cows from going off-fed after calving and also reduces the incidence of metabolic

disorders. DM intake reduces about 10-30% as cows approach calving. The foetus grows rapidly and requires more energy as calving approaches. The following points to be considered for feeding fresh cows.

i. **Dry matter**: Early fresh cow ration should be formulated for DM intake ranging from 15-20 kg.

ii. **Concentrate**: The amount of concentrate should be increased gradually by 0.5 kg per day for the first two weeks which will increase nutrient intake while minimizing digestive problems and acidosis. The concentrate portion should not be more than 60% of the DM to prevent acidosis.

iii. **Forage**: Forage should be about 40% of DM of the ration and forage DM should be minimum 1.5% of body weight for maintaining good rumination. The forage should contain 21% acid detergent fibre (ADF), 30% neutral detergent fibre (NDF) and 35% non-fibre carbohydrate (NFC) in the dietary DM. Adding starch can increase rumen microbial digestion and rate of feed passage. High quality legume forages should be the major source of forage. The physical form of the fibre is also important. About half of the forage should have particle length of atleast 2.6 cm to effectively stimulate chewing and rumination.

iv. **Protein**- For increasing milk production of fresh cows, feeding high quality proteins and rumen protected methionine and lysine supplementation are important. The crude protein content of fresh cow ration should be 17-19%, out of which 35-40% should be rumen undegraded protein, while 30% should be soluble protein.

v. **Energy**- The energy density of the ration should be increased to about 1.5Mcal net energy per kg of DM or greater to compensate for decreased DM intake. The energy density of ration can be increased by replacing grain by fat, leaving the fibre portion intact. Fats have twice the energy density of grain. However, only 3-5% unprotected dietary fat is tolerated by ruminal microbes and feed intake may be depressed when rations contain supplemental fat. So, the ration for fresh cow should contain less than 5.0-5.5% total fat, out of which 1-2% should come from ruminal inert sources with the remainder from base feed ingredients and high fat ingredients like oil seeds.

vi. **Additives:** Use of additives like calcium-propionate and propylene glycol may stimulate ruminal propionate production to improve energy status, niacin and rumen-protected choline may stimulate liver fat metabolism, yeast culture may stimulate DM intake and enhance the ruminal environment for fibre digesting bacteria.

Some important points regarding feeding of fresh cows :

- **Grinding of grains**: The grains should not be finely grounded, as they will breakdown rapidly in the rumen and lead to acidosis problem.
- **Time of concentrate feeding:** Cows usually eat after milking. So, fresh feed should always be available in the manger immediately after milking to encourage feed consumption.
- **Frequency of concentrate feeding**: Concentrate should be fed several times a day. This reduces daily variation in rumen pH and thus helps in stabilizing the rumen environment.
- **Feed availability**: Feed should be available to the cow atleast 20 hours a day.
- **Feeding of forages**: Fodder should be fed before grain feeding. If two or more forages are fed, it is preferable to mix them rather feeding them separately.

7.3.1.2. Check for metabolic disorders

The majority of the metabolic disorders occur during this period. So, fresh cows should be monitored routinely and steps should be taken to formulate a detailed examination protocol, record daily results and apply necessary treatment. The following points can be considered for prompt determination of health of the fresh cows.

(a) **Monitoring daily milk yield**: The daily milk yield of cows experiencing metabolic disorders like ketosis, displaced abomasum, general digestive disorders etc. will reduce. These problems could have diagnosed 5-6 days earlier than through clinical diagnosis.

(b) **Walking**: Reduced walking activity (detected by pedometer) is also a clear indicator of early problems.

(c) **Visual evaluation**: The visual evaluation of cow like letharginess, change in behaviour etc. is important to detect any early problem which indicates the cow need attention.

(d) **Rectal temperature**: The rectal (body) temperature should be measured once or twice daily. If the temperature is below 101°F or above 103°F, it necessitates intervention.

(e) **Metabolic status**: The identification of metabolic status of the cow is important and can be done by considering following points.

i. **Monitoring body condition score**: The cows nearing calving should have a body condition score of 3.25-3.75 (in 5 point scale). This is important to prepare them physically to support the forthcoming lactation and reproductive activities.

ii. **Rumen function examination**: The rumen function can be determined by stethoscope listening for 1-2 contractions per minute, a reasonable indicator of adequate ruminal function.

iii. **External indications**: The posture of the cow such as pointed out elbows, arched spine, or grinding teeth will indicate she is experiencing discomfort like abdominal pain which affects her willingness to eat and therefore, affects performance and health.

iv. **Ketosis testing**: Ketosis testing of a cow can be done by analyzing the presence of ketone bodies in milk or urine and smelling scent of ketone in cow's breath, a distinctive smell resembling aceto-acetic acid, which is similar to the odour of ripe apples.

v. **Miscellaneous:** Observation of eating behaviour and monitoring fresh cows' health by using a stethoscope to examine the lungs and heart rate, evaluating the consistency of dung, watching for nasal and vulval discharge etc. Vulval discharge may indicate a retain placenta and/or metritis.

7.3.2. Early Lactation (14-100 days)

Early lactation usually refers to the first 100 days of lactation. In this phase the milk production increases rapidly and reaches its peak at about 6-8 weeks after calving. The daily milk yield increase rapidly, but the DM intake does not increase in the same proportion. The demand for nutrients is therefore higher than the amount of nutrients consumed. Thus, the cow mobilizes body reserves and losses weight

(negative energy balance). The cow could loss as much as 0.7 kg per day. The genetic potential of the cow is generally expressed during this period and the ability of the cow to mobilize body fat contributed to its genetic potential (i.e., cows with higher genetic potential will mobilize body fats for a longer period than cows with a lower genetic potential). Towards the end of this period, the DM intake increases and reaches towards peak. There is also no further weight loss at the end of this period (Fig. 7.1).

The cow exhibit post partum oestrus at about 50-60 days after calving. The cow should be inseminated in the 2nd oestrus after calving i.e., about 80 days.

Feeding: Feed intake is the key factor in maintaining high milk production. Cows should be encouraged to maximize their intake during early lactation. Each additional kg of DM consumed can support 2-2.4 kg more milk.

The concentrate feeding will reach its desired level after 2 weeks of parturition. Grain intake should not exceed 2.5% of cows' body weight. Adding grains or feeds high in digestible fibre to the ration may be necessary to maintain an optimal rumen environment when high levels (55-60% of ration DM) of grain are being fed. As a thumb rule 1 kg concentrate is fed additionally for 2-2.5 kg milk production over and above maintenance requirement. The forage quality should still be high with intake of atleast 1.5% of BW (on DM basis) to maintain rumen function and normal fat test. The level of effective fibre and other feeding details regarding energy, protein and additives are same as discussed in fresh cow feeding.

7.3.3. Mid Lactation (100-200 days)

Mid lactation is the period from day 100 to 200 after calving. At the beginning of this phase the cow will be at her peak production. The main target during this period is to maintain peak milk production as long as possible. For each extra kg of milk at peak production, the average cow will produce 200-225 kg more milk for the entire lactation. The duration of peak milk production depends on the genetic potential as well as feeding. The cow reaches her peak DM intake during this period with no more BW losses (Fig. 7.1). Thus, the key strategy during mid lactation is to maximize DM intake. At this time, cow should consume DM atleast 4% of their BW. The cow should be fed a ration that will maintain peak production as long as possible. For every 2kg of expected milk production, large breed cows should eat atleast 1 kg

of DM. The cow should be fed high quality forage (minimum 40-45% of the ration DM) and the level of effective fibre should be maintained at a level similar to that of early lactation. Concentrates should not exceed 2.3% of BW and sources of non-forage fibres such as beet pulp, distiller's grains and cereal brans can replace part of the starch in the ration to maintain a healthy rumen environment. Protein requirements during mid lactation are lower than fresh and early lactation requirements and should contain 15-17% CP (on DM basis).

7.3.4. Late Lactation (200-305 days)

This phase begins at 200 days of lactation and ends at 305 days of lactation when the cow dries-off. During this phase milk production and DM intake declines. The feed intake easily matches the milk yield. The cow also gain weight during this period to replenish the adipose tissue lost during the early lactation (Fig. 7.1). However, as lactation approaches an end, more of the increase in BW is due to the increased size of growing foetus. The sources of protein and energy are not very critical during this period. Cheap rations can be formulated with non-protein nitrogen (NPN) and a source of readily fermentable carbohydrates such as molasses. The CP content of the ration should be about 13% (on DM basis).

Table 7.1 : Nutrients requirement of lactating dairy cows

Parameters	Early lactation	Mid lactation	Late lactation
Average milk yield (kg/d)	40	30	20
Dry matter intake (kg/d)	24-26	21-23	11-12
Crude protein (% DM)	17-19	15-16	13-15
Ruminal undegraded protein (% CP)	35-40	30-35	25
Soluble protein (% CP)	25-33	25-36	25-40
Neutral detergent fiber (% DM)	30-34	30-38	33-43
Acid detergent fiber (% DM)	19-21	19-23	22-26
Effective fiber (% NDF)	25	25	25
Net energy for lactation (Mcal/kg)	1.64	1.57	1.5
Non-fiber carbohydrates (% DM)	30-42	30-44	30-45
Total digestible nutrients (% DM)	72-74	69-71	66-68
Fat (maximum in DM)	5-6	4-6	3-5
Calcium (% DM)	0.8-1.1	0.8-1.0	0.7-0.9
Phosphorous (% DM)	0.5-0.9	0.4-0.8	0.4-0.7

Contd.

Potassium (% DM)	0.9-1.4	0.9-1.3	0.9-1.3
Sodium (% DM)	0.2-0.45	0.2-0.45	0.18-0.45
Chlorine (% DM)	0.25-0.30	0.25-0.30	0.25-30
Sulfur (% DM)	0.22-0.24	0.20-0.24	0.20-0.22
Cobalt (mg/kg DM)	0.2-0.3	0.2-0.3	0.2-0.3
Copper (mg/kg DM)	15-30	15-30	12-30
Manganese (mg/kg DM)	60	60	50
Zinc (mg/kg DM)	80	80	70
Iodine (mg/kg DM)	0.8-1.4	0.6-1.4	0.6-1.2
Iron (mg/kg DM)	100	75-100	50-100
Selenium (mg/kg DM)	0.3	0.3	0.3
Vitamin A (1000 IU/day)	100-200	100-200	100-200
Vitamin D (1000 IU/day)	20-30	20-30	20-30
Vitamin E (IU/day)	600-800	400-600	400-600

Source **:** National Research Council, 2001

7.4. OTHER MANAGEMENTAL STEPS

7.4.1. Regular Supervision

Regular and daily supervision of lactating cows is required regarding feeding, cleaning, milking, behaviour, swelling in mammary glands, heat symptoms, and disease occurrence. This will help to detect any abnormalities at earliest and prevent occurrence of any disease which helps in maintaining normal milk production and reproduction.

7.4.2. Regular Care

Cows become habituated with the kind of routine followed with her. Any sudden change in feeding, watering, milking, exercise, housing etc. will adversely affect their behaviour and production. So, regular care of the lactating animals should be maintained. If any change is required it should be done gradually.

7.4.3. Exercise

Cows need limited exercise to keep them fit, grow and maintaining appetite. Lack of exercise and too long confinement cause stiffness in their limbs, overgrown hooves leading to lameness and development of abnormal behaviour (vices). In case of loose housing system extra exercise is not required but in barn system the cows should be given an open area or run out for some exercise.

7.4.4. Grooming

Grooming of dairy cows keep coat clean, make hair glossy, stimulate circulation, remove external parasites, ensure clean milk production and make them docile.

7.4.5. Clipping Hairs

Clipping of hairs of the lower part of the body like belly, udder and rear areas is necessary for clean milk production. The hairs of these areas are often soiled with urine, dung, mud, feed material etc which can contaminate milk during milking. Trimming of switch of the tail should also be done to prevent contamination of milk.

7.4.6. Handling and Training

The cows should be treated kindly and handle gently. Any type of cruelty like abusing, kicking, beating should never be practiced. This type of cruelty will hamper the behaviour and milk production of the cows. The lactating cows should be trained from younger age to be lead by halter.

7.4.7. Foot Care

Healthy feet are important to the productive cows. Animals confined too long, having no freedom of movement and exercise, develop overgrown and misshapen hooves. Other foot problems are foot rot, laminitis, hairy foot warts etc. All these problems will cause lameness followed by swelling of foot, spreading of the toes and abscess of the above hooves. If not corrected, the infection will go deeper and infect the joints resulting in chronic arthritis. These cause discomfort and interfere with movement of animals, obtaining feed and water, exhibiting oestrus and general health.

So, regular hoof trimming is required to prevent overgrown and misshapen hooves. These managemental practices reduce hoof damage and avoid bruising, ultimately reduce the incidence of foot diseases. Proper drainage of all areas without standing water also helps. Early detection and treatment and various types of foot bath solutions may be used to decrease some foot diseases.

7.4.8. Drying-off Cows

The lactating cows should be given a dry period of atleast 60 days at the end of lactation length of 305 days to allow for involution

and regeneration of milk secretory tissue in the udder, prepare her for next lactation, increase production of colostrum, develop optimum body reserve to withstand the strain of calving, provide nutrition for the growing foetus, avoid nutritional deficiency diseases like milk fever etc. after calving.

7.4.9. Housing

The lactating cows should be provided with clean and hygienic housing to prevent from any mammary infections. They should be given proper space and overcrowding should be avoided. The housing should protect the animals from extreme climatic conditions like hot, cold, rain etc. and provide suitable microenvironment to reduce stress on the animals. Cow-dung should be removed periodically from animal shed & disposed to the manure pit. The manure pit should be located minimum 200 meters away from the milking barn or milk recording room.

7.4.10. Identification

Identification of lactating animals is important for keeping records of milk production, lactation length, date of post partum oestrus, date of insemination etc. Identification can preferably be done by branding, tattooing, ear tagging, tags attached to the neck chain, ear notching etc.

7.4.11. Bedding Materials

Different types of bedding materials can be used such as saw dust, paddy straw etc. @ 3-4 kg/cow/day. The bedding materials should be clean, dry, free from hard objects, soft, absorbs liquid manure and not contain or support the growth of bacterial pathogens at level that increases the risk of udder infection. They should be maintained by removing wet or soiled materials in a timely manner and replacing them with fresh materials.

7.4.12. Fly and Vector Control

Flies and vectors should be kept away from the lactating animals, milking barn and milk recording room. They cause annoyance to the animals and transmission of diseases through the milk and milk products. This can be ensured by keeping surrounding clean, proper disposal of manure, bedding materials and urine and destroying breeding places by use of suitable insecticides.

7.4.13. Breeding

The lactating cows normally show post-partum oestrus after 50-60 days of calving. They are generally inseminated in the 2nd heat at about 81 days post calving.

7.4.14. Provide Water

The lactating cows should be supplied *ad lib* clean and safe drinking water. A lactating cow needs additional 3 litres water per litre milk production. Water is also required for maintenance of the cow, washing, cleaning of barn, utensils and animals etc.

7.4.15. Health Management

Mastitis is most common udder health problem of dairy cows. It results from microbial infection of the udder entering through the teat opening. The most dangerous is the subclinical mastitis in which there is no gross change in milk or symptoms and is most prevalent. If not treated it may progress to clinical mastitis. Clinical mastitis results in reduced milk yield including development of symptoms like swelling and/or redness of udder, discomfort and abnormal milk secretion. In extreme cases, the particular infected quarter(s) may be damaged and remains non-functional throughout the life.

The emphasis of mastitis control should be prevention. The keys are proper sanitation and management of non-infected and sub-clinically infected animals. Early diagnosis of sub-clinical cases is necessary for early treatment and cure. Wet, manure-laden areas and beddings in lactating and dry cow pen and poor sanitation during the milking process increase the risk of mastitis. Udder should be clean and dry before and after milking. Teats should be sprayed or dipped with disinfectant after milking.

Proper vaccination of lactating cows is essential depending on occurrence of diseases in a particular area or herd. Regular deworming of the cows should be done to control endoparasites and to maintain proper health condition.

7.5. SUMMARY

The lactation is crucial phase of the life of a cow and recurs in a cyclic order throughout her life until culling or death. The care and management of the lactating cow are essential to obtain maximum milk, prepare her for next pregnancy and maintain good health

condition. The lactation cycle of a cow can be divided into following phases, viz., fresh cow (0-14 days), early lactation (14-100 days), mid lactation (100-200 days) and late lactation (200-305 days). The milk production increases gradually after parturition and reaches peak at about 6-8 weeks. The duration peak milk yield depends on genetic potential and feeding. The milk production starts declining and ultimately stops after the completion of lactation period. DM intake of the cow increases gradually after parturition and reaches peak at around mid lactation. The body weight of the cow starts declining after parturition and become stable at around end of the early lactation phase and then starts increasing. The nutrients like protein, energy etc. should be maintained at optimum level. The quality and physical from of forage form is vital for effective rumination. Other mangemental steps like exercise, grooming, foot care, housing, bedding materials, health management etc. are essential components of lactating cow management.

7.6. CHECK YOUR PROGRESS

(a) What is fresh cow?

(b) When the lactating cows reaches to the peak milk yield?

(c) When lactating cows exhibit first post partum oestrus?

(d) What is mid lactation period?

(e) How much unprotected fat is tolerated by the rumen microbes?

7.7. ANSWERS TO 'CHECK YOUR PROGRESS'

(a) The cow is called fresh cow in first 14 days after parturition.

(b) About 6-8 weeks after calving

(c) The cow exhibit post partum oestrus at about 50-60 days after calving.

(d) Mid lactation is the period from day 100 to 200 after calving.

(e) About 3-5% unprotected fat is tolerated by rumen microbes.

7.8. EXERCISES AND QUESTIONS

(a) How to check metabolic disorders in fresh cows?

(b) What are the different phases of lactation?

(c) Discuss feeding of early, mid and late lactation cows?

(d) Write about the health management of the lactating cows.

7.9. FURTHER READING

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CHAPTER - 8

Feeding Management

8.1. INTRODUCTION

Providing appropriate nutrition is an elementary step in dairy animal production. Improper nutrition prevents cattle to express full genetic potential for milk production and reproductive efficiency. Nutrition helps in maintaining good health condition of the animal.

Therefore, one should know the basic digestive physiology, various types of nutrients and their requirements in different categories of animals present in a dairy herd. As feed cost contributes principal expenditure of a dairy farm, balanced ration should be prepared in a cost effective manner. Proper understanding of feeds and rations also help to explore alternative feeds and supplements without hampering the health as well as productivity of the animals. Effective dairy farming requires converting feed into milk which worth more than the total cost of production (mostly contributed by feed cost).

8.2. OBJECTIVES

The objectives of feeding management are to:

- know the digestive system and it function.
- understand the digestion process in dairy cattle
- identify the feed resources
- understand the nutritive value of the different kind of feedstuffs
- explore unconventional feeds of feeding cattle

- formulate the ration in accordance to the requirement for different categories of animals
- reduce the expenditure on feed
- obtain maximum production with minimum input.

8.3. NUTRIENTS IN FEEDS

The materials, ingested by the animal or human are capable of being digested, absorbed into the system for the utilization in bodily functions, are called foods. The term 'feed' often used to describe the food items of the animals. In simple word anything edible to animals is called feed. After consumption, some of the components of the feeds are being absorbed and utilized by the animals called 'nutrients' and rest portion is excreted as faeces.

Animals usually consume plant and plant products, although animal products like fish meal, bone meal, blood meal, meat meal and milk are also used to a limited extent especially to the non-ruminant animals, however calves diet at their pre-ruminant stage (early life) contain animal products.

Plants can conserve the solar energy as chemical energy within the plant itself by means of photosynthesis. For photosynthesis, plant uses carbon dioxide from the air, water and inorganic materials from the soil. The animals get nutrients trapped in the plants, for their normal functioning of the body. It is established fact that the chemical composition of plants and animals are similar. Therefore, it is necessary to know the compositions of feeds (Fig. 8.1) and they are:

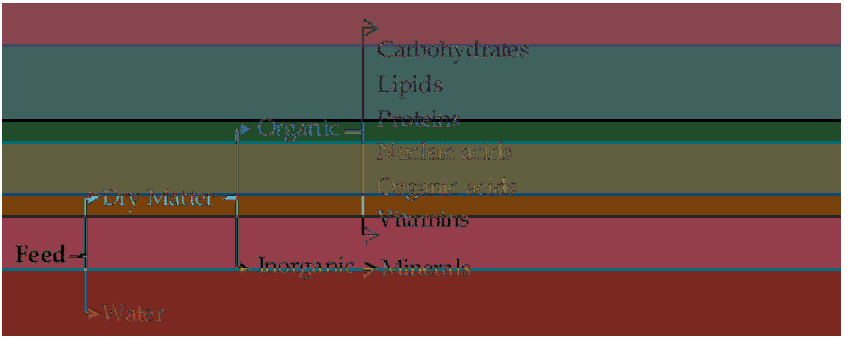

Fig. 8.1 : Nutrient composition of feed

8.3.1. Water

Water is the major constituent in the animal body. Adult animal body contains about 65% water. Deprivation of water for a short period would result in death of the animal, while deprivation of food for the same period would not consequence the same. Animal get water by drinking, from the succulent feeds (green succulent fodder contain as high as 75% water, while dry fodder and concentrate contain about 10% water) and from metabolic water derived from oxidation of nutrients. Carbohydrate, protein and fat produce metabolic water (g/ 100 g of substance) after oxidation about 60, 42 and 107, respectively. Water is continuously lost from the body through urine, faeces, expired air and skin (by evaporation). In addition milking cows lost water through milk (contain about 87% water). However, replenishment of water takes place from the previously mentioned sources.

Water plays many vital functions in the body like i) acts as a solvent, ii) regulation of body temperature, iii) soften and lubricate the feed in the elementary canal, iv) after absorption transport the nutrients to its place of requirement, and v) remove waste materials through urine and faeces.

The requirement of water increases along with hot summer months, milk yield, high protein diet and non-availability of succulent green fodder. The water content of the plant decreases with the maturity of the plant. Preferably water should be available to the animals throughout the day and night. If not possible a thumb rule may be applied. Total drinking water requirement per day= [10% of body weight +1.5 times of milk production (litre)] litre. Thus, a 400 kg cow produce 10 litres of milk, should be provided with; [(400X10%) + (1.5X10)] litres= [40+15] litres= 55 litres of drinking water.

8.3.2. Carbohydrates

Carbohydrates are made up of carbon, hydrogen and oxygen, and the last two elements are present in the ratio of 2:1 to form water. Plant carbohydrates are synthesized by means of photosynthesis in the presence of solar energy.

Carbohydrates are the major source of energy in cattle. Major parts of the plant nutrients are carbohydrate and plant is the single largest component in the cow's diet. Carbohydrate constitutes 65 to 75 percent of the dry weight of most feeds and fodders which include sugars, starch, cellulose, hemicellulose and lignin. Carbohydrates are

principle source of energy for the rumen microorganisms. It is not dietary most essential, but metabolically very essential. Inside the animal body oxidation of fat and protein is only possible in the presence of carbohydrate. Although animal body tissue contain very small amount of carbohydrate reserve (about 1%) but without which life will be at stake. Carbohydrates provide bulkiness of diet of the ruminant. Carbohydrates store in the body as glycogen or starch in the liver and muscle. Excess carbohydrate in the diet of animal is usually converted to fat and stored in the body.

Plant carbohydrates are divided into two groups based on their solubility and digestibility in ruminants, viz., soluble and insoluble

Soluble carbohydrates: Soluble carbohydrates are easily digestible in nature. They also come under into nitrogen free extract (NFE). These include simple sugar, starch, hemicellulose and other cell constituents.

Insoluble carbohydrates: Insoluble carbohydrates are less digestible in the rumen. They are mostly crude fibre (CF) like cellulose, lignin etc. They provide hard structure to the plant and provide bulkiness to the feed material. Lignin is a complex group of carbohydrate, having nitrogen other than CHO. Lignin provides strength and resistance to the plant. It is mostly present in the mature plants and in the crop residues. Lignin is highly indigestible.

8.3.3. Lipids

Lipids are important constituents of plant and animal tissues which are insoluble in water but soluble in organic solvent like ether, benzene, chloroform etc. In the proximate analysis of feeds they are included in ether extract fraction, as extracted in ether. Lipids are the wide variety of substances from simple fatty acids to large, very complex molecules, e.g., fat, oil, wax etc.

Fat supply energy to the diet in concentrated form and it provides 2.25 times more energy than carbohydrates. Besides energy it also acts as vehicle for the absorption and transportation of fat-soluble vitamins (A, D, E and K). Most of the fatty acids are synthesized in the body except three essential fatty acids like linoleic, linolenic and arachidonic acid. However, animals can synthesise arachidonic acid from linoleic acid, therefore linoleic and linolenic acid are truly essential fatty acids in the animals.

Usually, forages and most roughage contain low amount fat and concentrates are good source of fats. Reasonable amount of fat is

necessary to prevent dustiness of the feed and it improves palatability of the feed. To meet the higher energy demand of high yielding animals, dietary fat can be supplemented to the ration without increasing amount of concentrate. During the unproductive period like dry period, animals store fat as energy reserve. The animals in their early lactation demand higher energy than the intake capacity. Fat mobilizes from the body reserve to meet the energy deficit and maintain peak milk production. Therefore, storage of body fat during dry period has immense importance.

8.3.4. Proteins and Other Nitrogenous Compounds

Proteins are the structural components of animal tissue. It has utmost importance in the new tissue formation as well as maintenance of the already developed tissue. Proteins are highly complex chemical compound, composed of nitrogen, carbon, hydrogen and oxygen, occasionally phosphorus or sulphur or both and traces of other elements (iodine, iron, copper and zinc).

Proteins are complex organic compound composed of 'amino acids'. Amino acids are basically organic acids, contain amino group ($-NH_2$). About 200 amino acids are existed in nature, only 20 of these are commonly found as component of protein. Plants take nitrogen from soil as nitrate, nitrite or ammonia. They synthesize protein with the utilization of nitrogen and accumulate especially in the leaves and seeds.

The structure of the animal body is composed of protein. Protein is required for normal growth, development and repair of body tissue. Animal consume feed protein which is digested and then absorbed as amino acids. Approximately 40 to 75 percent of the natural protein in feed is broken down by the ruminal microbes. Thus, protein requirement is basically the requirement of the amino acids. There are about 20 amino acids which are classified as essential and non-essential. Some amino acids are called as essential as the animal can not synthesize the amounts needed. Essential amino acids are more relevant in case of simple stomach animals. Non-essential amino acids are synthesized in the animal body and fulfilled the requirement of the animals.

Ruminants can synthesize all the amino acids required for them as they have the unique process of digestion through microbial fermentation. However, recent studies indicate that high producing cattle need amino acids supplementation as they can not synthesize

sufficient amount required for them. Therefore, good quality undegradable protein is supplied to them which escape degradation in rumen and make available as intact to the small intestine for digestion and absorption.

The calves do not have functional rumen. At initial stage of life their stomach acts like simple stomach animal. Therefore, until the rumen becomes fully developed, the requirement of protein for the calves should be considered identical of simple-stomached animal.

Body can not store protein sufficiently, thus continuous supply of protein is needed. The protein requirement depends upon the physiological state of the animals. High producing, pregnant and growing animals require high amount of protein, whereas adult non-producing animals require limited amount of protein. Excess protein fed to the animals is converted to fat or provide energy or excreted from the body.

NPN compound

Large number of nitrogenous compounds naturally present in plants and animals which are not protein in nature, called as non-protein nitrogen (NPN). Ruminant has the unique ability to ferment NPN through microbial digestion and utilize as microbial protein. As protein-rich feeds are costly, NPN is extensively used in the dairy cattle ration to partly replace the protein requirement. Organic NPN includes ammonia, amides, amines, amino acids etc. Inorganic NPN compounds include variety of ammonium salts and ammoniated by-products. Among these urea is extensively used in the dairy cattle feed as it is easily available. In rumen, urea is broken down to ammonia by the microbial urease enzyme. Ammonia in the presence of carbohydrate form amino acids by the action of enzymes from microbes. Amino acids are then utilized by the microbes for synthesizing their own body proteins (called as microbial protein). Therefore, soluble carbohydrate must be available to the rumen for the utilistaion of urea by the ruminal microbes.

The protein value of feedstuffs is expressed by its crude protein (CP) content. Proteins usually contain 16% nitrogen. Therefore, CP of a feedstuff is determined by nitrogen content of the feed multiplied by 6.25 (100/16).

8.3.5. Minerals

All the organisms require inorganic elements or minerals for their life. About 3% minerals are present in the animal's body. Their

concentration in the body does not vary among the animals. Major portion (about 80%) of the mineral matters found in skeleton, and remaining mineral elements are found in tissues and blood where they remain in combination with the organic compounds and play vital role in the several body functions.

In nature there are about 40 mineral elements present in the tissue, plants and animals. Out of these, 21 minerals have been recognized as essential. Unlike other nutrients they are not synthesized in the animal body, therefore, sufficient amount of minerals must be present in the animals' diet.

Minerals are classified based on their quantitative presence in the plant and animal body into three categories:

(a) **Macro (major) minerals**: The minerals are present in the body at large amount and which are required in relatively large amount for the synthesis of structural tissues. Their concentration is expressed in terms of percentage. Average tissue concentration of these compounds is over 0.01%. The minerals are calcium, phosphorus, sodium, potassium, magnesium, sulphur and chlorine.

(b) **Micro (trace) minerals**: The minerals are present in body at a very low concentration and which are required in trace amount and functions like activators or as a component part of enzyme system. Their concentration is expressed in terms of parts per million (ppm) or parts per billion (ppb). Average tissue concentration of these minerals is much below 100 ppm. The minerals are iron, copper, iodine, cobalt, zinc, manganese, fluorine, selenium, molybodenum, chromium, nickel, silicon, tin and vanadium.

Function of minerals in the body

Minerals play several vital body functions. They are:

A. Constituents of

i. Bone and teeth (calcium, phosphorus etc.)

ii. Hair, hoof, and horn

iii. All soft tissues and body fluids

iv. Milk (calcium, phosphorus etc.)

v. Nucleoprotein (e.g., phosphorus)

vi. Vitamin (vitamin-B_{12} contains cobalt)

vii. Hormone (thyroxin contains iodine)

B. Physio-chemical actions like

i. Maintenance of pH

ii. Osmotic pressure

iii. Permeability of the cell membrane

iv. Maintenance of ionic equilibrium

v. Nerve irritability

C. Metabolic actions like

i. Oxygen and carbon-dioxide transport through blood (e.g., haemoglobin contains iron)

ii. Part of enzyme system (in metalloenzymes the transition metals are iron, copper, zinc etc.)

8.3.5.1. Macro (major) minerals

Calcium (Ca) and phosphorus (P): Major amount of calcium (about 98%) and phosphorus (about 85%) are present in the skeletal system of the body. Their absorption and utilization are interlinked. Phosphorus is associated with number of enzyme systems. Certain proportion of Ca and P along with vitamin D should present in the diet for proper absorption and utilization of both the minerals. The optimum ratio should be 1:1 to 2:1. The requirement of these minerals in growing and lactating animal is very high for their skeletal tissue growth and milk production, respectively. Ca in the body remains in dynamic state between blood and bone and their interchange depends upon the mineral status of the animals. In addition, at low dietary Ca level, animals absorb more Ca and vice-versa. Unlike Ca, a low dietary P level reflects the plasma inorganic P level. Therefore, bone mobiles P and become fragile. For Ca absorption and utilization vitamin D is required.

During dry period Ca and P requirements are 0.39% and 0.24% of DM, respectively. In high producing cows during lactation, Ca and P requirements are 0.80% and 0.50% of DM, respectively.

Ca deficiency caises ricket in young animal due to poor skeletal development and osteomalacia and osteoporosis in adult. Shortly after parturition, high yielding dairy cattle suffer from milk fever (parturient paresis) with the symptoms of muscular spasm and paralysis due to

low blood plasma Ca level. Animals respond quickly when calcium borogluconate is injected intravenously to the animals. P deficiency causes depressed appetite commonly referred as pica with a tendency to chew unusual objects like bones, wood or leather. Other incidents are like poor growth rate, decline in milk production. P deficiency also leads to development of anoestrus and low conception rate.

Sodium (Na), potassium (k) and chlorine (Cl): Sodium, potassium and chlorine are required for the maintenance of osmotic pressure and acid base balance. They regulate water metabolism, permeability and carrier of the cells. Deficiency of these minerals is resulted in retard growth, weakness etc. Deficiency of Na develops pica (an intense craving) in calf.

It is usual practice to supplement common salt (NaCl) in the dairy cattle ration. Growing and lactating animals require more salt. Hot and humid environmental condition promotes sweating in animals and thus, increases the salt requirement. Requirement of salt can be met by adding 1% salt with the concentrate mixture and offering additional salt free choice basis as salt licks. The requirement of K for calf and cows are 0.7% and 1% of ration DM, respectively. During heat stress, P requirement of cows increases to 1.3-1.5 % of ration DM.

Magnesium (Mg): About 70% of the total Mg is present in the skeleton and remaining 30% is distributed in soft tissues and fluids. It's role is similar to Ca and P. It plays important role in enzymatic reactions and takes part in carbohydrate metabolism. Mg deficiency causes development of conditions called as grass tetany, grass staggers or magnesium tetany. The requirement of Mg for calf and adult cows are 0.10% and 0.25% of ration DM, respectively.

Sulphur (S): Sulphur is present in all cell of the animal body. It is the component of amino acids like cystine, cysteine and methionine. It is also present in hormone like insulin, vitamins like biotin and thiamine, coenzyme like glutathione and anticoagulant like heparin. Specially, the ruminants need S for optimum growth of rumen microbes. Nitrogen and sulphur should be provided to the dairy cattle feed at the ratio of 10:1 for efficient utilization of urea. Dairy cattle require S @ 0.2% of ration DM.

8.3.5.2. Micro (trace) minerals

Functions and deficiency symptoms and daily requirements of the various trace minerals are tabulated (Table-8.1) below:

Table 8.1 : Trace minerals functions and deficiency symptoms and requirements in dairy cattle

Mineral	Functions	Deficiency symptoms	Daily requirement
Iron (Fe)	Essential component of haemoglobin and various enzymatic systems like cytochrome, peroxidase, catalase etc.	Anaemia, particularly in young calf maintained on milk as milk is poor source of iron.	300 ppm for growth, 100 ppm for adult in the ration
Copper (Cu)	Essential for haemoglobin synthesis and red cell maturation. Its requirement is less than Fe requirement and it is necessary for Fe absorption. Cu containing enzymes are cytochrome oxidase, lysine oxidase, tyrosinase etc.	Spontaneous fracture of bones, similar to rickets in young calves and osteoporosis in older animals. Depigmentation of hair, anaemia, scouring disease (severe diarrhoea), decreased reproductive potential and milk production.	5 ppm of ration DM, requirement increases with high Mo intake.
Iodine (I)	Influences the metabolism of nutrients including minerals. It is the component of thyroxine hormone, controls development of animals.	Reduces thyroxin production. Goiter in calves.	0.1ppm of ration DM.Toxic level >10ppm
Cobalt (Co)	Component of vitamin-$B_{12,}$ thus, rumen microbes require for its synthesis.	Vitamin-B_{12} deficiency symptoms like anaemia, anorexia, emaciation etc.	0.1ppm of ration DM
Zinc (Zn)	Constituent of several enzymes like carbonic anhydrase, carboxyl peptidase, alcohol dehydrogenase etc. Found in higher concentration in skin and hair.	Retarded growth, skin diseases, bone disorder, reduced feed utilization efficiency, delayed sexual maturity, sterility and loss of fertility, decreased semen quality, undersize testicular size.	8-10 ppm of ration DM.For calf and 40 ppm of ration DM for adult

Contd...

Manganese (Mn)	Acts as activator of several enzymes. Essential for the formation of bones, growth of the animals, development and function of reproductive system.	Poor growth, leg disorders, poor fertility, frequent abortion. In new born calf deformed bones enlarged joints, stiffness etc.	7-10 ppm of ration DMFor calf and 20 ppm of ration DM for adult
Fluorine (F)	Combines with calcium phosphate and provides hardness to the teeth enamel and protect the teeth from decay. In adult osteoporosis is retarded by the action of F.	Deficiency is not a great concern. However, toxicity causes formation of cavity in the teeth, bone and joints abnormalities, drastic reduction of appetite etc.	Requires in very small amount. Toxic level >10ppm
Selenium (Se)	Acts as non-specific antioxidant. Requires for metabolism, development of skeleton and reproduction. Vitamin E and Se are interrelated in the metabolic functions.	Nutritional muscular dystrophy, increased calf mortality.	0.05 to 0.10ppm of ration DM
Molybodenum (Mo)	Component of enzyme xanthine oxidase, an enzyme involved in purine metabolism. Stimulate the rumen microbes.	Deficiency symptoms are still unclear. However, excess of Mo causes extreme diarrhoea, loss of weight and reduces milk yield. The condition is termed as “teartness”.	Requires extremely low level
Chromium (Cr)	Needed for normal glucose utilization. Also involves in protein metabolism.	Impaired growth, defects in sugar metabolism.	Requires extremely low level

Mineral supplements

All the feed components contain some minerals. However, kind and amount of minerals varies widely and their availability to the cattle not to the fullest extent. Therefore, cattle, maintained in natural diet may suffer from mineral deficiency. Since, natural feedstuffs can not fulfill the mineral requirement of cattle, it should be available to the cattle according to their requirement on a regular basis. Mixture of minerals should be supplied to the cattle with the following methods;

- mixing with concentrates and feeding to the individual cows
- injections or oral dosing
- mineral block as lick

Mineral mixture should contain all the macro and micro-minerals required for cattle to remain healthy and productive.

8.3.6. Vitamins

Vitamins are organic compounds which are required in small quantities for maintaining growth, health and productivity of the animals. Vitamins are divided into two categories based on their solubility and association with water or fat, viz., fat soluble and water soluble.

Vitamins

Fat soluble Vitamins

e.g.,
Vitamin A (retinol)
Vitamin D_2 (ergocalciferol)
Vitamin D_3 (cholecalciferol)
Vitamin E (tocopherol)
Vitamin K (phylloquinone)

Water soluble Vitamins

e.g.,
Vitamin B complex
B_1 (thiamin)
B_2 (riboflavin)
B_3 (Niacin)
B_6 (pyridoxin)
B_5 (Pantothenic acid)
B_8 (Biotin)
B_9 (Folic acid)
Choline
B_{12} (cyanocobalamin)
Vitamin C (ascorbic acid)

Like other domestic animals dairy cattle need all the vitamins. Usually, ruminants do not need vitamins supplementation, because most of the vitamins are synthesized either by the rumen

microorganisms or in the tissues. The rumen micro-organisms can synthesise all of the B-vitamins and vitamin-K which is sufficient for growth and maintenance. Vitamin C is synthesized in sufficient quantities within the body tissues to meet the animal's need. However, in conditions when the rumen microbial population becomes upset due to some disease conditions or digestive disturbances, vitamin B and K supplementation may be necessary. Niacin (B_3) and thiamine (B_1) may be needed under stress conditions. Vitamin-B_{12} deficiency may occur due to the deficiency of cobalt. Vitamin deficiency is not a usual phenomenon in cattle unless specific condition arises. Various kinds of stresses like peak production, vaccination, antibiotic treatments, and extreme environment increase requirement of vitamins and therefore, vitamins should be supplemented to the animals. Shortage of green fodder imposes carotene insufficiency and which ultimately leads to vitamin A deficiency.

8.3.6.1. Fat soluble vitamins

8.3.6.1.1. Vitamin-A

Vitamin A has many functions, including maintenance of epithelial cells, vision, gene regulation, and immune cell function. Feedstuffs do not have Vitamin A, however, especially green forages contain substantial amounts of β-carotene, a precursor to vitamin A. In the mucosal cells of the small intestine β-carotene converts into vitamin A. Good quality forages contain large amounts of β-carotene. However, low-quality forages or forages which have been stored for long time have low levels of β-carotene.

Vitamin A requirements for adult cow and calf are 76 and 42 IU/kg of BW, respectively (NRC, 1989). The requirement is based on a conversion factor of 1 mg of β-carotene equals to 400 IU of vitamin A. Vitamin A increases under hot, humid and stress conditions.

Vitamin A plays an important role in vision. Deficiency of vitamin A causes night blindness. It may also cause several reproductive disorders like increased frequency of abortions, shortened gestation period, retained placenta, and birth of weakened, blind or dead calves. Due to vitamin A deficiency calves become susceptible to diarrhea, cold, pneumonia and other infections.

8.3.6.1.2. Vitamin D

Vitamin D is involved with calcium and phosphorous in maintaining homeostasis and immunity. It is essential for the normal

calcification of bones. It plays an important role in the synthesis of protein that binds calcium during its absorption.

There are several forms of vitamin D. Among these D_2 (ergocalciferol) and D_3 (cholecalciferol) are important from nutritional point of view. Sun-dried hay, straw and dead leaves of freshly cut forages tend to be good sources of ergosterol, precursor of vitamin D_2. Another compound, 7-dehydrocholesterol, precursor of vitamin D_3 presents in the animal's body. Ultraviolet ray of sunlight is required to convert both vitamin D_2 and D_3 to their active form calcitriol. It again converted into more active form by the liver and kidney to perform its functions. Among D vitamins, D_3 is used more efficiently by dairy cattle. Thus, cow exposed to sunlight can synthesize vitamin D and there is no need of supplementation. Vitamin D requirement of adult dairy cows is 30 IU/kg of BW or 450 IU/lb of DM of feed (NRC, 1989).

Deficiency of vitamin D causes rickets in calf and osteomalacia in adult. The deficiency signs in the animals are bent forelegs, swollen and stiff joints, and thickening of the metatarsal and metacarpal bones.

8.3.6.1.3. Vitamin E

Among several naturally occurring Vitamin E, α-tocopherol is the most biologically active and most widely distributed. Vitamin E acts as a cellular antioxidant and free radical scavenger. Vitamin E is closely related to the mineral selenium. Cell wall contains vitamin E, which acts as an antioxidant, and inside the cells selenium containing enzyme glutathione peroxidase acts as an antioxidant.

The vitamin E requirement of dairy cows is 15 IU/kg of DM. Vitamin E concentration in most concentrates remains low except in raw oilseeds. Heat treatment and grinding greatly reduce the vitamin E content in concentrate feeds.

Except growing calves vitamin E deficiency is uncommon. The symptom of vitamin E deficiency in growing calves is dystrophic lesions in the muscle known as "white muscle disease". In adult deficiency of vitamin E may result in cystic ovaries, increased incidence of retained placenta, and, possibly, increased risk of mastitis.

8.3.6.1.4. Vitamin K

Vitamin K is necessary for prothrombin formation in liver which is required for normal blood clotting mechanism. Ruminants can synthesise vitamin K by the ruminal microbes. Green and leafy fodders

are also good source of this vitamin. Therefore, ruminants usually do not suffer from vitamin K deficiency.

Under certain conditions, vitamin K deficiency may occur in cattle, e.g., feeding of mouldy sweet clover. The mouldy sweet clover contains coumarin which is converted to dicoumarol, an anti-vitamin of K, thereby reduces the prothrombin level. Therefore, bleeding syndrome develops throughout the animal body which is called "sweet clover poisoning" or "bleeding disease".

8.3.6.2. Water soluble vitamins

8.3.6.2.1. Vitamin C (ascorbic acid)

Vitamin C (ascorbic acid) is synthesized within the tissues of the ruminants and dietary vitamin C is destroyed in the digestive tract. Thus, the dairy animal does not suffer from vitamin C deficiency. The synthesis of this vitamin, however, may be closely associated with the vitamin A nutrition of the animal.

8.3.6.2.2. B-Vitamins

The B-vitamins comprise thiamin (B_1), riboflavin (B_2), niacin (B_3), pantothenic acid (B_5), the B_6 complex (pyridoxal, pyridoxamine, pyridoxine), biotin (B_8 or Vitamin H), folic acid (B_9), and cyanocobalamin (B_{12}). B-vitamins act as either an enzymatic cofactor or metabolic constituent of intermediary metabolism. B-vitamins play key roles in the metabolism of carbohydrates, fats, and proteins.

In the rumen, B-vitamins are synthesized by the ruminal microbes. Green fodder, hay, silage etc. also are good source of B-vitamins. Thus, these vitamins are usually not required to be supplemented in the ration. Although, calves do not have functional rumen, however B-vitamin deficiency not occur in the calf as milk is a rich source. Ruminal disorders, high concentrate diet, deficiency of some trace minerals and other stressful conditions when feed intake is low can impair vitamin B synthesis. In the above mentioned conditions, B-vitamins supplementation may be beneficial.

8.4. DIGESTIVE SYSTEM

The digestive system of cattle (Fig. 8.2) comprises of mouth, oesophagus, a complex four-chambered stomach, small intestine and large intestine.

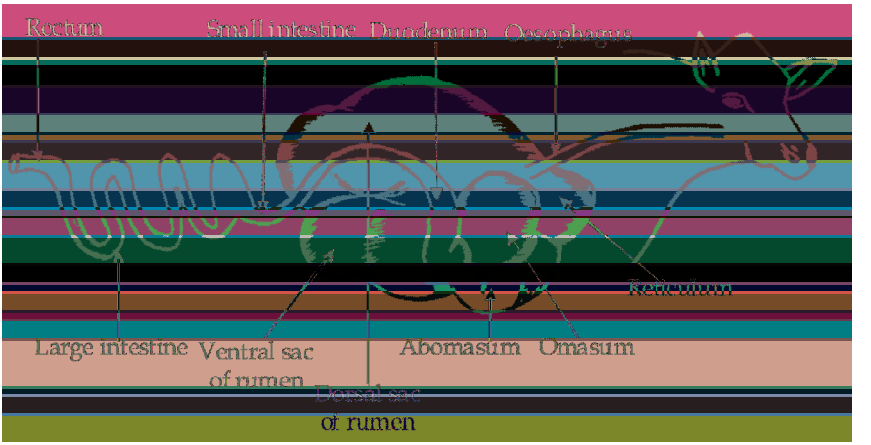

Fig. 8.2 : Digestive tract of ruminant animal

8.4.1. Mouth

The elementary canal starts with mouth. Through mouth feed enters into the digestive system. Strong teeth (in adult cow 32 in numbers) help to chew the feed called mastication and thus, feed items are broken down mechanically. Cattle do not have any incisor teeth at the upper jaw. However, dental pad is found in its place which helps to grind the feed into smaller size particles. Salivary glands are found in the mouth, secrete saliva which acts as lubricant. The pH of the saliva is about 8.2. Major functions of the saliva are to moisten the feed, reduce acidity (acts as buffer) in the rumen and to guide the ingested feed from mouth to the rumen via esophagus.

8.4.2. Oesophagus

Oesophagus is a muscular canal connects between the mouth and stomach.

8.4.3. Stomach

As cattle are herbivorous animals, it has unique structure (like other ruminant) of stomach to digest and assimilate coarse roughages. It is a misconception that ruminant has four stomachs; in reality it has only one stomach, having four compartments. The stomach includes the rumen or "paunch", reticulum or "honeycomb," the omasum or "manyplies," and the abomasum or "true stomach." First three compartments are non-glandular (no secretion) called as fore-stomach and last one (abomasum) is glandular that functions like simple stomach animal.

Whenever cattle get opportunity, they feed at a faster rate without chewing properly and later they 'chew the cud'. At the time of resting, either in sitting or standing position, they regurgitate the feed (from stomach to mouth) for thorough chewing. The sequential events like regurgitation, re-mastication, re-salivation and reglutination is called rumination. Cattle usually ruminate 8-10 hours daily. Rumination helps to reduce the particle size of fibrous food materials. Therefore, it helps to increase the surface area exposed to the microbes and breakdown of impervious plant coating. For every mouthful they usually chew 30-60 times before re-swallow the feed. The whole process is repeated in every few minutes. Stoppage of rumination is an indication that the animal may have a digestive upset, and rumen is not functioning properly.

8.4.3.1. Rumen

Rumen is located in the left side of the abdominal cavity. Rumen plays principal role in ruminant digestion. It acts as fermentation vat. It is the store house of the microorganisms containing favourable bacteria, protozoa and fungi. These organisms make it possible to utilize coarse fibrous feedstuffs by the ruminants. Rumen provides favourable environment for the growth of the microorganisms. Wall of the rumen has large number of tiny projections called papillae, which increase the surface area for absorption. The major activities of the rumen are i) mixing of feed ii) rumination iii) carbohydrate fermentation iv) microbial growth v) protein synthesis vi) vitamin synthesis and vii) absorption. The feature of rumen environment is given in (Table 8.2).

Activities in Rumen

Table 8.2. : Features of the rumen environment.

Parameters	Normal value	Remarks
pH	5.8-6.8	Large amount of readily fermentable carbohydrate may reduce the pH to 4.0, in contrast poor quality roughages increase the pH to 7.5 or above. Extreme higher or lower pH is not conducive for the rumen environment
Temperature	38 – 41° C	Temperature higher than body temperature is due to the heat produced during fermentation
Bacteria (flora)	10^8 – 10^{10}/ml fluid	About 60 species of non-spore forming anaerobic bacteria found in the rumen
Protozoa (fauna)	10^6/ml fluid	Protozoa are larger than bacteria and prey bacteria for their survival. Most of the protozoa are ciliated.

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Gas Phase	Anaerobic, CO_2 (65%), CH_4(25%), N_2 (7%) traces of H_2 and O_2	Usually anaerobic environment (devoid of oxygen), however, small amount of N_2 and O_2 enters the rumen through ingested feed. Traces of O_2 immediately after entering the rumen are utilized. In absence of O_2, carbon is the ultimate acceptor of H_2 and form methane (CH_4). Gases are lost by eructation (belching). Bloat is another condition that occurs when cows can't eructate.
Solid Phase	Undigested or partially digested fibrous feeds	Contents of rumen stay in two phases; solid and liquid phases. Solid coarse feed occupy the drier upper layer of the rumen content.
Liquid Phase	Volatile Fatty Acids (VFA) Ammonia Minerals Soluble Protein	Liquid phase occupy lower layer of the rumen content.
VFA's	Acetate (60-70%) Propionate (15-20%) Butyrate (10-15%)	Microorganism degrades the feed materials and produce VFAs (acetic acid, propionic acid and butyric acid). VFAs are absorbed directly through the rumen wall and fulfill about 60 to 80 % of the energy requirement of the cow.

8.4.3.2. Microbial metabolism

Microorganisms present in the rumen facilitate

- break down of coarse fibrous feeds and make nutrients available for the host (animal) as well as for own growth and reproduction
- synthesis of volatile fatty acids (used as energy by the ruminants)
- utilization of simple, inexpensive, low quality protein, nitrogen-containing substances (like urea) and store as microbial protein and energy in their cells. Therefore, they upgrade low quality protein to high quality microbial protein and ultimately meet the protein requirement of the animal.
- synthesis of B-vitamins and vitamin K, essential for animal health.
- detoxification of some toxic compounds

However, high quality protein feeds are broken down and converted to microbial protein, thereby reduces the protein value of the feed.

8.4.3.3. Symbiotic relationship between rumen and microbes

A. Microbes provide the ruminant

a. Digestion of cellulose and hemicelluloses: Cellulases are all of microbial origin, without which cellulose digestion is not possible and ultimately animal, would not be able to utilise the fibrous feeds.

b. Energy substrates: VFAs are the end products of microbial fermentation which are used by the animals as energy source and lipid synthesis in the mammary gland.

c. Provision of high quality protein: Amino acid composition of the microbial protein is very similar to the protein requirement of the ruminant.

d. Provision of B vitamins: Microbes synthesise B vitamins, are sufficient for the animals under most of the circumstances.

e. Detoxification of toxic compounds: Some toxic compound present in the feed e.g., Mimosine in *Leucaena lucocephala* (subabool) is detoxified in the rumen by the microbes, therefore subabool can be fed to the ruminant without any toxic effect

B. Ruminants provide microbes

a. Shelter: Rumen provides favourable anaerobic environment to the microbes.

b. Rapid removal of end product digestion: Removal of gaseous elements like CO_2 and CH_4 through eructation and absorption of VFAs from the rumen wall helps to maintain the stable rumen environment.

c. Nutrients: Rumen provides nutrients for the microbes such as feed. Other than feed, the rumen microbes also get nitrogen through saliva and diffusion through rumen wall.

d. Neutral environment: Rumen provide primarily liquid medium and nearer to the neutral environment (pH around 7) for microbial action

8.4.3.4. Reticulum

The wall of the reticulum has honeycomb like lining. Reticulum is not actually separated from rumen. A small tissue fold lies between rumen and reticulum, materials exchange easily between them, therefore, collectively called reticulo-rumen. The feed must be broken down into small particles before it can pass from reticulum to omasum. Particles greater than 2 mm length are not able to pass the reticulum, thus, return back to rumen and ultimately regurgitated for re-chewing (chewing the curd). Reticulum also acts as a trap for foreign objects (like rocks, nails, and pieces of wire and metal) ingested by the cow along with feed. The nail, wire or sharp metal may puncture the side of the reticulum and can cause "hardware disease". Reticulum plays major functions like reducing particle size and absorbing some amount of water and VFAs through the reticular wall. Reticulum also acts as pacemaker of rumen contraction. Contraction starts in reticulum which spread to the rumen and thereby mixing of the ruminal content.

8.4.3.5. Omasum

Omasum has many leaf-like folds and also called as 'manypiles'. Function of the omasum is not clear. When the ruminal content reaches to the omasum, it contains 90-95% water. However, content passes to abomasum contain only 50% water. Besides water, omasum also absorbs VFAs.

8.4.3.6. Abomasum

Abomasum (true stomach) is the first glandular portion of the ruminant digestive system. It secretes gastric juices, containing hydrochloric acid and enzymes (pepsin and rennin). At birth new born calf, 80% of the total stomach volume is contributed by abomasum. In mature cow the volume of abomasum is about 10% only. pH of the abomasal contents is about 2.0 which facilitates initial breakdown of protein and kills the bacteria which have spilled over from the rumen. The ingesta remain in the abomasum for 1 to 2 hours.

8.4.4. Liver

Liver is the largest gland in the body. It is the center of metabolic activity in the body. It secretes bile, has major role for digestion and absorption of fats. Bile temporarily get stored and concentrated in the gall bladder.

8.4.5. Pancreas

Pancreas is a dual organ. It acts both as an endocrine and exocrine organ. Exocrine functions include secretion of pancreatic juice into the duodenum which is essential for digestion of fats, carbohydrates and protein. Endocrine functions include secretion of hormones like insulin, glucagon etc.

8.4.6. Small Intestine

Small intestine has three parts; duodenum, jejunum and ileum. It receives secretions from gallbladder and pancreas, which help in digestion. In small intestine almost all the nutrients are absorbed through the villi (small finger-like projections) into the blood and lymphatic systems after final stages of chemical enzymatic digestion. Protected (by-pass) protein and fats are digested in the small intestine.

8.4.7. Large Intestine

Large intestine consists of caecum and colon. This is the last part of the elementary canal. Some bacterial digestion of undigested feed occur here and feces formed. Primary function of the large intestine is to absorb water, however minerals are also absorbed.

8.5. DIGESTION

8.5.1. Digestion of Carbohydrates

Among the different carbohydrates present in the roughages, sugars are totally digested. Others degraded in the rumen are arranged according to the degradability as follows; starch, cellulose and hemicellulose.

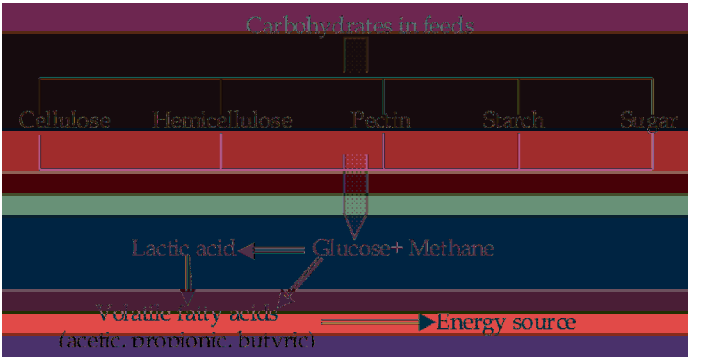


Fig. 8.3 : Digestion of carbohydrate in cattle

Rumen microbes digest simple as well as complex carbohydrates (fibre) and converts them into volatile fatty acids (VFAs). VFAs consist of acetic, propionic and butyric acids with the proportion of about 60-70%, 15-20% and 10-15%, respectively, which are primary source of energy for the ruminants. Other VFAs like valleric acid, isovaleric acid etc are also produced in traces. Among the VFAs, acetic and butyric acids are glucogenic in nature, whereas propionic acid is ketogenic in nature. Large amount of forages in the diet increases production of acetic acid, whereas large amount of grain feeding increases production of propionic acid. The VFAs are mostly absorbed through the rumen, reticulum and omasum. Small amount of VFAs may pass to abomasum and small intestine from where they are absorbed. VFAs are then transported through blood stream to the body tissues including the udder. They serve as source of energy for the ruminants. The dairy cows obtain about 60 percent of its energy from the VFAs. In the udder acetic acids acts as precursor of fat synthesis. A smaller portion of the VFAs is utilized by the rumen microbes to form carbon skeleton for the synthesis of microbial protein.

Rumen acts as a fermentation vat. Fermentation of carbohydrates leads to the production of huge amount of gases and among these principally carbon-dioxide and methane are produced. Most of these gases are lost through eructation. Due to some metabolic disorders, these gases are trapped inside the rumen which leads to the distension of abdomen and create bloat in ruminants.

8.5.2. Digestion of Proteins

Protein digestion in ruminant is unique. Unlike simple stomach animal, there is no free proteolytic enzyme in the ruminant. Rumen microorganism produce proteolytic enzymes, mostly intracellular which hydrolyse the dietary proteins to peptides and amino acids which are further fermented by deamination to carbon-dioxide, ammonia and short chain fatty acids.

The ammonia in the rumen liquor is partly utilized by the rumen microbes along with carbon skeleton (from VFAs) to synthesise the microbial protein. Rest of the ammonia is absorbed by the rumen wall and come to the liver via blood for deamination as ammonia is toxic to the tissues. In the liver ammonia is converted into urea through urea cycle. Some portion of the urea (formed in the liver) may return to the rumen directly by diffusion from the rumen wall or via saliva. However, greater portion of the urea is excreted through urine and thus wasted. Rumen fluid has pronounced urease activity, thus, urea

entering rumen is rapidly hydrolysed into ammonia and carbon-dioxide. So, supply of sufficient readily available carbohydrate especially starch is essential for effectively utilization of ammonia by the rumen microbes.

During rapid multiplication of rumen microbes they utilize ammonia and synthesize their body protein called microbial protein which comprises of essential and non-essential amino acids. Along with the flow of ruminal fluid, the billion of microbes come to abomasum, where microbes get digested by the proteolytic enzymes secreted by the numerous glands of abomasum. Then dead microbes reach the small intestine where pancreatic secretions and proteolytic enzymes act on them and resulting in complete breakdown of microbial protein into end products like amino acids. The amino acids are then absorbed through the microvilli of the small intestine and utilized by different tissue of the body for maintenance, production and reproduction.

Utilization of Non-Protein Nitrogen (NPN) compound

Rumen microbes have the unique ability to utilize non-protein nitrogenous (NPN) compounds into valuable essential and non-essential amino acids for the host. Thus, the proteins which are costly compound can be spared to some extent from the ration of the ruminant.

Commercially available NPN sources are urea, biurate etc. Among them urea is most commonly available. Urea contains about 45% nitrogen. Thus, CP value of the urea would be 45X6.25=281 percent.

As the rumen has strong bacterial urease activity, urea entering the rumen rapidly hydrolyses to ammonia and carbon-dioxide. The microbes utilize ammonia for synthesis of microbial protein provided supply of sufficient readily available carbohydrates which supply carbon skeleton. Addition of sulfur and phosphorus in the ration, containing urea helps in the synthesis of sulphur containing amino acids, essential for microbial body components.

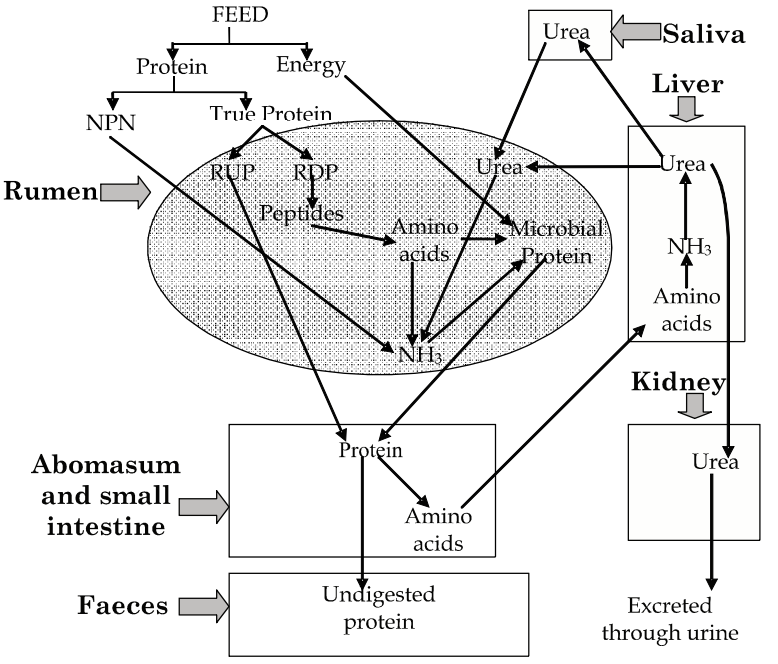


Fig. 8.4 : Digestion of protein in cattle (RUP = Rumen Undegradable Protein) (RDP = Rumen Degradable Protein)

Protection of dietary protein from ruminal degradation (bypass protein)

Although, rumen through ruminal microbes can generate high quality protein from the NPN, however, true protein is fermented in the rumen is largely wasted as essential amino acids are broken down and deaminated.

The main objective of protection of feed protein from the ruminal degradation is to provide sufficient essential amino acids to the productive ruminants, which can not be met only through the endogenous microbial proteins. Therefore, dietary protein is treated in such a way that susceptibility of the ruminal microbial attack will be reduced to a great extent. As the protein bypasses the ruminal degradation, it is called as bypass protein.

Various methods are employed to make bypass protein viz.,

- **Heat treatment:** Heat treatment of proteins resulted in formation of cross linkages within and between free amino groups.

- **Formaldehyde treatment:** The aldehyde reacts with free amino groups and nitrogen terminal groups to form cross linkages between protein chains.
- **Tannic acid treatment:** Tannins form hydrogen bonds with proteins, thereby protect protein from enzymatic degradation.
- **Protection of amino acids:** This can be done by encapsulation of amino acids.

8.5.3. Digestion of Lipids

The ruminant diets contain small amount of lipids (about 3-5% on dry matter basis). Digestion of lipid by the ruminal microorganism is strictly limited. If the animals are in pasture, the diets contain esterified form of lipid such as mono and digalactoglycerides. Triglycerides are the major component of concentrate based diet fed to the animals. In the rumen under the action of microbial lipases lipids are hydrolysed to form fatty acids of various sizes (long and short chain), glycerol and galactose. The glycerol and galactose are readily fermented to yield VFAs, among these propionic acid is the major product of glycerol fermentaion. The unsaturated fatty acids are hydrogenated in the rumen by the ruminal microbes. All short chain fatty acids and volatile fatty acids are absorbed from the rumen wall. However, long chain fatty acids are mostly saturated and not absorbed in the rumen, which are transported to small intestine via abomasum from where they are absorbed by micelle formation.

8.6. FEED EVALUATION

Understanding the nutritive value of the feeds along with its requirement for different classes of animals has immense importance for the animal owners as well as researchers. Various methods are employed to evaluate nutritive value of feeds as accurately as possible to reduce the feed costs by selecting right kind of feed, and avoid over-feeding or under-feeding and maintain normal health and production.

Performances of the animals are the best indicator of the nutritive value of the feed. Different classes of animals with their varying requirements along with large number of feed resources with nutritive value varying over time and growth phase makes it impossible to test each and every feed item for every class of animals. Thus, it is practically

very difficult to make recommendation based on the actual performance of the animals. Evaluation of feeds is therefore based on the simplest way by which nutritive value of the feeds can be judged.

Laboratory methods for evaluation of feeds for ruminants can be broadly classified as follows:

A. Chemical analysis
   a. Proximate analysis (Weende system of feed analysis)
   b. The Van Soest method of analysis
B. Digestibility trials (*In-vivo* & *In-vitro*)
C. Estimation of energy content of the feed
   a. Carbon nitrogen balance technique
   b. By bomb calorimeter
   c. By calculating TDN from digestion trial
   d. From chemical composition
D. Evaluation of protein value
   a. Digestible crude protein (DCP) estimation by digestion trial
   b. Nitrogen balance experiment

8.6.1. Chemical Analysis

8.6.1.1. Proximate analysis (Weende system of feed analysis)

Weende system of feed analysis was proposed long back in mid 1800's and still popular method of proximate analysis for feeds and fodders. This system of analysis is based on the principle that crude fibre is less digestible and nitrogen free extract is more digestible. Moisture, crude protein (CP), crude fibre (CF), ether extracts (EE), nitrogen free extract (NFE) and ash or mineral matter are known as proximate principles of feed.

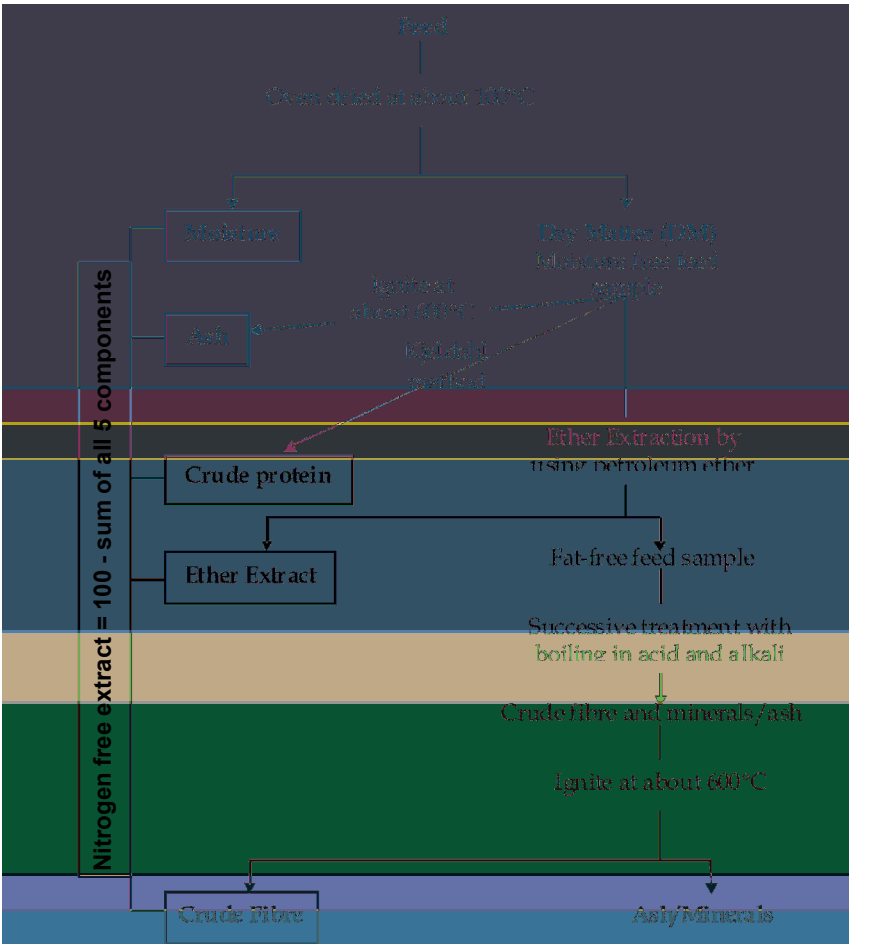


Fig. 8.5 : Summary of Proximate Analysis of Feedstuffs

Moisture: Moisture content of the feed is the first parameter which is estimated in the proximate analysis. Moisture content of the feed indicates the type of feed i.e., succulent or dry. This is done by drying the feed in hot air oven at about 100°C.

$$\text{Dry matter}\,(\%) = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

$$\text{Moisture}\,(\%) = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100 \qquad \text{Or} \qquad (100 - \%\text{Dry matter})$$

Crude protein (CP): In proximate analysis protein and non-protein nitrogen are analysed jointly and considered as crude protein (CP). The CP is estimated Kjeldahl method based on the assumptions that all nitrogen present in the feed are protein which are digestible and all type of protein contains 16% nitrogen. In Kjeldahl method, nitrogen is estimated and CP value of the feed is calculated by multiplying nitrogen with the factor 6.25 (100/16).

$$\text{Total protein (\% on DM basis)} = \frac{\text{Nitrogen} \times 6.25}{\text{Dry weight of feed sample}} \times 100$$

Ether extracts (EE): Known amount of dried feed sample is subjected to ether extraction, resulting in dissolution of fat and other ether-soluble substances in the ether. The remainder, after evaporation of ether is called as ether extract or crude fat.

$$\text{Ether Extract (\% on DM basis)} = \frac{\text{Weight of ether etract}}{\text{Dry weight of feed sample}} \times 100$$

Crude fibre (CF): After ether extraction feed samples are subjected to boiling successively in acid and alkali. Then the solution is filtrated. The filtrate/residue is dried, which contain crude fibre and ash or minerals. The residue is then ignited at the temperature about 600°C until all carbon particles disappear. Then weight of the ash is taken. Amount of crude fibre is obtained by the deduction of weight of ash from the weight of residue before ignition.

$$\text{Crude fibre (\% on DM basis)} = \frac{\text{Weight of crude fibre}}{\text{Dry weight of feed sample}} \times 100$$

Ash: Dried feed sample is ignited in a temperature around 600°C until all carbon particles are vanished. The recovered residue is ash. This is the inorganic part of the feed which is composed of different kinds of minerals.

$$\text{Ash (\% on DM basis)} = \frac{\text{Weight of ash}}{\text{Dry weight of feed sample}} \times 100$$

Nitrogen free extract (NFE): This is the leftover substances which are not measured in any of the previous fractions. This fraction of the feed is determined mathematically by calculating the differences with use of following formula.

$$\text{Nitrogen free extract (\%)} = 100 - (\%\text{Moisture} + \%\text{CP} + \%\text{EE} + \%\text{CF} + \%\text{Ash})$$

Table 8.3 : Constituents of various fractions of proximate analysis

Fraction	Procedure in brief	Major constituent measured
Moisture	Oven dried at about 100°C	Water along with volatile substance
Ash	Ignite at about 600°C	Macro and micro minerals
Crude protein	Estimate N_2 by Kjeldahl method	Protein, amino acids and non-protein N_2
Ether extract	Extraction of ether (petroleum ether) soluble substances	Fats, oils, waxes, organic acids, pigments, sterols, fat soluble vitamins like A,D, E and K.
Crude fibre	Fat free feed sample boiled in acid and alkali successively and filtered residue ignitest (600°C) to deduct ash.	Cellulose, hemicellulose, lignin
Nitrogen free extract	Mathematically calculated i.e., 100 - sum of all fractions	Starch, sugar, some organic acids, resins, tannins, pigments, water soluble vitamins, small portion of cellulose, hemicellulose and lignin.

Source : Modified from G. C. Banerjee. 1998. Feeds and Principles of Animal Nutrition. 2nd edition. Oxford & IBH Pbulication Co. Pvt. Ltd.

8.6.1.2. The Van Soest method of analysis

In 1965, Van Soest developed a newer method based on the principle that whole plant is divided into two parts; cell wall and cell contents. Cell contents are soluble in neutral detergent. Cell wall components are soluble in acid detergent. Details of these fractions are described in (Fig. 8.6).

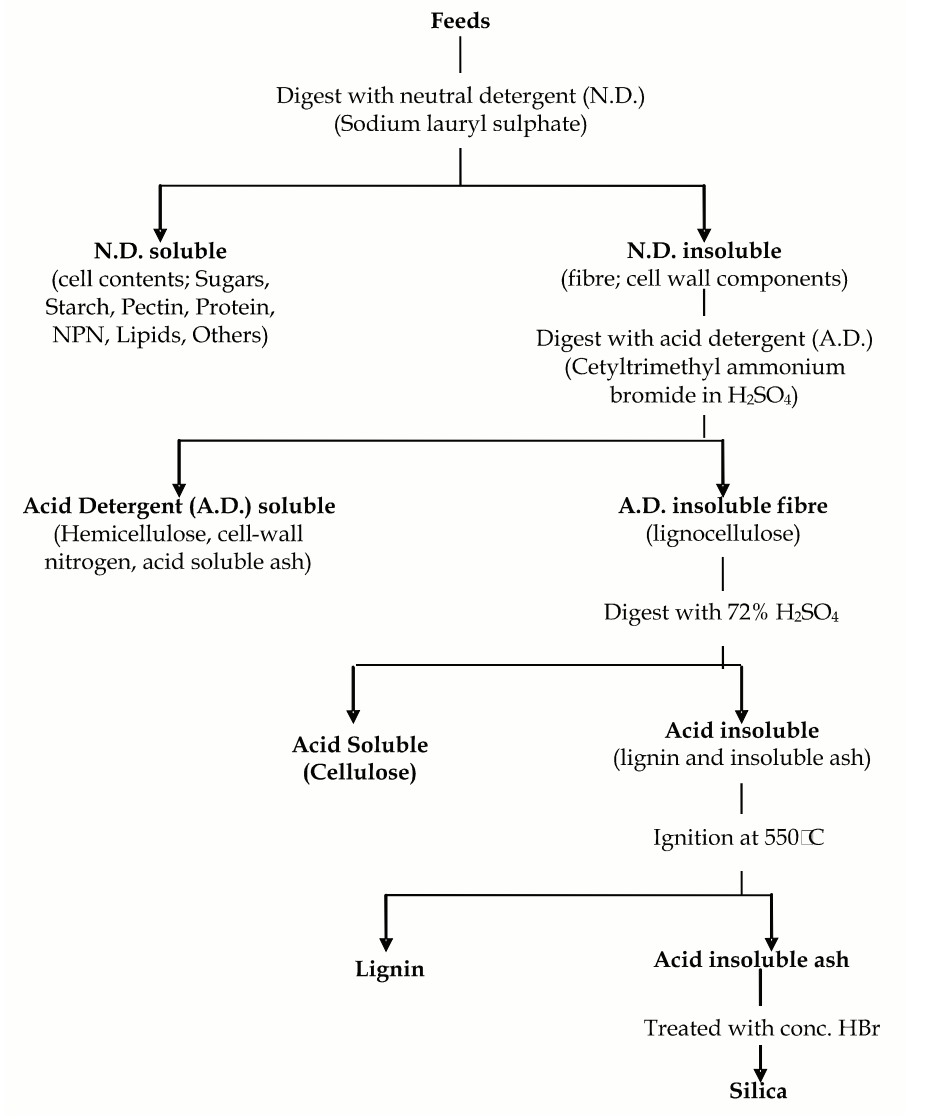
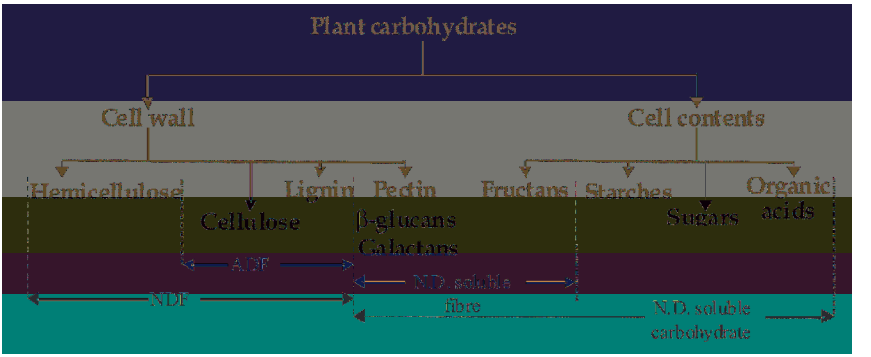


Fig. 8.6 : Partitioning of feed nutrients by detergent analysis
(*Source* : G.C. Banerjee, 1998: Feeds and Principles of Animal Nutrition, 2nd Edition)

Plant carbohydrates are divided into two categories viz., cell wall and cell components. Cell wall composed of cellulose, hemicellulose and lignin. Among three components lignins have little digestiblility and other two are digested by the ruminants. Cell contents composed of fructans, starches, sugars and organic acids which are mostly digestible (about 98%) in ruminants.



For evaluation of carbohydrates feed carbohydrates are divided into two parts crude fibre (CF) and nitrogen free extract (NFE). Crude fibre composed of cellulose, hemi-cellulose and lignin. Rest of the plant carbohydrate is considered as NFE. Among these, CF least digestible and NFE is most digestible portion of the carbohydrates. Therefore, as the CF increases, digestible energy usually decreases. However, in some good quality roughages, the CF fraction is as digestible as the NFE. CF is low in grains and high in forages.

Non-fibre carbohydrates (NFC) are the cell contents with the exception of neutral detergent soluble fiber (NDSF) compounds like fructans. Non-fibre carbohydrates include organic acids, sugars, starch and NDSF. Among these sugars and starches are very rapidly fermented in the rumen. Non-fibre carbohydrates are readily available energy for the ruminal microbes which is require for their growth. Digestibility of feed increases with the presence of high amount of non-fibre carbohydrates.

On the other hand, fibrous carbohydrates comprise of the cell wall components, termed as structural carbohydrates which are usually insoluble in neutral detergent (N.D.), except pectin, β-glucans, galactans etc which are soluble. Structural carbohydrates are slowly fermentable and thus yield low energy compare to the NFC.

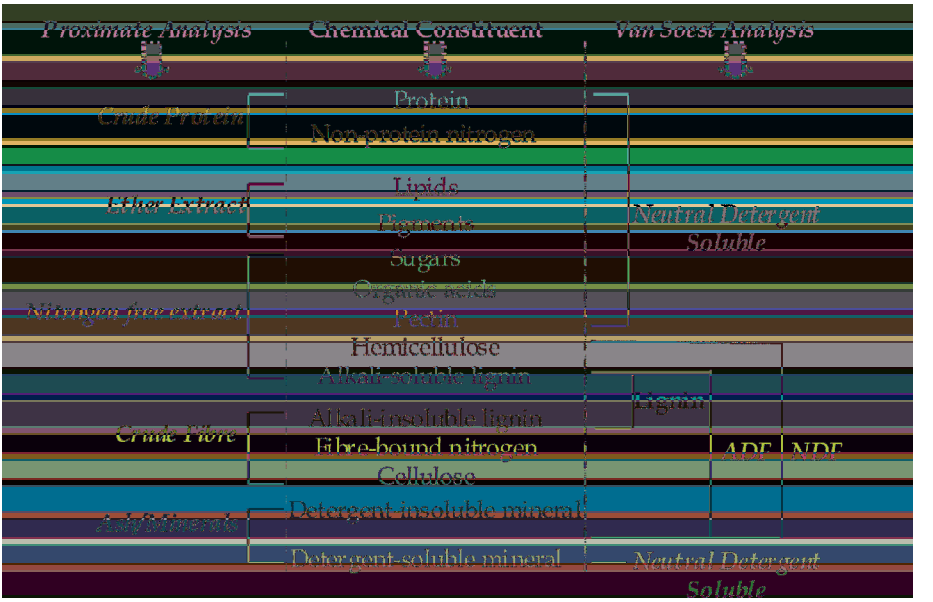


Fig. 8.7 : Contrasts of Proximate and Detergent (Van Soest) Systems of Feed Analysis (Fisher et al., 1995) [ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre]

8.6.2. Digestibility Trials

Analyzing the chemical composition of the feedstuffs provide information regarding nutrients present in feedstuffs. When the animal consumes feedstuffs, it can not utilize whole nutrients. In the process of digestion, absorption and metabolism, some amount of nutrients losses through faeces, urine, gases etc. Major portion of the loss is through faeces. Therefore, chemical composition of the feedstuffs does not provide actual nutritive value of the feedstuffs until above mentioned losses are taken into consideration.

The digestibility of a feedstuff or nutrients is defined as the proportion of feed or nutrient digested and absorbed, i.e. not recovered through faeces, by the animals. In digestibility trial, measurements are taken in to account regarding amount of feed or nutrient actually digested and absorbed from the measured amount of feed/nutrient consumed by the animals. Animal are maintained in a specially designed stall to collect faeces. Digestibility trials can be conducted either *in-vivo* (inside the animal) or *in-vitro* (outside the animal).

When digestibility is expressed in percentage it is known as digestibility coefficient.

$$\text{Digestibility coefficient of nutrient} = \frac{\text{Amount of nutrient consumed - Amount of nutrient in faeces}}{\text{Amount of nutrient consumed}} \times 100$$

8.6.3. Estimation of Energy Content of the Feed

Energy is the major component of most of the animal feeds. Therefore, energy intake is synonymous with the feed intake. Following are the methods through which energy value of the feed can be measured.

8.6.3.1. By calculating Total Digestible Nutrients (TDN) from digestion trial

The simplest method of measuring the value of the feed is through Total Digestible Nutrients (TDN) analysis. TDN is expressed in kg, lb or percent. TDN can be measured by adding all organic nutrients in the following way:

TDN (%)= %Digestible crude fibre (DCF) + %Digestible crude protein (DCP)+% Digestible nitrogen free extract (DNFE) +% Digestible ether extract (DEE) x 2.25

Since, fat generate 2.25 times more energy on oxidation as compared to carbohydrate, thus, DCF is multiplied with 2.25. DCP is included in the equation, as when excess protein is consumed by the animals it will then be used as energy source.

8.6.3.2. Gross energy (GE)

Gross energy of feed is defined as the energy given out in the form of heat when the feed is completely burnt down to its ultimate oxidation products- CO_2 and H_2O. Gross energy of a feed includes digestible and indigestible energy. Goss energy value of the feed is measured in the laboratory by bomb calorimeter. Animal can not absorb whole plant nutrients and utilize it. Some of the energy is lost through faeces. Sometimes it is calculated based on standard energy value 4.15, 5.65 and 9.40 for the carbohydrate, protein and fat, respectively. Gross energy value has little significance in ruminant as it consume huge amount of crude fibre.

8.6.3.3. Digestible Energy (DE)

It is part of gross energy which does not get waste through faeces. Gross energy of a feed is measured by bomb calorimeter. In the same way energy value of the faeces is measured. The difference between gross energy and the faecal energy provides the digestible energy. The

digestible energy includes metabolisable energy and energy lost through urine and gases like methane.

8.6.3.4. Metabolisable Energy (ME)

It is the portion of the digestible energy except energy lost through urine and gases (mainly methane). Metablisable energy is comparable with the energy of TDN after deducting the energy value of gases.

8.6.3.5. Net Energy (NE)

It is the most useful portion of energy that is utilized by the animals. Net energy is calculated by deducting all the energy losses through faeces, urine, gases and heat increment. Heat increment is the expenditure of energy during the assimilation of feeds e.g., heat generated from the fermentation of feeds in the digestive tract, nutrient metabolism etc. Net energy is utilized by the animals for maintenance, work, growth, reproduction, milk production and heat production.

The consequences of gross energy of the feed is described in (Fig. 8.8)

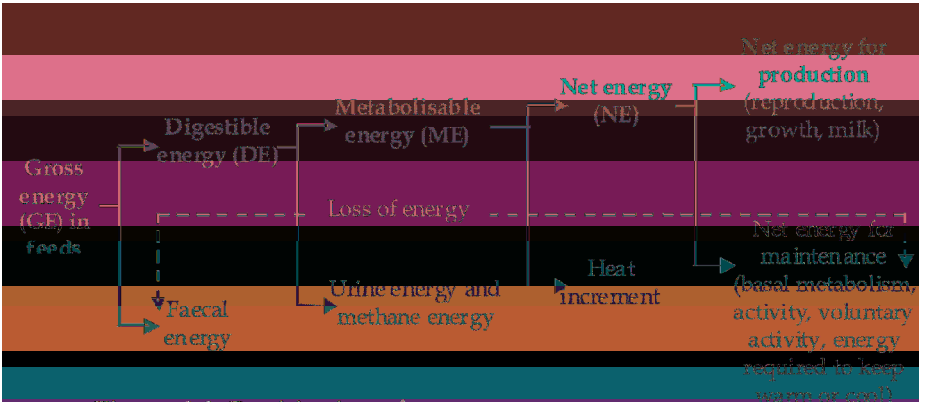


Fig. 8.8 : Partitioning of energy

8.6.3.6. Chemical composition

Gross chemical composition of feeds are analysed by any of the methods. Energy is obtained from carbohydrate, protein and ether extract out of all chemical composition of the feed. Appropriate factor of heat of combustion can be multiplied with these chemical compounds to get the energy value. This system has limited applicability in ruminant.

8.6.3.7. Carbon nitrogen balance technique

Animals get carbon and nitrogen only through feed. Some of them are assimilated within the body and stored as protein or fat, as carbohydrates has limited storage space within animal body. Rest carbon exits from the body through faeces, urine, methane and carbon dioxide. Rest nitrogen exits from the body through faeces and urine. Thus, the balance between intake and exits is the indication of the value of the feed. The balance trial is conducted in the "respiration chamber".

8.6.4. Evaluation of Protein Value of Feed

8.6.4.1. Digestible crude protein (DCP) estimation by digestion trial

The crude protein of the feed includes both true protein and NPN. Ruminants like dairy cattle are bestowed with the unique capability to utilize non-protein nitrogen (NPN) by rumen microbes which convert them into valuable microbial proteins. NPN includes amides, amino acids, alkaloids, ammonium salts etc. present in the feeds. True protein of the feed is consumed by the animals, major portion of which are broken down by the rumen microbes; ultimately form short chain fatty acids, ammonia and carbon dioxide which are again utilized by the rumen microbes and form microbial protein. Therefore, distinction between true and NPN of the feeds has no longer worthwhile.

Crude protein content of the feed can easily be estimated by Kjeldhal method. However, it does not provide sufficient information on how efficiently it is utilized by the animals. To sort out this problem digestibility trials can be conducted to see how much protein is absorbed within the body. But, again it will provide the 'apparent' digestibility, not the 'true' of the feeds as feaces contain metabolic N_2 (obtained from the bodily metabolism, not from the feed origin). Since, in the digestibility trial the metabolic N_2 is unavoidable, apparent digestibility is considered for protein evaluation in ruminant.

Digestibility coefficients of most of the concentrates are known from various experiments. However, it is not easily available for roughages as a result of their protein content. Presently, the protein requirement of the ruminant is expressed by DCP and protein value of the feedstuff for ruminants is also tabulated in the same way.

8.6.4.2. Nitrogen balance experiment

Animals can not get nitrogen other than feed. However, excretion of N_2 through faeces and urine occurs even when animal not consume any nitrogen, these are called as endogenous urinary N_2 (EUN) and metabolic faecal N_2 (MFN), for urine and faeces, respectively.

N_2 balance technique is more or less similar to the digestibility trial, except that collection and analysis of urine and any nitrogenous product like milk are made. It must be ensured that faeces and urine are collected separately. For that reason, the experiment is especially conducted in the metabolic crate. The nitrogen value of the faeces and urine are then evaluated. Now exogenous urinary nitrogen and faecal nitrogen from feed origin can be calculated with the following ways;

Exogenous urinary N_2= Total urinary N_2 - endogenous urinary N_2

Faecal nitrogen from feed origin= Total faecal N_2 - metabolic faecal N_2

Depending upon the N_2 intake and outgo of the animals, their state is described as;

Animal is in positive nitrogen balance when N_2 intake> N_2 outgo.

Animal is in nitrogen equilibrium state when N_2 intake= N_2 outgo.

Animal is in negative nitrogen balance when N_2 intake< N_2 outgo.

8.6.4.3. Recent concepts

Metabolisable protein

Metabolisable protein can be defined as the quantity of protein absorbed in the post ruminal portion of the digestive tract and available to the tissue for utilization. Metabolisable protein consists partly of dietary true protein that escape from ruminal breakdown as well as microbial protein.

Rumen degradable protein (RDP**) and rumen undegradable protein** (RUP)

This system of protein evaluation is proposed by Agricultural Research Council (ARC). Major portion of the dietary protein are degraded in the rumen by the microbes, i.e., rumen degradable protein (RDP) and some portion of the protein escape the attack of microbes i.e., undegradable fraction of protein is called as rumen undegradable protein (RUP). The degradability of the protein varies to a great extent among the natural feed resources.

The degradability of dietary protein is measured by:

$$\text{Degradability} = 1 - \frac{\text{Dietary protein entering duodenum}}{\text{Total dietary protein intake}}$$

8.7. FEEDING STANDARDS

Feeding standards are the quantitative descriptions of nutrients required for different classes of livestock to maintain normal bodily function, growth, production and reproduction. Feeding standards may be described separately for different functions of the animals like maintenance, production, reproduction etc. or as overall values for the combined functions.

Individual variations exist among the animals in terms of digestibility and utilization of the feeds. Variations are also common in terms of nutrients present in the feeds. Therefore, feeding standard should be used as guidelines and flexibility can be ensured in computation of rations for the individual animals or groups of animals.

Commonly used feeding standards are enlisted in the (Table 8.4) below.

Table 8.4 : Commonly used feeding standards used for dairy cattle in different countries

Feeding standard	Protein expressed as	Energy expressed as
National research council (NRC)	CP, DCP	TDN, DE, ME, NE
Agricultural research council (ARC)	DCP, AP	DE, ME
Scandinavian	DTP	FU
Morrison	DCP	TDN
Japanese	CP, DCP	TDN, DE, ME
India	DCP	TDN, SE

CP= Crude protein, DCP=Digestible crude protein, AP= Available protein, DTP=Digestible true protein, TDN= Total digestible nutrients, DE= Digestible energy, ME= Metabolisable energy, NE= Net energy, FU= Feed unit, SE= Starch Equivalent

8.8. NUTRIENTS REQUIREMENT FOR DAIRY ANIMALS

Nutrient demand for different stages of life of cows varies considerably. Nutrient requirements are discussed below on the basis of DCP and TDN requirement.

8.8.1. Nutrient Requirement for Maintenance

An animal is in maintenance state when it is not growing, not giving any product like milk, not engaging in reproduction, not working, i.e., its body composition remain constant. This is the phase when animals require minimum feed or nutrients. If the animals consume less than maintenance requirement, then it will loose body weight through breakdown of body tissues and various consequences may develop.

Energy requirement : This is determined by the study of basal metabolism by the animal. This is the energy which spent for working of heart, breathing, normal activities etc.

Protein requirement: Loss of protein from the body through wear and tear is a continuous process. If these losses are not corrected by the supply of protein through feed, the animal will rundown in condition and its health and productivity is adversely affected. The losses are detected in the faeces as metabolic faecal nitrogen (MFN) and in the urine as endogenous urinary nitrogen (EUN), when they are kept in protein free diet. The requirement of protein is determined based on the protein required to balance MFN and EUN.

Minerals and vitamins requirement: Essential minerals are continuously lost through faeces. The ration should contain sufficient minerals to replace the same. Most feeds and fodders contain sufficient minerals to meet the requirement. However, salt should be added to the animal ration. Dairy animals can synthesise all water soluble vitamins within their body, however for the sysnthesis of fat soluble vitamin sufficient precursor of those vitamins are needed and that is present sufficient amount in the forages.

8.8.2. Nutrient Requirement for Growth

Growth curve of the animal is sigmoid in nature. Growth is marked by the increased weight of animals due to increased muscles, bones, organs and connective tissues. Therefore, demand of nutrients is higher for the weight gain than maintenance.

Energy requirement: Energy requirement of growth is variable which depends upon the rate of growth.

Protein requirement: Protein requirement is expressed as DCP. It is the sum of requirement for growth and maintenance. Protein requirement is measured by nitrogen balance techniques through feeding trials.

Minerals and vitamins requirement: Since there is considerable growth of bone, so calcium and phosphorus along with vitamin D requirement is high in growing animals.

8.8.3. Nutrient Requirement for Milk Production

The quantity and quality of the milk depend upon the quality of the feed supplied to the cows. For milk production cows need extra nutrients over and above the maintenance requirement.

Energy requirement: Energy requirement depends upon the milk fat content. First energy requirement of the milk is calculated based on the fat percentage. Then it is added with the maintenance requirement.

Protein requirement: Milk is a rich protein source. On the basis of fat percentage in milk the protein requirement for milk production is calculated. This allowance should be provided in addition to the maintenance requirement.

Minerals and vitamins requirement : Significant amount of minerals and vitamins are drained out through milk. Therefore, minerals and fat soluble vitamins like A, D and E should be supplemented through feed. Water soluble vitamins need not be supplemented as they are synthesized in the rumen.

8.8.4. Nutrient requirement for reproduction

Nutrition greatly affects the cattle reproduction from the heifer-hood. Plane of nutrition affects the age of puberty. Deficiency of some specific minerals affects the synthesis of reproductive hormones. In the last trimester of pregnancy adequate nutrition is required as maximum growth of the foetus takes place at this time.

Energy requirement: During the last three months of pregnancy energy requirement is increased due to rapid foetal growth as well as storage of energy in body tissue of cows during the dry period. The target should be that the pregnant cows are in good flesh at parturition without being too fat.

Protein requirement: During the last trimester of pregnancy protein supply should be adequate to support the foetal growth and milk production besides maintenance requirement.

Minerals and vitamins requirement: It should be ensure that calcium, phosphorus and vitamin A are available to the pregnant animals over and above the maintenance and production requirement for the growing foetus.

Nutrient requirement for different categories of cattle has been shown in (Table 8.5).

Table 8.5 : Daily nutrient requirement of dairy cattle

Body weight (kg)	Daily gain (g)	Dry matter intake (kg)	DCP (g)	TDN (gk)	ME (Mcal)	Ca (g)	P (g)
1	2	3	4	5	6	7	8
Growing heifers (large breed)							
40	200	0.5	100	0.5	1.8	2.2	1.7
45	300	0.6	120	0.6	2.1	3.2	2.5
55	400	1.2	145	0.9	3.3	4.5	3.5
75	750	2.1	245	1.5	5.4	9.1	7.9
100	750	2.9	260	2.0	7.2	10.9	8.4
150	750	4.1	295	2.7	9.8	15.0	12
200	750	5.3	330	3.4	12.3	18.0	14
250	750	6.5	365	4.0	14.4	21.0	16
300	750	7.5	395	4.5	16.2	24.0	18
350	750	8.4	430	4.9	17.7	25.0	19
400	750	9.3	465	5.2	18.8	26.0	20
450	700	9.5	495	5.3	19.2	27.0	21
500	600	9.5	505	5.3	19.2	27.0	21
550	400	8.9	475	5.0	18.0	26.0	20
600	150	8.6	405	4.3	15.5	24.0	18
Growing heifers (small breed)							
20	100	0.3	60	0.3	1.1	1.1	0.8
25	150	0.4	80	0.4	1.5	1.5	1.1
35	300	0.8	110	0.6	2.1	3.2	2.5
50	500	1.2	160	0.9	3.3	4.9	3.8
75	550	1.7	190	1.2	4.3	7.0	5.4
100	550	2.4	210	1.6	5.8	9.0	7.0
150	550	3.6	245	2.3	8.3	12.0	9.0
200	550	4.8	280	2.9	10.5	15.0	11.0
250	550	6.1	320	3.5	12.6	17.0	13.0
300	500	6.8	330	3.8	13.7	19.0	14.0

Contd...

350	350	6.6	315	3.7	13.4	19.0	14.0
400	150	6.4	290	3.6	13.0	19.0	14.0
450	50	6.1	290	3.4	12.3	19.0	14.0
Growing bulls (large breed)							
40	200	0.5	110	0.5	1.8	2.2	1.7
45	300	0.6	120	0.6	2.1	3.2	2.5
55	400	1.2	145	0.9	3.3	4.5	3.5
75	800	2.1	255	1.5	5.4	9.7	7.5
100	1000	3.2	320	2.2	8.0	13.0	10
150	1000	4.5	355	3.0	10.8	18.0	14
200	1000	5.9	390	3.8	13.7	21.0	16
250	1000	7.3	430	4.5	16.3	24.0	18
300	1000	8.7	465	5.2	18.8	27.0	20
350	1000	10.2	500	5.9	21.3	29.0	22
400	1000	11.8	540	6.6	23.8	30.0	23
450	1000	12.5	590	7.0	25.3	30.0	23
500	900	13.0	610	7.3	26.4	30.0	23
550	800	13.8	625	7.7	27.8	30.0	23
600	700	13.8	630	7.7	27.8	30.0	23
650	600	13.6	635	7.6	27.5	30.0	23
700	500	13.4	630	7.5	27.1	30.0	23
750	400	13.2	620	7.4	26.6	30.0	23
800	250	12.7	570	7.1	25.7	30.0	23
850	100	12.1	510	6.8	24.5	30.0	23
Growing bulls (small breed)							
20	100	0.3	60	0.3	1.1	1.1	0.8
25	150	0.4	80	0.4	1.5	1.5	1.1
35	300	0.8	110	0.6	2.2	3.2	2.5
50	650	1.4	200	1	3.6	6.5	5
75	750	2.0	240	1.4	5.1	8.4	6.5
100	750	2.8	255	1.9	6.9	11.0	8
150	750	4.3	295	2.7	9.8	15.0	11
200	750	5.7	330	3.4	12.3	18.0	14
250	750	7.0	365	4.0	14.5	21.0	16
300	750	8.2	395	4.6	16.6	23.0	17
350	750	9.3	430	5.2	18.8	24.0	18

400	700	10.2	450	5.7	20.6	25.0	19
450	600	10	465	5.8	20.9	26.0	20
500	400	10	455	5.6	20.2	26.0	20
550	250	10	420	5.6	20.2	25.0	19
600	100	9.8	385	5.5	19.9	24.0	18
Maintenance mature breeding bulls							
500		8.3	300	4.6	16.6	20	15
600		9.6	345	5.4	19.5	22	17
700		10.9	390	6.1	22.1	25	19
800		12.0	430	6.7	24.2	27	21
900		13.1	470	7.3	26.4	30	23
1000		14.1	505	7.9	28.6	32	25
1100		15.1	545	8.4	30.4	35	27
1200		16.1	580	9.0	32.5	38	29
1300		17.1	615	9.6	34.7	40	31
1400		18.1	650	10.1	39.8	43	33
Maintenance mature lactating cows							
350		5.0	220	2.8	10.1	14	11
400		5.5	245	3.1	11.2	17	14
450		6.1	275	3.4	12.3	18	13
500		6.5	300	3.7	13.4	20	15
550		7.0	325	4.0	14.4	21	16
600		7.5	345	4.2	15.5	22	17
650		8.0	365	4.5	16.2	23	18
700		8.5	390	4.8	17.3	25	19
750		9.0	410	5.0	18.0	26	20
800		9.5	430	5.3	19.1	27	21
Maintenance and pregnancy (last two months gestation)							
350		6.4	315	2.8	10.1	14	11
400		7.2	355	3.1	11.2	17	14
450		7.9	400	3.4	12.3	**10**	13
500		8.6	430	3.7	13.4	20	15
550		9.3	465	4.0	14.4	21	16
600		10.0	500	4.2	15.5	22	17

650		10.6	530	4.5	16.2	23	18
700		11.3	555	4.8	17.3	25	19
750		12.0	595	5.0	18.0	26	20
800		12.6	630	5.3	19.1	27	21
Milk production (nutrient required per kg of milk)							
% Fat							
2.5		0.66	42	0.255	0.91	2.4	1.7
3.0		0.70	45	0.280	0.99	2.5	1.8
3.5		0.74	48	0.305	1.06	2.6	1.9
4.0		0.78	51	0.330	1.13	2.7	2
4.5		0.82	54	0.355	1.21	2.8	2.1
5.0		0.86	56	0.380	1.28	2.9	2.2
5.5		0.90	58	0.405	1.36	3.0	2.3
6.0		0.94	60	0.430	1.43	3.1	2.4

* ***Source*** **:** NRC (1989) on the calf starter

8.9. FEEDSTUFFS

Dairy animals consume wide variety of feedstuffs most of them are of plant origin. A combination of various feeds and fodders are usually fed to the animals to fulfill its requirement. The feedstuffs can be classified (Fig. 8.9) based on the crude fibre (CF) and total digestible nutrients (TDN) present. Initially feedstuffs are classified into:

8.9.1. Roughages

The feedstuffs contain less than 60% TDN and more than 18 % CF is usually called roughages. Roughages are usually bulky feeds. Nutrient density of roughages varies from very low (rice straws, cereal straws etc.) to very high (berseem, lucerne etc.). Roughages especially the straws, crop residues are produced after full maturation of plants, thus they have high content of cell wall with low digestibility due to the presence higher proportion of cellulose, lignin, silica etc. Lignin content of roughages play major role in the digestibility. In general, roughages are poor source of readily available carbohydrates.

Mineral content of the roughages are highly variable. Most of the roughages are good source of Ca and Mg, particularly legumes. Trace mineral content of roughages greatly depends upon the soil nutritional status, plant species, fertilizer application etc.

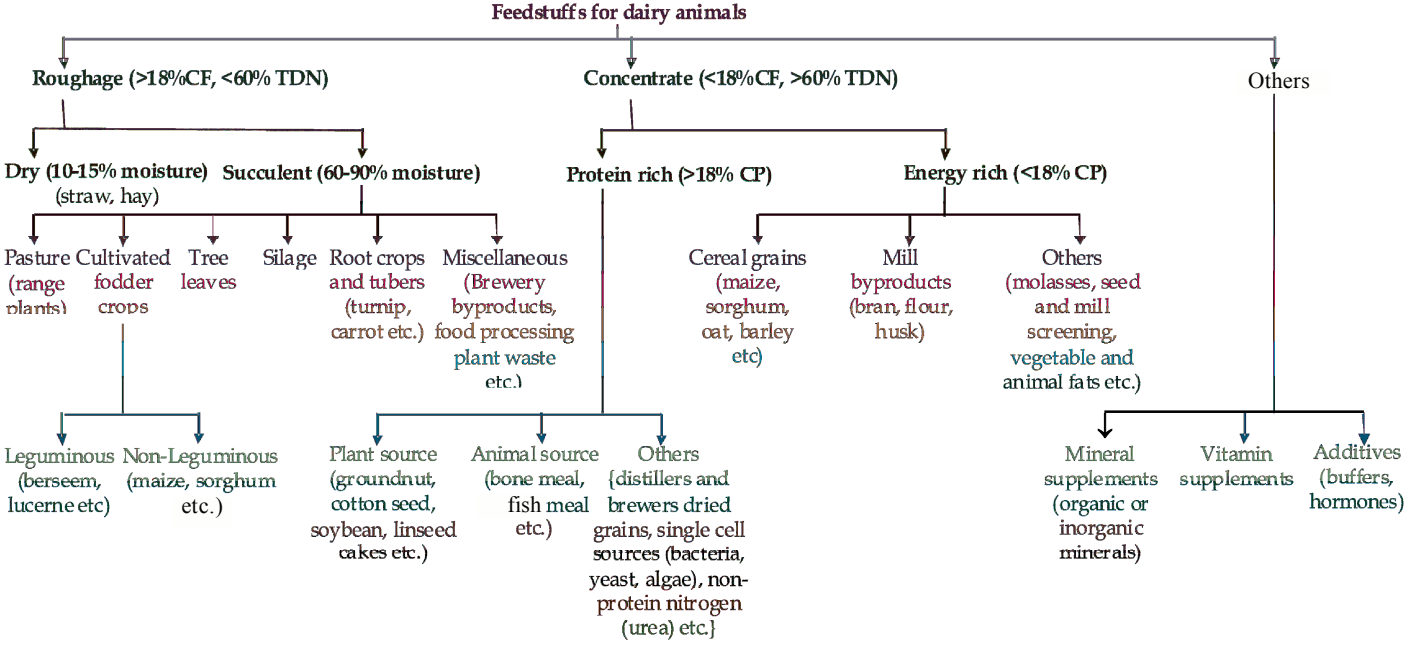


Fig. 8.9 : Classification of feedstuffs for dairy cattle

On the basis of the moisture content roughages are classified into dry and succulent. Dry roughages contain about 10-15% moisture, whereas succulent roughages contain about 60-90% moisture.

8.9.1.1. Dry roughages

Dry roughages are less palatable and usually have low nutritive value except hay. In this category hay, different kinds of straws are enlisted.

Hay making is the method of conservation of the green fodder crops by reducing the moisture close to 15% to inhibit the action of plant and microbial enzymes. Leguminous as well as non-leguminous fodder crops are used for hay making. Good quality hay produced from legume may contain 14-15% DCP and about 50-60% TDN.

Tropical countries like India are having large number of dairy animals. But the green fodder supply to this large population is inadequate. Therefore crop residues like straw, bhusa, karbi etc are used as animal feed. In developed countries these materials are never used as animal feed. They are used as bedding materials.

These crop residues have poor nutritive value. TDN content ranges between 40-50% and DCP nearer to '0'. They have very low digestibility and highly deficient in other nutrients like minerals, vitamins, fatty acids etc. Various methods are being tried are improve the quality of these crops residues and these are enlisted in (Fig. 8.10).

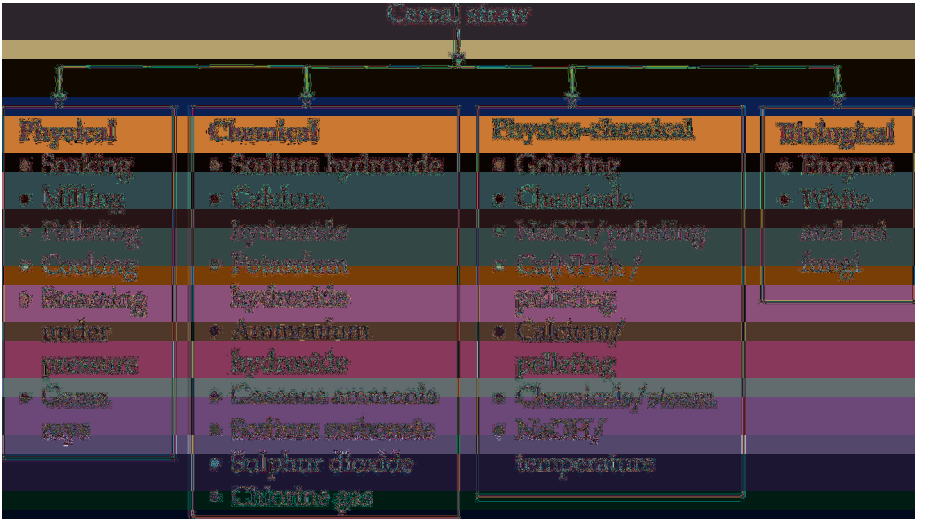


Fig. 8.10 : Various methods of treatment of crop residues

8.9.1.2. Succulent roughages

8.9.1.2.1. Pasture (range plants)

Management of animals in the pasture is recognized long back throughout the world, as it is the cheapest source of food for the animals. In the natural pasture, practically no cost of growing, cutting, transporting or storing of forages is required. In countries having less population density like Australia, New Zealand etc. pasture is still used as animal feed sources. In India, out of 238.8 million hectares of land only, 8.6 million hectares are under natural pasture and that too in the undulating hilly areas and in the semiarid and arid region. Excessive population pressure and cheap labour makes other agricultural operations more profitable.

India's pasture land classified into five categories;

Table 8.6 : Major types of grassland seen in India

Pastureland	Area	Elevation	Grass Species
***Sehima - Dichanthium* grasslands**	**Peninsular region:** Spread over the Central Indian plateau, Chota Nagpur plateau and Aravallis, covering an area of 1,740,000 km^2.	300-1200 m	There are 24 species of perennial grasses, 89 species of annual grasses, and 129 species of dicots including 56 legumes.
***Dichanthium - Cenchrus - Lasiurus* grasslands**	**N-W arid and semi-arid region:** Spread over an area of 436,000 km^2, including northern parts of Gujarat, Rajasthan, Aravalli ranges, south-western Uttar Pradesh, Delhi and Punjab.	150-300 m.	There are 11 perennial grass species, 43 annual grass species, and 45 dicots with 19 legumes.
***Phragmites - Saccharum - Imperata* grasslands**	**Eastern Humid region**: Cover an area of 2,800,000 km^2 in the Gangetic plains, the Brahamputra Valley and the plains of Punjab.	300-500 m	There are 10 perennial grasses, 26 annual grasses, and 56 herbaceous species including 16 legumes.
***Themeda - Arundinella* grasslands**	**Northern mountain belt:** Cover over 230,400 km^2 and include the States of Manipur, Assam, West Bengal, Uttar Pradesh, Himachal Pradesh and Jammu and Kashmir.	350-1200 m	There are 37 major perennial grasses, 32 annual grasses, and 34 dicots with 9 legumes.

Contd...

Temperate - Alpine grasslands	**Hills of Himalayan region:** Include the temperate and cold arid areas of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, West Bengal and the north-eastern states.	Altitudes higher than 2100 m	There are 47 perennial grasses, 5 annual grasses and 68 dicots including 6 legumes.

8.9.1.2.2. Cultivated fodder crops

Fodder crops are cultivated in the farm to feed the dairy cattle. Fodder crops are either harvested fresh and fed to the animals or preserved as hay or silage for the use during scarcity. Cultivated fodder crops are broadly classified as leguminous and non-leguminous. Leguminous fodders are usually rich in protein, minerals and vitamins, and are palatable than non-leguminous. Leguminous fodders generally contain about 2.5-3.0 % DCP and 10 % TDN (on fresh basis) and most non-leguminous fodders contain about 0.5-1% DCP and 11-15 % TDN (on fresh basis) except maize which is the richer source of TDN about 17%. The common cultivated fodders and their agronomical practices are tabulated below (Table 8.7a & 7b Next Page).

8.9.1.2.3. Tree leaves

Tree leaves are not commonly used as fodder crops for dairy animals. Usually they are fed to the small ruminants like sheep and goat. However, during the time of feed scarcity in some places the tree leaves are also used as fodder for dairy animals. Leaves are usually rich in crude protein and low crude fibre content when they are young, as it matures fibre content increases and protein content reduced. Tree leaves are fairly good source of calcium.

Table 8.7 : Tree species suitable for different agro-climates of India

Arid and Semi-arid Tropics	*Acacia albida, A. nilotica, A. tortilis, A. Senegal, Albizia lebbek, A. amara, Inga dulcts, Leucaena leucocephala, Prospopis cineraria, Sesbania aegyptica, Hardwickia binata, Dalbergia sisoo, Melia azadirach. Azadiracuta indica*
Humid Tropics	*Gliricidia sepium, Leucaena leucocephala, Sesbania grandiflora, Acacia mangium, Albizia falcataria, A. lebbek, A. procera, Calliandra calothyrsus*
Highland Tropics	*Acacia farnesiana, A. mearnsii, Leucaena diversifolia, Albzia falcataria*
Temperate	*Robina pseudoacacia, Alnus glutinosa, A. nepalensis, A. acuminaata*

Source **:** Gawai, V.G. (1991). Fodder Production-Why and Where. Paper presented at Workshop on Fodder production. 28th Jan-1st Feb, 19991, N.D.R.I., Hyderabad

Table 8.7a : Package of practices of cultivated fodder

Practices	**Maize** (*Zea mays*)	**Sorghum** (*Sorghum bocolar*)	**Bajra/Pearl Millet** (*Pennisetum typhoides*)	**Oats** (*Avana sativa*)	**Berseem** (*Trifolium alexandrinum*)	**Lucerne** (*Medicago sativa*)	**Cowpea** (*Vigna signensis*)	**Hybrid Napier** (*Pennisetum perpureum*)
Variety	African tall, Vijay composite, Moti composite, J-1006, A-de cuba	PC-6, PC-9, PC-23, HC-171, HC-260, HC-136, patna Chari, Hara sona (855F)	Giant bajra, Rajko, UUJ-IV-M, TNSC-1	Kent, OS-6, OS-7, OS-9, JHO-822, UPO-94, UPO-212, OL-125	Mescavi, Warden (S-99-1), BL-1, BL-2, BL-10, BL-22, JB-1, 2, JB-3, UPB-110	Co-1, T-9, LLC-3, LLC-5, Ananda-3, Ananda-5 GFC-3, Shewta	Russian giant, UPC-287, UPC-5286, UPC-4200, GFC-1, GFC-2, 10, PNB-83 (No. 988)	Pusa giant, NB-21, Co-1, IGFRI-3, IGFRI-6, IGFRI-7, IGFRI-
Sowing time	April-August	March-July	March-August	Mid Oct.-Mid nov.	Oct.-Nov.	Oct.-1st Week	March-August	March-August
Seed rate (kg/ha)	60-75	40-50	10-12	80-90	20-25	15-20	30-40	28000 root slips
Row- spacing (cm)	25-30	25-30	30-40	20-25	Broadcast	Broadcast	40-50	60 X 60 cm
Manuring/ha								
FYM (tonnes)	25	20-25	10-12	20	25	20	10	25
N (kg)	50-60 (2 Splits)	60 (2 Splits)	40	80 (2 Splits)	20	20	20	40
P_2O_5 (kg)	30	30	30	30	60	80	40	30
K_2O (kg)	20	30	20	20	30	30	30	20
Irrigation	4-5	4-7	2-3	3-4	Weekly interval	8-10 days interval	3-4 (summer) 1-2 (kharif)	10-15 days interval
Harvesting (days from)	70-80	80-90 (late variety) 70-75 (early variety)	50-60	70-75 for early cut, 120 for single cut	60-70, subsequent cut at 40 days interval	70-80, subsequent cut at 30-40 days interval	60-70	75, subsequent cuts at 45 days intervals
No. of cuts	One	One 3-4 (multicut)	2-3 cuts at 30-35 days intervals	2-3 for multicut	4-5	9-10	2 cuts (summer) 1 (kharif)	6-8
Fodder Yield (Tonnes/ha)	35-45	30-40 (Single cut) 50-70 (multicut)	30-40	40-45	75-80	80-100	45 (summer) 25-30 (kharif)	120-150

Table 8.7b : Package of practices of cultivated fodder

Practices	Teosinte (*Euclaena maxicana*)	Guar (*Cyamopsis tetragandoldra*)	Senji (*Melilotus parviflora*)	Para grass (*Brachiaria multica*)	Rhodes grass (*Chloris gayana*)	Ginea grass (*Panicum maximum*)	Sudan grass *Sorghum sudanense*)	Mustard (*Brasica Spp.)*
Variety	Improved teosinte, TL-1	FS 227	FOS-1	–	–	Macuenni, Hamil, PGG-1, PGG-9, PGG-13, PGG-14, PGG-19	Piper, J-69, G-287	LGL (Japan rape), Chinese Cabbage
Sowing time	June to July	June to July		June to August	March to July	March to August	April to July	Early September to end November
Seed rate (kg/ha)	35-40	35-40 for branched, 50-55 for un-branched	40-50	10-11 kg (seed) or 27000 sets	5-8 kg (seed) or 28,000 sets	3-4 kg (seed) or 40,000 rooted slips	20-25	8-10
Row-spacing(cm)	30-40	30-40	20-25	60-60	60-60	50 X 50	30-35	30
Manuring/ha	25-30	5	5	25-30	20	25-30	15-20	10-15
FYM (tonnes)	50	20	10	30kg at plantation	30kgat	30-40kg after	30kg basal and	30 (2 splits)
N (kg)	(2 splits)			and 20-30 kg after each cut	plantation and 20kg after each	cut	each cut	20kg after each cut
P_2O_5 (kg)	40	50	20-30	30	30	30	60	On soil test basis
K_2O (kg)	30	On soil test	20					On soil test basis
Irrigation	4-5	basis 1-2	1-2	1-2	1-2	10-15 days interval	18-21 days interval	2-3
Harvesting	80-90	65-75	80-90	1st cut at 80-90 days, subsequent at 35-40 days interval	1st cut at 90days, subsequent at 35-40 days interval	1st cut at 75 days, subsequent at 30-40 days interval	1st cut at 55 days, subsequent at 45 days interval	60-70
No. of cuts	2-3 at 60-70 days	1	1-2	4-5	5-6	5-6	3-4	1
Fodder Yield (Tonnes/ha)	interval 50-55	30-35	20-30	75	40	120	60-90	30-35

8.9.1.2.4. Miscellaneous (brewery byproducts, food processing plant waste etc.)

Various types of plant byproducts like brewery byproducts, food processing plant byproducts etc can be used as high moisture feed for the dairy cattle. It can be fed to the dairy animals as a part of ration. Plants byproducts are rich in energy.

8.9.1.2.5. Root crops

Root crops like sugar beet, turnips, carrot etc are cultivated for its sugar content and are used for feeding the cattle. Tubers like potatoes, cassava, sweet potatoes etc are also cultivated for its starch content.

8.9.2. Concentrates

Concentrates are the feed which contain less than 18 % CF and have more than 60% TDN. Concentrates usually have less moisture and have higher digestibility.

On the basis of CP content, concentrates are classified as energy rich (CP<18%) and protein rich concentrate (CP>18%).

8.9.2.1. Energy rich concentrates

Energy rich concentrates include cereal grains, mill by-products, molasses, seed and mill screenings, animal and vegetable fats. They are usually rich in energy and have low protein content.

Maize, barley, sorghum, oats are commonly used grains in the animal feed. Although grains have low protein, it is highly digestible in nature. Grains have high TDN value, but deficient in other nutrients like fat soluble vitamins, some minerals and that can be corrected by the addition of other feedstuffs.

Mill by-products like bran, flour, gluten, hulls, middling, polishes etc. can be used in the preparation of concentrate mixture. Their nutritive value is less than grain.

Molasses are the high energy concentrated water solution of sugars, hemicelluloses and minerals which are obtained from juices or extract manufacturing industries. Various types of molasses are available viz., cane molasses, beet molasses, citrus molasses, wood molasses etc. Molasses are used in the concentrate mixture as a source of energy as well as it act as binder and prevents dustiness of the concentrate mixture.

Animal and vegetable fats are used as fat supplement to the high producing animals especially at the early lactation when the animal remains in the severe negative energy balance. High concentrate feeding does not able to fulfill the energy requirement. Therefore, fat is supplemented to the ration to some extent. Excess fat again depress the dry matter intake of the animals.

8.9.2.2. Protein rich concentrates

The concentrate containing more than 18% CP is considered as protein rich concentrate. It is the most vital nutrient especially for the young, growing, pregnant and high producing animals. Protein rich concentrates are usually expensive than energy rich concentrates. Therefore, optimum use of it must be ensured to minimize the feed cost. Protein rich concentrates can be from different sources like plant, animal and others sources.

Plant protein sources like various types of oil cakes are extensively used as animal feed. Oils are removed from oil seeds and the residue called oil cakes can be used as animal feed. Oil cakes are rich source of protein content, usually range from 25 -50 % as well as reasonably high energy content. Two types of oil cakes are available in the market viz., expeller type and solvent extracted type. Expeller type of oil cakes usually have more energy value than solvent extracted type. Commonly used oil cakes are groundnut cake (popularly known as GNC), linseed meal, cotton seed meal, soybean meal etc. Pulses like black gram, bengal gram etc can be used as protein sources to the animals, however, their utility as animal feed is very much limited as they are primarily used for human consumption. However, byproducts of the pulses are used as animal feed.

Inedible tissues such as meat, blood, surplus milk, marine byproducts, hatchery by product etc. can be used as protein rich concentrate feed. However, it has very limited used in dairy animals.

Other protein supplements like distillers and brewers dried grains, single cell sources (bacteria, yeast, algae), non-protein nitrogen (urea) etc can also be used as protein source for the animals. Urea can be supplemented to the dairy cow's ration. But, it should not exceed 1% of the total dry matter of the ration. Again for very high yielding animals it does not have any significance. Urea can be fed to the animals either by mixing with the concentrate mixture or as an aqueous solution.

8.10. CONSERVATION OF FORAGE

Forage is the major component of the diet of the dairy cattle. For efficient milk production forage should be supplied to the animals thoughout the year. Growth of forage is very high during rainy season. On the other hand, during dry season it grows slowly or stops growing unless irrigation facilities are there. Therefore farmer has to plan in such a way that forage would be available round the year. Above all, periodic droughts imposed bigger threat to the dairy animal producer.

To make green forage available throughout the year, it can be conserved either in the dry form such as hay or in succulent form such as silage. Other methods like haylage, baylage etc. are available, but these have little significance in terms of wide use.

8.10.1. Hay

A thin stemmed forage crop when preserved through reducing the moisture content (<15%) to the level at which plant tissues are dead or dormant is termed hay. The aim of hay making is to reduce the moisture content of the green crop to a level low enough to inhibit the action of plant and microbial enzymes.

8.10.1.1. Plants suitable for hay making

Fodder crops with thin, soft, pliable and hollow stems are more suitable for hay making.

(a) **Legume hay :** Lucerne is an ideal leguminous crop for hay making. Berseem, cowpea, clovers etc. are other leguminous crops fit for hay making. It has high dry matter yield, high digestible protein, mineral (rich in Ca) and rich in carotene content and highly palatable.

(b) **Non-legume hay :** Certain thin stemmed arable crops like oats and barley and grasses like Congo signal, Spear grass and brome grass are also used for hay making. Hay made from non-legume crops is usually rich in carbohydrate and low protein and minerals.

(c) **Mixed hay :** Mixed hay is usually made from a mixed crop of leguminous and non-leguminous plants. A mixture of Congo signal, styloxanthes and centrosema is popular in some heavy rainfall regions.

8.10.1.2. Methods of hay making

(a) Stage of harvesting crop : To prepare good hay, the crops should be harvested in the pre-flowering or early flowering stage so that maximum percentage of nutrients is preserved. An early cut means more nutritive value but lesser yeild. Late cutting results in more bulk, but less nutritive value and palatability. Taking into consideration the quality, yield and composition, the best time to harvest the forage crops is at early flowering stage in most cases.

(b) Curing : Curing literally means preservation by drying. The objectives of curing are to preserve the maximum amount of plant nutrients and discourage the growth of moulds and spoilage by reducing the moisture content of the plant.

After cutting the crops at their suitable stage they are kept as such in the field over the rack for few hours for curing. It will reduce the moisture level about half of the initial moisture content. If it is a sunny day, then fodder may be turned upside down after 4-5 hours. In the evening the partially cured fodders are raked in small loose heaps called "windrows". If the weather condition remains good, then fodder will be cured in the windrows. When weather condition is not favourable for fast curing, one or two turning is necessary. It will reduce the moisture level about 25-30%. It is better to handle the hay in the morning especially in the very dry season, because in the morning the leaves remain soft and chance of shattering loss is least. Hay should be stored when the moisture level <20%. High moisture generates heat and thus fermentation takes place which causes loss of nutrients.

Chemical drying agents : A waxy cuticle surface covers the plants, especially forage legumes which reduces moisture loss and increases the amount of time necessary for a cut plant to cure. Drying agents like sodium or potassium carbonate or a mixture of both change the chemistry of the cuticle and reduce its effectiveness as a barrier to moisture loss. They do not remove water from plants, but reduce the amount of energy as well as time required to dry plants.

8.10.1.3. Storage of hay

After successful preparation of hay, it should be preserved in a suitable manner. The hay is generally stored in the following form.

(a) Loose hay : It is prepared locally by simply sun cure method in the loose form. Loose hay can be stored in open

environment. In open environment hay can be stored in the following ways:-

i. Hay stack on ground

ii. Hay stack on platform

iii. Hay stack on tree

(b) **Chopped hay :** Dry hay is chopped and stored. The bulkiness is not reduced. Besides it is dusty and highly prone to spontaneous combustion. Chopped hay cannot be stored in the open environment because of the heavy losses incurred by wind and rain.

(c) **Bailed hay :** A large bundle or package of hay is called bale hay. For baling of hay machines are available. This reduces the requirement of space in comparison to loose or chopped hay. The bales may be stored in open environment or in the barn. Racks are placed on the elevated ground in a shady place

(d) **Wafers :** The long hay is chopped into 3-5cm length and is then compressed in the wafering machine.

(e) **Pellets :** Pellets of straw are prepared after grinding it. Pellets are cylindrical compact masses chalk like structure. They are very much palatable. It reduces loss during feeding due to increased density of the hay and requires less storage space.

8.10.1.4. Losses during hay making

The original nutritive value of the fodder can not be maintained in the hay as some losses are occurred during curing. Following are the kind of losses that occur during preparation of hay:

(a) **Shattering of leaves :** Leaves are rich in nutrients. Shattering of leaves increase when leaves dry earlier than stem.

(b) **Fermentation :** When the weather condition is unfavourable, prolonged drying process favours the oxidation of starch and sugars and formation of CO_2 and water present in the green fodder and thus, loss of carbohydrate occurs.

(c) **Vitamins :** Carotene, a precursor of vitamin A is lost when the cut plants are exposed to sun for long time. In extreme condition the carotene loss may be as high as 90%.

(d) Leaching : Prolonged heavy rain at the time of processing of hay leach plant nutrients like protein, NFE, soluble vitamins and minerals.

8.10.1.5. Quality of a good hay

1. Good quality hay should be leafy, as leaves are generally rich in protein, vitamins and minerals.
2. It should be green in colour.
3. It should be made out of thin-stemmed crops so that it is soft and pliable
4. It should be free from weeds and stubbles, dust, moulds and poisonous plants.
5. In good quality hay, moisture content is about 15%.
6. It should have appetizing pleasant aroma.

8.10.2. Silage

'Silage' is the fermented feed produced by controlled fermentation under strict anaerobic condition, retaining high moisture content of green forages. The process of silage making is termed as 'ensilage'. An air-tight or semi air-tight structure designed for the storage and preservation of silage is called 'silo'.

8.10.2.1. Advantages of silage

i. Green fodder can be kept in a succulent condition for a considerably long period. Silage furnishes high quality forage in any desired season of year at a low expense.

ii. Silage preserves 85 % or more of the feed value of the crops, where as hay making will preserve significantly less percentage of nutrients.

iii. During monsoon months, hay making is very difficult. Preserving the fodder as silage avoids this difficulty.

iv. Weedy crops, which tend to make poor hay, may produce good quality of silage.

v. The entire plant being consumed, this is an important consideration with coarse, steamy forages.

vi. It is better source of protein and certain vitamins, especially carotene and perhaps some of the unknown factors than dried forage.

vii. Require less storage space than dry fodder. Cubic feet of silage contain 3 times more DM than hay.

viii. The ensiling process kills practically all weeds that are present in the field because they are harvested before seed formation.

ix. It is very palatable & slightly laxative in nature.

x. Fear of fire is avoided; however it is common in case of storage hay.

xi. Many by-products can be economically used.

xii. With the early removal of Kharif crops from field for silage making, enough time is available for preparing the land for sowing of Rabi crops, which follow.

xiii. In some places, because of the early harvest of crops for silage making, some insect pests, which appear at later stages, are controlled.

8.10.2.2. Types of silo

Depending upon the structure of the silo they are classified as:

1) Upright (tower) silo
2) Gastight (oxygen-limiting) silo
3) Pit silo
4) Horizontal silo
   (i) Trench silo (below ground level)
   (ii) Bunker silo (above ground level)
5) Temporary silo
   (i) Plastic or polythene bag silo
   (ii) Modified trench-stack silo

8.10.2.3. Principles of silage making

1. **Achieve anaerobic condition at earliest**: It is done by chopping the crop, rapid filling of the silo and by adequate consolidation and sealing.

2. **Discourage the activity of undesirable micro-organism**: Growth of microorganisms such as *Clostridia* and *Enterobacteria* which produce objectionable fermentation products should be discouraged.

8.10.2.4. Crops suitable for silage making

Almost any crop can be preserved as silage, although the commonest crops used are grasses, legumes and whole cereals, especially maize. For the preparation of silage crops should have following characteristics

1. **Adequate carbohydrates**: Crops should have adequate amount of readily fermentable carbohydrates.
2. **Sufficient moisture**; At the time of ensiling it should have 25-35% DM less than 25% DM content produce sour silage more than 35% DM content do not pack well and will frequently develop spots of mold during storage.
3. **Solid stem**: The crops should have solid stem, so that small amount of air is trapped. However, hollow stemmed crop can also produce good silage but trampling should be adequate.
4. **Proper stage of growth**: Stages of crop is also important

Crop	**Stage**
Maize	Early dent stage
Oats, Sorghum, Bajra	Milk or dough stage
Berseem, Lucerne	25-50% bloom
Natural & cultivated grasses	At flowering stage

8.10.2.5. Process of silage making

A. Harvesting forage at proper stage of maturity

The crops should be harvested at the optimum stage to maintain their highest nutritive value.

B. Maintain desirable moisture content

About 30-35% DM content (65-70% moisture) is most suitable for silage making. If the moisture content is low then sprinkle water

over the crops to increase moisture content which also facilitates proper compaction of silo.

If the moisture content is high,

1. It is heavier and more costly to handle.
2. Produce slimy, putrid silage, due to the presence of butyric and other undesirable acids.
3. Excessive seepage of juices and some loss of nutrients, except carotene.
4. Due to the high acidity, excessive deterioration of the silo wall
5. Ultimately it exerts high pressure on the silo walls.

High moisture content can be reduced by:-

1. **Conditioning (wilting)**: Conditioning and/or wilting for 3 to 4 hours on a good drying day may reduce 10-15% reduction of moisture content.
2. **Adding dry hay or straw**: During poor wilting weather, the moisture content of grass forage can be reduced within the desired range by adding 5-20% straw.
3. **Combining high and low moisture crop**: Desired moisture content can be obtained by mixing at a calculated ratio between high and low moisture crops.
4. **Adding dry preservative**: Dry preservatives as ground grains, maize and cob meal, dried molasses etc., will reduce moisture content.

C. Cut the forages at proper length

The crop is chopped to 2 to 4 cm in length. Grass silages, wilted, dry forages, forage with hollow stems should be chopped more finely than forage of high moisture content.

D. Add additive or preservative (if necessary)

Preservatives can be added to the silage as they:

1. add nutrient
2. provide fermentable carbohydrate

3. furnish additional acids.
4. inhibit undesirable types of bacteria and moulds
5. reduce the amount of oxygen present, directly or indirectly.
6. reduce moisture content of the silage
7. absorb some acids which might otherwise be lost in seepage.
8. increase nitrogen content of the silage.

Common additives and preservatives, which are used for silage preparation, are as follows :

- **Use of sterilizing agents**
  - v **Sodium metabisulphite:**
    - X It has been used for a controlled microbial growth with variable results.
    - X It reduces loss of dry matter and crude protein.
  - v **Antibiotics:**
    - X Some of the antibiotics like zinc bacitracin, aureomycin, terramycin, chloramphecinol, streptomycin, etc. have been used
    - X These antibiotics increased the digestibility of the organic matter.
    - X It reduced the depression in the growth of lactic producing bacteria.
  - v **Direct acidification:**

  (b) Mineral acids and AIV methods:
    - X Some mineral acids like sulphuric and hydrochloric acids are used but due to corrosive nature of the mineral acid their use in not encourage.
    - X In AIV method, a mixture of sulphuric and hydrochloride acid is added to green forage to bring pH below 4.0. Resultant mixture is preserved for a sufficient long period.

  (c) Organic acid:
    - X Addition of lactic acid at 1 percent level has increased the bacterial fermentation of silage.
    - X "Sihlohife" is used which containing 0.4 percent and

0.4 percent formaldehyde produced silage with low lactic acid, no butyric acid and VFA level higher than lactic acid.

- Propionic acid and formic acid can be used to reduce losses and produce good quality silage without loss of palatability.

- **Lactic acid stimulants**
  - **Bacterial cultures and other micro-organism:**
    - Use of lactic acid producing bacterial culture inoculation on production of good quality silage.
    - Acid forming bacteria like; *Lactobacillus acidophilus, Torulopsis spp., Bacillus subtilis* are used.
  - **Sugar and molasses:**
    - Generally used with legume and certain grasses those have low sugar content and high moisture content (75-85%). Molasses may be added 3.5-4.0 % of the green weight of the forage in either liquid or dehydrated form.
    - The value of molasses in legumes or legume grass silage is stressed for forages containing 75-85 percent moisture.
    - Through dispersion of molasses into ensiled forage is required to obtain maximum benefits.
    - The forage should be chopped to promote active and rapid fermentation.
    - Molasses treated silage generally has higher lactic acid, lower pH, reduce organic matter losses and no butyric acid. It improves preservation and digestibility of silage.
    - Ground shelled corn, tapioca etc. can be added to the silo to increase the sugar content of the silage.
  - **Whey:**
    - Whey treated silage had an effective lactic acid content, low ammonia and butyric acid.

- **Urea, limestone treatment:**
  - Generally used with cereal forages those have low N_2 content.

- Addition of limestone (0.5-1%) benefits fermentation by increasing lactic acid production, improved acceptability and feed efficiency.
- The combined addition of urea and limestone at ensiling produced similar effect to those produced when adding each separately.

E. Rapid filling of silo

The filling process should be rapid. Once the silo filling is started, it is preferably be finished within two or less days for creating the desired anaerobic condition. Never fill the silo when it is raining.

F. Uniform distribution of forage in the silo

In order to avoid the presence of air pockets and spoilage, chopped forage should uniformly be distributed in the silo and packed well. The upper portion of pit should be dome shape.

G. Sealing of silo

When filling is completed a permanent seal should be put in place as rapidly as possible. Plastic sheet is ideal for this purpose. Light covering of soil or a layer of straw bales are also useful for this purpose

For the formation of silage it will take 3 to 4 weeks. After that it could be used for feeding to the animals.

8.10.2.6. Phases of silage formation

There are two main phases in the ensiling process. The first is the **aerobic phase**, which occurs in the presence of oxygen (air). The oxygen that is present in the forage, as it is placed into storage, is consumed by the plant material through the process of respiration. Under aerobic conditions, plant enzymes and microorganisms consume oxygen and burn up plant water-soluble carbohydrates (sugars), producing carbon dioxide and heat. The first phase should be as brief as possible to maintain the quality of the silage. Excessive aerobic fermentation reduces the energy content of the silage and may cause heat damage to proteins due to the production of heat..

The second or **anaerobic phase** begins when available oxygen is used up by respiration and aerobic bacteria cease to function.

Anaerobic bacteria (bacteria that grow in the absence of oxygen) then begin to multiply rapidly and the fermentation process begins. The best silage is produced when the most rapidly growing microorganisms are predominately of the lactobacilli species, as they produce lactic acid from the fermented plant material. Lactic acid lowers the pH of the silage. Fermentation completely ceases after three to four weeks when the pH becomes so low that all microbial growth is inhibited.

8.10.2.7. Standard for silage

Standard	Qualities	
Physical standard:	3 It should have an acceptable aroma with no mould growth. 3 Good silage keeps a greenish yellow colour. 3 It should be highly palatable by animals. 3 A fermentation loss of around 10-15 percent is almost inevitable due to silage making and quite acceptable.	
Chemical standard:	**Very good silage**	3 It is clean, the taste is acidic, and has no butyric acid, no mould, nor sliminess nor proteolysis. 3 Its pH varies between 3.5-4.2. 3 The amount of ammoniacal nitrogen should be less than 10 % of the total nitrogen.
	Good silage	3 The taste is acidic. There may be traces of butyric acid. 3 The pH is between 4.2-4.5. 3 Ammoniacal nitrogen is 10-15 % of the total nitrogen.
	Fair silage	3 The silage is mixed with a little amount of butyric acid. There may be slightly proteolysis along with some mould. 3 The pH is between 4.5-4.8. 3 Ammoniacal nitrogen is 15-20 % of the total nitrogen
	Poor silage	3 It has bad smell due to high butyric acid and high proteolysis. The silage may be infested with moulds. Less acidic. 3 Its pH is above 4.8. 3 The amount of ammoniacal nitrogen is more than 20 % of the total nitrogen

8.10.2.8. Quality of a good silage

Salient features of good quality silage are as follows:

pH	—	4.2 to 4.5
Lactic acid	—	$\geq$2.5%
Acetic acid	—	0.5 to 0.8%
Butyric acid	—	$\leq$ 0.1%
Ammonia nitrogen	—	$\leq$10%
DM loss	—	<10%
Effluent loss	—	Almost nil
Aroma	—	Pleasant
Colour	—	Greenish golden yellow

8.10.2.9. Losses during ensiling process

During the processing and preservation of silage various losses are encountered are enlisted below:

I. **Respiration losses** occur when plant cells continue to breakdown carbohydrates and sugars due to excessive amounts of air present in the silage.

II. **Fermentation losses** result from excessive breakdown of sugars by yeasts and moulds contained on the plant material. The main breakdown product of both these losses are carbon dioxide along with water and heat.

III. **Seepage losses** result when excessively wet silage compresses the silage mass forcing moisture out of the silo. This seepage carries carbohydrates and other nutrients with it.

IV. **Surface spoilage** is another loss which occurs when the less compacted silage in the upper portion of the silo is exposed to air.

V. Finally, there is **heat damage** which is mainly a quality problem with dryer silages reducing protein availability.

8.10.3. Haylage

When the forages are preserved with high dry mater content (about 50%) compared to silage, the ensiled forages are called 'haylage'. As the dry matter and moisture level are in-between silage and hay

that's why the product is called haylage. To achieve the desired moisture level, the forages can be cut and conditioned in the same manner that a hay crop is harvested. Then it is field wilted to 40 to 60 per cent moisture and preserved.

8.10.4. Baylage

Baylage is another form of stored forage. In this case hay, alfalfa or grass is cut and baled while still in fairly wet condition. It is too wet to be baled and then stored as hay. In this case the dry matter is around 60 to 70%. The bales are wrapped tightly in plastic wrappers. The material then goes through a limited fermentation resulting in production of short chain fatty acids, which protect and preserve the forage.

8.11. SUMMARY

Feed cost is the major expense of the dairy farm, contributing about 60-70% of the total cost of dairy animal rearing. Thus, judicious use of suitable feedstuffs is necessary to provide sufficient nutrition to the animals with minimum expenditure. Feeds contain various nutrients like water, carbohydrates, lipids, proteins, minerals and vitamins. The ruminant can utilize non-protein nitrogenous substances which is an added advantage. The ruminants have peculiarity in their digestive system as the stomach contains four compartments e.g., rumen, reticulum, omasum and abomasum. The rumen contains microorganisms which help in the digestion of feeds and fodders including NPN, resulting in the formation of microbial proteins. These microbial proteins are digested in the small intestine into amino acids which are ultimately absorbed and fulfill the protein requirement of the animals. The rumen microbes can synthesise vitamins B and K. Evaluation of feed nutritive value can be done by different methods like chemical analysis, digestibility trials, carbon-nitrogen balance, bomb calorimeter etc. There are different feeding standards which guide feeding to fulfill the nutrient requirements for different purposes like growth, maintenance, production and reproduction. Feedstuffs are classified into roughage and concentrate based on their TDN and CF content. Roughages are classified into dry and succulent depending on moisture content. Concentrates are also classified into protein and energy rich concentrates. The excess fodders during flush season can be preserved in the form of hay, silage, haylage, baylage etc. for using during lean seasons.

8.12. CHECK YOUR PROGRESS

(a) What is non protein nitrogen compound?

(b) What is white muscle disease?

(c) What is bypass protein?

(d) What is crude protein?

(e) What is silage?

8.13. ANSWERS TO 'CHECK YOUR PROGRESS'

(a) Large number of nitrogenous compounds naturally present in plants and animals which are not protein in nature, called as non-protein nitrogen (NPN).

(b) The symptoms of vitamin E deficiency in growing calves are dystrophic lesions in the muscle known as "white muscle disease".

(c) The protein which bypasses the ruminal degradation to provide sufficient essential amino acids to the productive ruminants, which can not be met only through the endogenous microbial proteins, is called bypass protein.

(d) The true protein and protein from non-protein nitrogenous sources are together called crude protein.

(e) 'Silage' is the fermented feed produced by controlled fermentation under strict anaerobic condition, retaining high moisture content of green forages.

8.14. EXERCISES AND QUESTIONS

(a) Classify feed stuffs used for animal feeding.

(b) Discuss the digestive system of cow.

(c) Describe digestion of protein in ruminants.

(d) What are the different methods of evaluating a feed?

(e) Describe the nutrient requirement of dairy cattle.

(f) What are the methods of hay making?

(g) Discuss the process of silage making.

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CHAPTER - 9

Reproduction in Cattle

9.1. INTRODUCTION

Reproduction is an important event in the life of an animal (both male and female). The success of a dairy farm depends on the reproductive efficiency of cattle which depends on the efficient reproductive management. The animals should be reproductively sound. The cow should be a regular breeder with calving interval of 12-13 months to minimize the generation interval and to increase the profitability of the dairy farm. The bull should have high libido, produce good quality semen with high fertility rate.

9.2. OBJECTIVES

The objectives of reproductive management are as follows

- to understand the reproductive system of cattle.
- to ensure calving interval of 12-13 months.
- to maximise the lifetime milk production of cow.
- to get maximum number pregnancies in the lifetime of the cow.
- to minimize the reproductive problems and thereby reduces the economic losses.
- to reduce the culling rate of animals due to reproductive problems.
- to increase reproductive efficiency of the dairy herd.

9.3. REPRODUCTIVE SYSTEMS OF MALE AND FEMALE

9.3.1. Male Reproductive System

Male reproductive system (Fig. 9.1) consists of testes, scrotum, epididymis, vas deferens, accessory sex glands, & penis.

9.3.1.1. Testes

A pair of testes, ovoid in shape is suspended vertically in the scrotum. Each testis measures 10-15 cm in length, 5-8 cm in width and 300-600g in weight depending on age, size and breed of the animal. Testes consist of thousands of seminiferous tubules. Seminiferous tubule epithelium consists of germ cells and sertoli cells. Initially the sperm cell (called spermatogenic cell) are produced by the germ cells, which get support and nourishment from the sertoli cells. The space between the seminiferious tubules are occupied by interstitial (Leydig) cells. The seminiferous tubules converge onto larger tubules known as rete testis which is continued from the head of the testis as epididymis.

The testicle has two vital functions: (1) producing the spermatozoa and (2) producing the specific male hormone, testosterone.

9.3.1.2. Scrotum

The testicles are located outside of the body cavity in the scrotum which acts as thermo-regulator. Normal sperm formation occurs only at a temperature few degrees (4–7°C) below the normal body temperature. The variation of environmental temperature does not the effect much on the sperm production by the testes due to thermoregulation by the scrotum. The following are the mechanisms by which thermoregulatory function of the scrotum is maintained.

(a) Numerous sweat glands are present in the scrotal skin which help to maintain normal temperature of the scrotum in hot environmental condition through evaporation.

(b) Temperature receptors present in the scrotal skin control the sweating and contraction or extension of the scrotum by stimulating the dartos and cremaster muscles of the scrotum.

(c) The dartos and cremaster layers control thickness and surface area of the scrotum and also closeness of the testes with the body. In cold condition, these layers contract bringing the testes close to the body, along with wrinkling and thickening

of the scrotal wall, thus reducing surface area for evaporation. In hot condition, these muscles relax lowering the testicle (away from the body) within thin walled pendulous scrotum.

(d) The arterial coils of testes are intimately enmeshed by the pampiniform plexus of testicular veins. In this counter current mechanism the arterial blood entering the testes is cooled by venous blood leaving the testes.

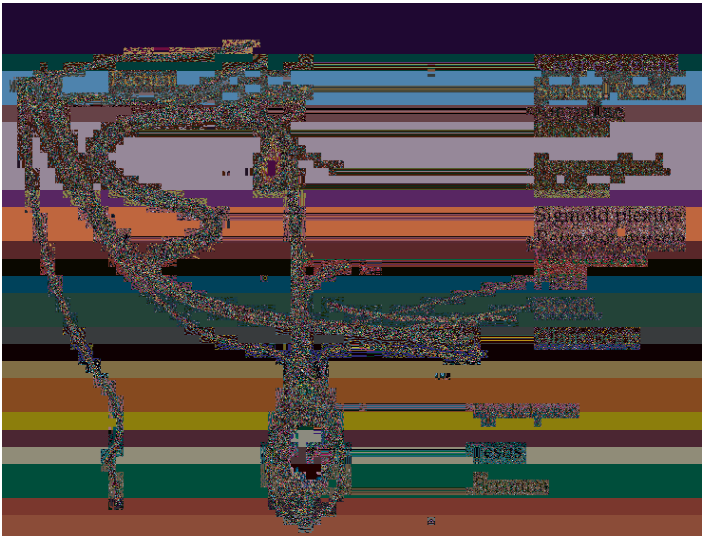


Fig. 9.1 : Structure of male reproductive system

9.3.1.3. Spermatic cord

The spermatic cord composed of blood vessels, nerves and tubes necessary to carry sperm from the testes to the urethra.

9.3.1.4. Epididymis

Epididymis is a long convoluted single tube attached to the testes. It is divided into three parts viz., caput (head), corpus (body), and cauda (tail). The sperms get mature during transmit through the epididymis. The cauda epididymis is the principal storage organ and provides factors that enhance the fertilizing ability of the sperm. From the cauda epididymis sperms are transported to the vas deference.

9.3.1.5. Vas deferens

Vas deferens is a long muscular tube extends from tail of epididymis to the neck of bladder where it joins with urethra. It carries sperms from epididymis to urethra during ejaculation. It passes through the inguinal ring into the body cavity as part of the spermatic cord. It opens into the utretha through ampulla. The ampulla produces and secretes small amount of fructose and citric acid to the seminal fluid.

9.3.1.6. Urethra

Urethra is a single tube like structure formed by the union of two vas deferens, originating from each testis. It passes through the penis to the tip of glans penis as the external urethral orifice. It serves as a common passage of semen (from reproductive tract) and urine (from urinary tract).

9.3.1.7. Accessory sex glands

Accessory sex glands include vesicular glands, prostate gland and bulbourethral (cowper's) glands. These glands are located along the pelvic portion of the urethra and ducts of these glands open to the urethra which contributes volume of semen and acts as liquid vehicle for the transport of the sperms. Secretions of these glands provide nutrition, buffering capability and other substrates to maintain motility as well as fertility of sperms.

9.3.1.7.1. Vesicular glands (seminal vesicles)

Paired vesicular glands are open near the bifurcation where ampullae (terminal part of vas deferens) merge with the urethra. They contribute about half of the total fluid volume of semen and supply fructose and sorbitol as sources of energy for sperms. The secretion also helps to maintain the pH of the semen with the provision of both phosphate and carbonate buffers.

9.3.1.7.2. Prostate gland

Single prostate gland is situated at the neck of the urinary bladder where it opens into the urethra. It contribute small amount of secretions which is high in inorganic ions like sodium, chlorine, calcium, and magnesium.

9.3.1.7.3. Bulbourethral (Cowper's) glands

Paired small Bulbourethral glands are located on either side of the urethra. Their secretion is hardly contributed to the part of semen. However, their secretion helps to flush urine residue from the urethra before ejaculation, as urine might be harmful to spermatozoa. These clear secretions often drips from the prepuce just before ejaculation.

9.3.1.8. Penis

The penis is the organ of copulation. The penis starts at the dorsal part of the urethra where it leaves the pelvis and extends upto glans penis (free end of the penis). The glans penis is richly supplied with nerves and is the source of the sensations associated with copulation and is homologous to the clitoris of the female. A sigmoid flexure, an S-shaped configuration present in the penis which allows penis to retract (at normal condition) and extend (at excitement) with help of a pair of strong retractor muscles called the "ischiocavernosus muscle". The corpus cavarnosum of the penis consist of large cavernous spaces. During sexual excitement these spaces are filled with blood that facilitates relaxation of the retractor penis muscle which allows the sigmoid flexure to straighten and so penis is extended. The length of the penis is about 3 feet and the diameter is about 1 inch.

9.3.1.9. Prepuce

The free end of the penis is covered with an invagination of skin (a sheath) called as prepuce. Prepuce is divided into pre-penile portion or outer fold, and penile portion, or inner folds. The prepuce is surrounded by long and tough preputial hairs.

9.3.2. Female reproductive system

Basic functions of the female reproductive system are production of ovum, creation of suitable environment for fertilization, growth and development of the foetus, and ultimately birth of new born.

Reproductive tract (Fig. 9.2) of the cow consists of vulva, vestibule, vagina, cervix, uterus, oviducts and ovaries. Except vulva rest of the part of the reproductive tract remain inside the body. The reproductive tract is located parallel to and just beneath the rectum. This position of reproductive tract is helpful for palpation through rectum.

9.3.2.1. Vulva

Vulva is the only part of the female reproductive tract, remains outside the body. It is external vertical opening of genital tract, having two lateral vulval lips- labia majora and labia minora. During oestrus vulva swell and become red due to increased blood flow. The labia majora contains plenty of sebaceous and tubular glands which are especially active during sexual excitement. These changes along with other signs can be helpful in estrous detection.

9.3.2.2. Vestibule

Vestibule is the part of the reproductive tract shared with the urinary system. The vestibule joins the vagina at the external urethral orifice. A blind sac just posterior to the external urethral orifice is called the suburethral diverticulum.

9.3.2.3. Vagina

Vagina is the copulatory organ of the female. It extends from external uterthral orifice to the cervix, about 6 inches in length. Vaginal epithelium secretes fluids which combine with cervical fluids inhibit growth of undesirable bacteria, thereby protect the internal delicate reproductive organs. Bull deposits semen in the vagina during natural service.

9.3.2.4. Cervix

Cervix is the connecting link between vagina and uterus. The interior of the cervix contains four to five muscular rings or folds (transverse interlocking ridges) which are called annular rings. The folds make an impervious seal to protect the uterus from the external hostile environment except at the time of oestrus and parturition.

9.3.2.5. Uterus

The uterus (figure-9.2) is a muscular Y shaped structure of the reproductive organ consists of a short body and two (right and left) long uterine horns (cornua). The uterus is suspended by the broad ligament in a coiled or curled manner. The uterine wall has three layers- outer survosa, middle muscularis and inner mucosa. The inner mucosa of uterus contains a number of raised spots called caruncles which develop into cotyledons during pregnancy, and is provided with uterine glands to secrete uterine milk for early nutrition of the embryo.

The functions of the uterus are

(a) Sperm transport from the site of ejaculation to the site of fertilization in the oviduct.

(b) Regulation of corpus luteum (CL) function.

(c) Initiation of implantation, pregnancy and parturition.

(d) Uterine glands secretion (uterine milk) provides nutrition to the early embryo.

9.3.2.6. Oviduct (fallopian tube)

The oviduct is a convoluted tube which extends from tip of uterine horn to the ovaries. Fallopian tube is divided into three parts, viz., isthmus (attached to the uterine horn), ampulla and infundibulum (funnel shaped structure partially covering ovary). In the oviduct the ova and spermatozoa move in the opposite direction i.e., ova move towards the site of fertilization (ampulla-isthmus junction) after shedding from the ovary and spermatozoa move towards this site from the site of ejaculation. Their functions include transport of ova and spermatozoa, ovum maturation, sperm capacitation, sperm hyperactivation, fertilization and early pre-implantation development of embryo.

9.3.2.7. Ovary

Ovary is the primary reproductive organ of the cow. It is almond-shaped, 1 to 4 cm long and 1 to 3 cm in diameter. The size of the ovary varies depending on the stages of oestrous cycle. The ovary is composed of medulla and cortex, surrounded by the superficial epithelium called germinal epithelium. Just beneath the germinal epithelium a connective tissue layer is present known as tunica albuginea. The cortex contains ovarian follicles and/or CL at various stages of development or regression. The medulla consists of fibroelastic connective tissues, nerves and blood vessels. Two ovaries are related with the respective uterine horns.

Major functions of the ovaries are to

- produce egg (ovum)
- secrete hormones (estrogen and progesterone) which control growth of ovum, oestrus behaviour, prepare reproductive tract for pregnancy

Fig. 9.2 : Structure of female reproductive tract

9.4. HORMONES OF REPRODUCTION

9.4.1. Hormones Associated with Male Reproduction

Testes function like endocrine gland. The interstitial cells (Leydig cell) produce male sex hormone, androgen (testosterone) and a small quantity of estrogen. The synthesis of testosterone is under the control of LH (leutinising hormone) produced by anterior pituitary gland. Follicle stimulating hormone (FSH) helps in spermatogenesis. The blood testosterone level in turn regulates the secretion of the gonadotropic hormones (FSH and LH) by means of a feedback mechanism. A proper balance of all hormones is vital for successful reproductive functions.

Testosterone controls the function of male reproductive system through various effects like:

- It is responsible for the development of the male reproductive tract.
- It causes the development and maintenance of the secondary sex characteristics associated with "masculinity," of the bull.

- It is responsible for manifestation of libido and sexual behaviour.
- It is essential for spermatogenesis and semen ejaculation.

9.4.2. Hormones associated with female reproduction

Hormone of Hypothalamus: The key hormone which regulates the reproduction of cow is gonadotropic releasing hormone (GnRH), a peptide hormone.

Hormone of Anterior Pituitary: GnRH is secreted from the hypothalamic neurosecretory cells in pulsatile manner and influences the release of follicle stimulating hormone (FSH) and leutinising hormone (LH) from anterior pituitary. FSH stimulates development and maturation of the Graafian follicles. In turn, the follicle secretes estrogen under the influence of FSH and LH. Further, increased concentration of estrogen may cause increased sensitivity of the hypothalamus to increase secretion of GnRH. Contrary to this, if progesterone concentration increases, it decreases the secretion of GnRH. Therefore, estrogen and progesterone has opposite action on the secretion of GnRH. LH acts on fully developed Graafian follicle, thereby ovulation takes place. LH also helps in the leutinisation process of the granulosa cells of the rupture follicle and helps in the formation of corpus leutium (CL). CL secretes progesterone.

Hormone of Ovary and Placenta: Estrogen and progesterone are the two steroid hormone secreted from the ovary. Estrogen is secreted from Graafian follicle and placenta in case of pregnant animals. This hormone is helpful for the development, maintenance and cyclical changes of the female genital tract and expression of the sexual behaviour. Estrogen is also responsible for ductal and lobular development of the mammary glands. Under the influence of LH, fully mature follicle ruptures and releases ovum. Rupture follicle then converted into CL, an endocrine organ. CL secretes progesterone. During pregnancy placenta also secretes progesterone. In the presence of estrogen, progesterone prepare reproductive tract for the implantation of the zygote and maintain pregnancy. Progesterone is also helpful in the glandular development of the mammary gland.

Hormone of Uterus: Uterine endometrium secretes prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$), a natural luteolytic agent. $PGF_{2\alpha}$ regresses CL and thereby causes initiation of another oestrous cycle in absence of fertilization. It is also responsible for early termination of pregnancy.

9.4.3. Puberty

Puberty may be defined as the age of onset of reproductive life. The puberty of the animals depends upon the age and body weight. Cattle generally reach puberty at about 12 months of age.

In male, puberty is initiated with the secretion of androgen (testosterone) from the testis and become evident with the secretion of semen containing very less number of sperms.

As the female attain proper age and adequate growth, pre-pubertal gonads starts secreting estrogen at higher concentration. Higher estrogen concentration provides positive feedback to the hypothalamus. There is a sudden gonadotropin surge involving both hypothalamus and pituitary. Gonadotropins act on the ovary and therefore start secreting ovarian hormones. These hormones help in the growth and development of reproductive organs and at last onset of their functional activity, which is expressed by the first estrus. First estrus may or may not release ova. When the animals reach complete structural as well as functional development i.e., attaining full reproductive capacity is termed as "sexual maturity'. Puberty and sexual maturity of the animals are depended upon several factors like breed, nutrition, climate etc.

9.4.4. Post-pubertal Reproductive Events

As the animal reaches puberty a number of important reproductive events starts with are associated with its reproductive performance. The reproductive events are discussed as follows.

9.4.4.1. Gametogenesis

The animal starts producing gamete when they become sexually mature. The process by which germ cells become gamete is called gametogenesis. In male, it is called spermatogenesis (as end-product is sperm) and in female it is called as oogenesis (as end-product is ovum).

9.4.4.1.1. Spermatogenesis

Spermatogenesis is a process by which spermatogonia (2n) are converted to mature spermatozoa (n). In this process, the developing germ cells (stem cells), present in the seminiferous epithelium begin the development process as spermatogonia (2n), becomes spermatocytes and finally spermatids (n) which mature into spermatozoa (n).

The spermatogenesis consists of three stages:

(a) **Spermatocytogenesis**: Repeated division (mitotic) of the spermatogonia leads to development of primary spermatocytes and replenishment of the spermatogonia pool maintained.

(b) **Meiosis**: Primary spermatocytes undergo meiotic division. It plays two significant role i) reduction of chromosome number from diploid (2n) to haploid (n), and ii) exchange of genetic materials between the homologous pair of chromosomes. Thus, one primary spermatocyte produces four spermatids.

(c) **Spermiogenesis:** The process of formation of spermatozoa from spermatid. In this process the spermatozoa are formed from spermatids through a progressive series of structural developmental changes.

After formation, the spermatozoa are attached to the sertoli cells for physiological and mechanical changes. After 6-7 days spermatozoa get detached from sertoli cells and reach the epididymis through rete testes for further development and maturation. After reaching puberty the whole process continues and produces billions of sperm daily (Fig. 9.3).

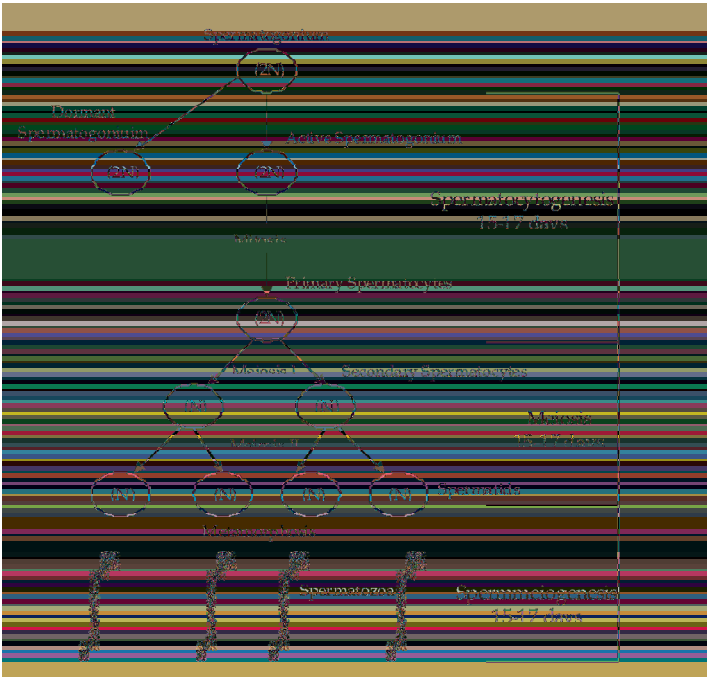


Fig. 9.3 : Diagram illustrating Spermatogenesis in bull (2N=Deploid, 1N=Haploid) Spermatogonium

9.4.4.1.2. Oogenesis

Oogenesis (Fig. 9.4) is a process by which female germ cell or oogonium (2n) develops and matures into ovum (n). Oogenesis occurs simultaneously with the folliculogenesis (follicular growth and development). It differs from spermatogenesis where at end four functional spermatozoa are formed but in oogenesis only one functional ovum and three polar bodies (non-functional) are formed.

The ovarian cortex contains ovarian follicles at different stages of development. Primary oocyte is present inside the primordial follicle surrounded by single layer of follicular cells (granulose cells). Mitotic division of the oogonium starts at prenatal period (before birth). The size of the oogonium increases by storing carbohydrates, lipids and proteins. A 'yolk' is formed within the oogonium by storing a protein and lipid rich substance which is used by the developing embryo as its food. This large-sized oogonial cell undergoes prophase of the first meiotic division (meiosis-I) around the time of birth and is called as primary oocyte. At birth their numbers are about 1 lakhs.

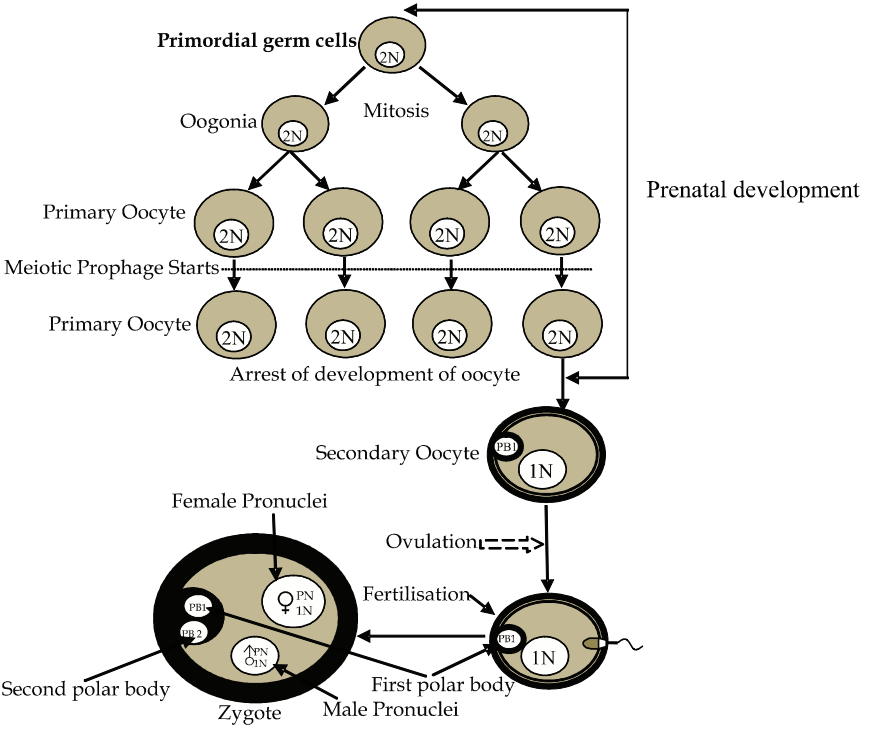


Fig. 9.4 : Diagram illustrating oogenesis in cow (2N= Deploid, 1N= Haploid)

(*Source* : Dukes' Physiology of Domestic Animals, 12th edition, Panima Publishing Corporation, New Delhi, India)

Thereafter, the primary oocytes remain inactive with arrested developmental process. After reaching the sexual maturity, few hours before ovulation, first meiotic division is completed and resulted in a haploid very smaller cell, the primary polar body and a haploid larger cell, the secondary oocyte. The secondary oocyte undergoes meiosis II and produces a large-sized yolk-rich oocyte and a secondary polar body. When second meiotic division reaches to metaphase stage, ovulation takes place. Until ovulation, all the developmental stages of oocyte occur within the follicle. The primary polar body also divides by meiosis II resulting into two secondary polar bodies. All these three secondary polar bodies are soon degenerated. Inside the fallopian tube oocyte completes second meiosis (maturation) division.

9.4.4.2. Oestrous cycle (female)

A cyclical, regular, repetitive change of morphological, secretory and endocrinal activities of ovary as well as genitalia is known as oestrous cycle.

On attainment of the puberty female shows rhythmic pattern of physiological events in the form of (i) morphological changes of reproductive system and (ii) behavioural changes in the animal. These changes are cyclical, repetitive and continuous until there is pregnancy. At specific phases of this changes female exhibits signs of sexual receptivity, termed as oestrus or heat. It is characterized by the animals being willing to be mounted by other cattle, both male and female. The series of events occurring between two oestrus, is termed as oestrous cycle. Average oestrous cycle length of cows is 21 days. The oestrous cycle passes through a series of events like follicular development and maturation, ovulation, CL formation and CL regression.

9.4.4.2.1. Phases of oestrous cycle

Oestrous cycle (Fig. 9.5) is divided into four different phases viz., proestrus, oestrus, metoestrus and dioestrus. Proestrus and oestrus phases are associated with the development as well as maturation of follicle under the strong influence of oestrogen. These phases are jointly called as follicular phase. However, metestrus and diestrus phases are associated with the formation of corpus luteum (CL) and synthesis of progesterone from CL. These phases are jointly called as luteal phase.

(**a) Proestrus :** Proestrus initiates along with the regression of CL and thus drop in progesterone concentration. There is certain increase of oestrogen hormone which helps in the maturation of the follicle through the secretion of FSH from anterior pituitary gland.

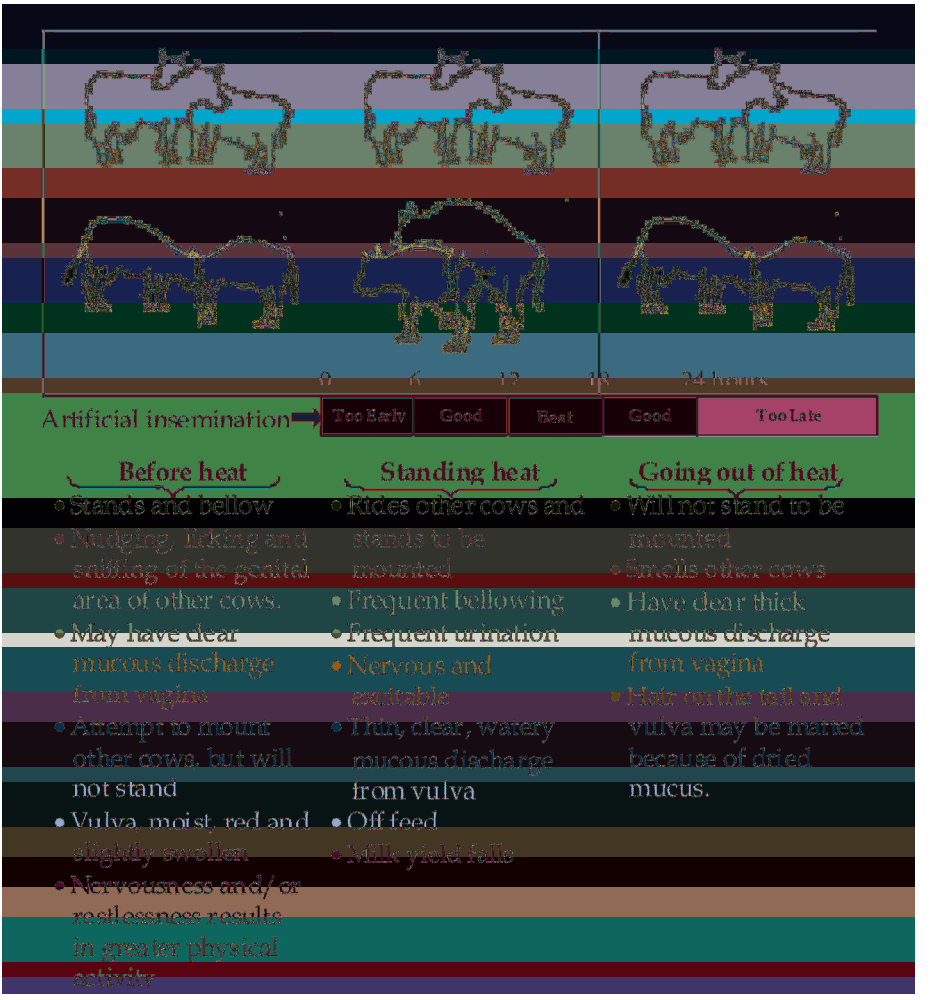


Fig. 9.5 : Signs and symptoms of oestrus

(b) Oestrus : Oestrus is the time when female is receptive to the male and mating results in a successful pregnancy. This phase lasts about 18 hours. Intense sexual behaviour is observed during this phase of the oestrous cycle. The vaginal and cervical mucus secretion is greatly increased. Thin, clear, watery mucous discharge is visible hanging from vulva or wrapped around the tail. The day of oestrus is usually designated either as day 0 or day 1 of the cycle, depending on individual preference.

(c) Metestrus : Metoestrus phase begins with cessation of oestrus. This period lasts for about 3-4 days. Ovulation takes place during metestrus, 10-12 hours after the end oestrus due to the surge of luteinizing hormone (LH). Corpus luteum is formed from the rupture

of mature follicle. Estrogen concentration sharply decline. In some cows, bleeding occurs during this phase, however, this is no way related to conception or failure of conception. During metestrus, prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) is not effective for luteolysis because CL is immature, growing and non-responsive to $PGF_{2\alpha}$. However, luteolysis of CL can be achieved by large doses of estrogen at this phase.

(d) Diestrus : About 5th day of cycle this phase starts. CL becomes fully functional during this phase. CL secrets progesterone, thus its concentration in the blood increases. At day 16 to 17, regression of CL takes place due to the action of $PGF_{2\alpha}$.

9.4.4.3. Ovulation

Ovulation can be defined as release of ovum from the graafian follicle (Fig. 9.6). In the follicular phase of the oestrous cycle the dominant follicle become mature under the influence of FSH hormone. Granulosa cells of the mature follicle continuously secrete follicular fluid. Increased follicular fluid creates pressure, leads to the bulging and subsequently thinning of the follicular wall. The ovulation process is under the control of LH hormone. After the end of the oestrus there is LH surge which causes secretion of oxytocin and prostaglandin in the uterus. These hormones cause contraction of smooth muscles of ovarian stroma. Ultimately rupture of the follicle occurs and ovum releases. Usually single ovum is discharged at a time. It takes about 10-12 hours after the end of the heat. The process of ovulation is spontaneous in cow. Among the two ovaries, ovulation most commonly takes place from the right ovary.

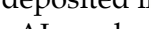
Fig. 9.6 : Structure of graafian follicle

9.4.4.4. Gamete transport

9.4.4.4.1 Ovum transport

At the time of ovulation the fimbriated end (infundibulum) of oviduct come in close contact with the ovarian surface and pick up the ovum. Ovum is transported towards the site of fertilization (ampullary isthmus junction) with the cilliary movement of the mucosa and peristaltic contraction of the uterine muscle. Ovum remains viable for 12-24 hours. For successful fertilization sperm should reach the site and prepare for fertilization within this time limit.

9.4.4.4.2. Sperm transport

During mating the semen is deposited in the vagina. However, in artificial insemination (AI) semen is deposited i 

x or on the body of the uterus. Mating or AI produces reflex action which in turn release oxytocin from posterior pituitary. This stimulates contraction of the uterine muscles. These contractions drive the motile sperm towards utero-tubal junction within a few minutes (rapid phase of transport). Cervix and utero-tubal junction both act as barrier of spermatozoal transport as well as reservoirs of spermatozoa for sustained release. Sperm transport in the female reproductive tract occurs rapidly and in sustained phases. A significant number of spermatozoa are lost due to phagocytosis by the neutrophils during transport which increase at the time of oestrus due to increase blood flow to the reproductive tract. Neutrophils also engulf the microbes entered during mating or AI.

Sustain release or slow release of sperm ensures continuous availability of sperm at the fertilization site. From cervix to the utero-tubal junction, spermatozoa do not transport through its own motility, rather it is dependent on the uterine muscular contraction and fluid flow. After reaching the utero-tubal junction spermatozoa movement is dependent on their own motility. Spermatozoa having poor motility, abnormality or any other defects are usually screened out in the barrier. Therefore, only viable and very less percent spermatozoa reach at the site of fertilization. Slow release of spermatozoa from the reservoir also reduces the number of spermatozoa reaching the site of fertilization at a time, which perhaps prevents polyspermy (fertilization of ovum with more than one sperm).

9.4.4.5. Fertilization

Fertilization is the process of union of male and female gametes to form a single cell called zygote. Just after mating or insemination some sperms reach at the site of fertilization within 2-10 minutes. But the sperms must go through certain bio-chemical changes called capacitation to attain fertilizing ability. Capacitation takes place in the isthmic region of the oviduct. Capacitated sperm reaches the ampullary region of the oviduct and become hyper-activated. This event increases chance of contact with the ovum. In the presence of ovum, capacitated sperms undergo another morphological change termed as "acrosome reaction (AR)". AR causes releace of enzymes like acrosine, hyaluronidase etc. which are needed for the passage of sperm through the zona. The capacitated and acrosome reacted sperm-head then penetrate the cumulus oophorus of ovum and attach with zona pellucida. Within 5-15 minutes after attachment the sperm penetrate zona by the sperm motility and action of acrocin enzyme (released from acrosome). Then sperm head attach to the vitelline membrane and thus oocyte is activated. Plasma membranes of the sperm and ovum are intermixed. The AR is a prerequisite for fusion between ova and spermatozoa plasma membrane. Immediately after fertilisation, zona pellucida undergoes certain changes which prevents the entry of any other sperm and takes part in the fertilization process (block to polyspermy). By the time, ovum completes meiosis and extrude second polar body to the perivitelline space. Male chromosome condenses and fusion takes place with the female pronuclei which is called zygote. This marks the completion of the fertilization process. Combination of male and female gamete restores the diploid state.

Fertilisation may fail due to:

- aging or death of the egg before sperm entry at the point of fertilisation
- aging of sperm
- abnormality in the gametes (sperm or egg)
- abnormality in female genital tract which prevents the sperm or egg to reach at the site of fertilisation
- diseases of the reproductive tract.

The gender of the offspring depends upon the participation of male gamete (sperm) in the fertilization process which is either X or Y chromosome. As female gametes (ova) only carry X chromosome, it

does not play any role in the process of determination of sex. X chromosome bearing sperm will produce female offspring (XX), where as Y chromosome bearing sperm will produce male offspring (XY) after uniting with the ovum (X).

After fertilization development process of the zygote starts. Zygote, one cell stage divides into two-cell embryo through mitotic division within two days of fertilization. This process is called cleavage. The cell division continues and 4, 8 and 16-cell embryo forms (figure-9.8) within another two days inside the oviduct. After that the embryo moves towards uterus, which now prepares to support for the growth and development of the embryo. Each cell of the embryo is called blastomere. Upto 8-cell stage embryo, blastomere remains totipotent (capability of giving rise to an intact embryo). At 16-cell stage the embryo becomes compact and is called as morula, because of its resemblance to mulberry. As embryo further develops accumulation of fluid occurs within the central cavity called blastocoel and the total cell mass is called blastocyst.

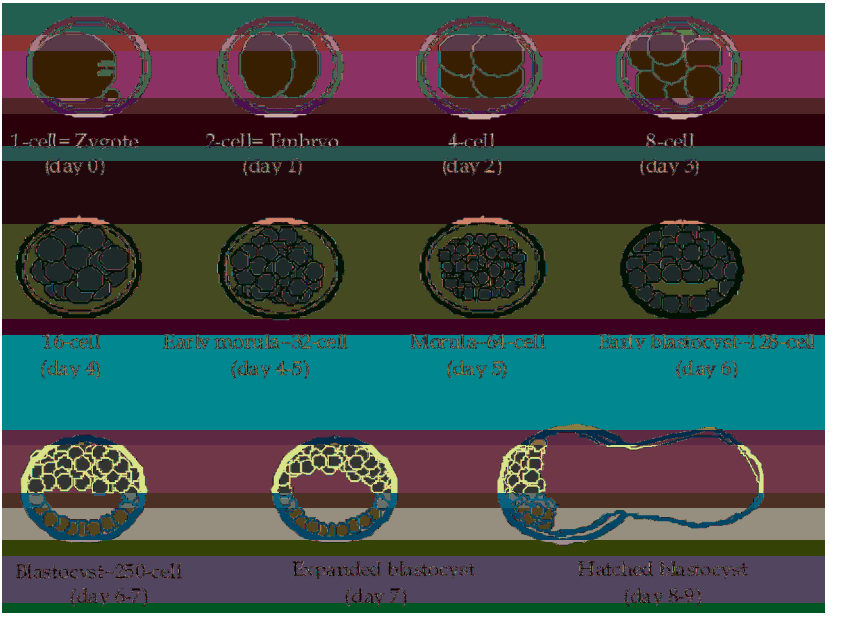


Fig. 9.7 : Different stages of embryo development from fertilisation

9.4.4.6. Corpus luteum (CL) formation and maintenance

Rupture of the graafian follicle causes ovulation which leads to the formation of cavity in the ovary. Initially the cavity is full of

haemorrage and called as corpus haemorrahgicum. The remnants of rupture follicle containing theca and granulosa cells (figure-9.3) develop into luteal cells by the action of LH hormone. Luteal cells then invaded by the blood capillaries and form a mature CL. The mature CL is called corpus luteum spurium in non-pregnant cycling animals and corpus luteum verum in pregnant animals.

CL acts as temporary endocrine structure. It secretes a hormone, progesterone. In pregnant animal the CL secretes progesterone with a greater intensity and remains throughout the pregnancy period. In non-pregnant cyclic animal the life of the CL is limited. It secretes progesterone until it undergoes luteolysis (about 16^{th} day of cycle) by the action of $PGF_{2\alpha}$, secreted by the uterine endometrium.

9.4.4.7. Pregnancy

Pregnancy period starts with the fertilization (formation of zygote) and ends with parturition (expulsion of foetus). After fertilization, zygote passes through various developmental and maturation stages, and ultimately form foetus (conceptus). The conceptus can be defined as an embryo or fetus along with all the tissues that surround it throughout pregnancy, including the placenta, amniotic sac and fluid, and the umbilical cord. The life of conceptus can be divided in to two phases:

Period of embryo: Zygote undergoes cleavage and rapid cell differentiation takes place. Until organogenesis and placenta formation starts, the conceptus is called embryo. Within 4-5 days the free living conceptus (blastocyst) reaches the uterus and nourished by the "uterine milk" (a secretion of uterine glands composed of protein, fat and traces of glycogen). At this stage it is covered with zona pellucida. At about 9 days, the embryo come out from the zona is termed as "zona hatching". At about 30-35 days of embryonic life, the embryo starts attaching gradually to the uterine wall (called "implantation") and formation of placenta starts.

Period of foetus : In this period placental growth continues. The placenta is formed by foetal tissue and uterine tissue of dam. It provides communication between dam and foetus for nutrients, gaseous and waste exchange. This period is ended with the parturition.

The hormone, progesterone is essential for the maintenance of pregnancy which is secreted initially by CL and later by CL and/or placenta.

9.4.4.8. Parturition

Parturition is the physiological process of expulsion of foetus and placenta after completion of development of the foetus in the uterus.

A number of hormones responsible for the parturition process viz., cortisol (from foetal adrenal gland), oxytocin, oestrogen, progesterone, PGF_{2a} etc. Their actions are depicted in the figure-9.9.

Signs of parturition :

A wide range of parturition signs are found in cattle and these are enumerated below:

- Swelling of udder
- Entire external genital organs become reddish and swollen
- Animals looking for solitary place
- Sign of anorexia and distress
- Cow feels uneasy, bellows and sometimes become excited.
- Just before parturition body temperature drops

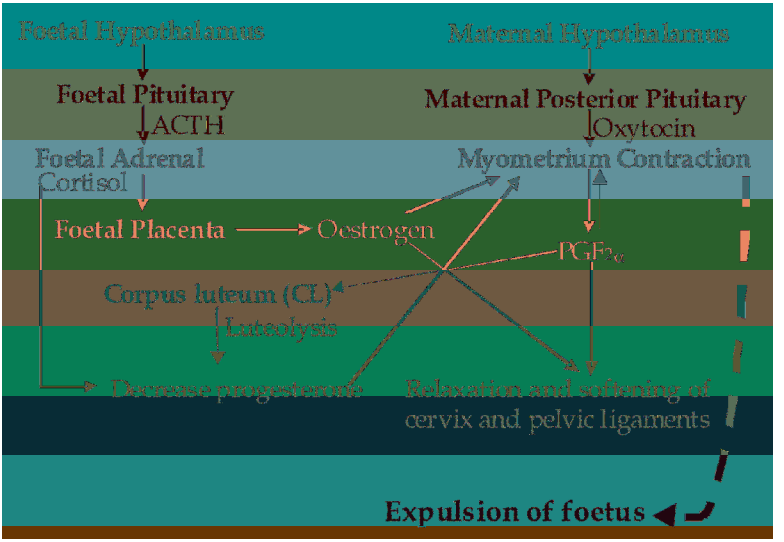


Fig. 9.8 : Hormonal control of parturition

9.5. SUMMARY

Efficient reproduction of both male and female is needed for sustainability of the dairy farm. Without reproduction there will be no pregnancy, lactation, nor replacements for the future. For efficient

reproduction the male and female reproductive system should be sound. The animals should reach puberty and sexual maturity at an early age and this reduces the unproductive life as well as generation interval. Proper secretion of reproductive hormones is essential for occurrence and exhibition of normal reproductive events in an efficient manner. The reproductive events include good libido and efficient sperm production in male, proper exhibition of sign and symptoms of heat, ovulation, fertilization, maintenance of pregnancy, parturition in female.

9.6. CHECK YOUR PROGRESS

(a) Enlist the accessory sex glands of male.

(b) Name the hormone secreted by the mature follicle.

(c) What is fertilization?

(d) What is corpus luteum (CL)?

(e) Name the hormones responsible for the process of parturition.

9.7. ANSWERS TO 'CHECK YOUR PROGRESS'

(a) Accessory sex glands include vesicular glands, prostate gland and bulbourethral (cowper's) glands.

(b) Oestrogen.

(c) Fertilization is the process of union of male and female gametes to form a single cell called zygote.

(d) Rupture of the graafian follicle causes ovulation which leads to the formation of cavity in the ovary called corpus luteum.

(e) The hormones responsible for the parturition process are cortisol, oxytocin, oestrogen, progesterone, PGF_{2a} etc.

9.8. EXERCISES AND QUESTIONS

(a) Draw and label the different parts of male reproductive system.

(b) Draw and label the different parts of female reproductive system.

(c) Discuss gametogenesis.

(d) Discuss the different phases of oestrous cycle.

(e) Discuss in detail about the transport of both male and female gametes.

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CHAPTER - 10

Reproductive Techniques

10.1. INTRODUCTION

During last few decades dairy animal production has been intensified several folds, along with this reproductive problems have also increased. For efficient dairy animal production, the cow should show regular reproductive activities like cyclic breeding activity, pregnancy at appropriate time, give birth of a live healthy calf and again pregnant after sometimes. If any of these activities are inadequate, then it substantially affects the profitability of the farm. There is an ample scope of improvement of these reproductive setbacks through traditional breeding, feeding and management. However, reproductive problems can be minimized by the use of recently developed reproductive techniques. It not only minimizes reproductive problems, but also improves the reproductive efficiency of the dairy herd and better exploitation of the genetic potential of high merit animals.

10.2. OBJECTIVES

The objectives of application of reproductive techniques in dairy animal productions are as follows

- To exploit full reproductive potential of the animals.
- To solve problems of heat detection
- To detect pregnancy at earliest and therefore better management can be provided to the animals.
- To use superior genetic potential of a cow to a maximum extent through the embryo transfer (ET).

- Efficient use of bulls through the use of artificial insemination (AI)
- To reduce reproductive culling rate.

10.3. REPRODUCTIVE TECHNIQUES

Commonly use reproductive techniques are discussed as follows:

10.3.1. Heat Detection Techniques

Heat (oestrus) detection is the single most important component of reproductive management. Accurate heat detection is very much essential to maintain a 12-month calving interval. Under natural condition, male has the ability to detect the female in heat through sensorial ability and mating takes place in time. In intensive production system, natural mating is discouraged especially in dairy cattle. Cows are inseminated artificially either by liquid semen or cryo-preserved semen (called artificial insemination; AI). As the insemination activity is human driven, therefore detection of heat period of particular cow has immense importance to conduct AI and ensure pregnancy. Proper timing of insemination is important as improper timing fails to make cow pregnant. When cows are confined in a place, oestrus expression is not so intense, sometimes not visible or unnoticed, even teaser bulls are unable to detect. The weak oestrus activity is also closely related to the productivity and the genetic make-up of the cow. If the cow could not achieve pregnancy at proper time, there will be increase of open period. As the open period increases, calving interval increases and therefore, the profitability of a dairy farm decreases drastically. AI in the developing countries has not been popularized because of unsatisfactory heat detection efficiency. Heat detection would only be successful in the following conditions; i) proper identification of cows, ii) maintenance of breeding records, iii) trained personnel and iv) spending sufficient time to observe oestrus sign and symptoms.

Following are the methods commonly applied to large as well as small dairy farms.

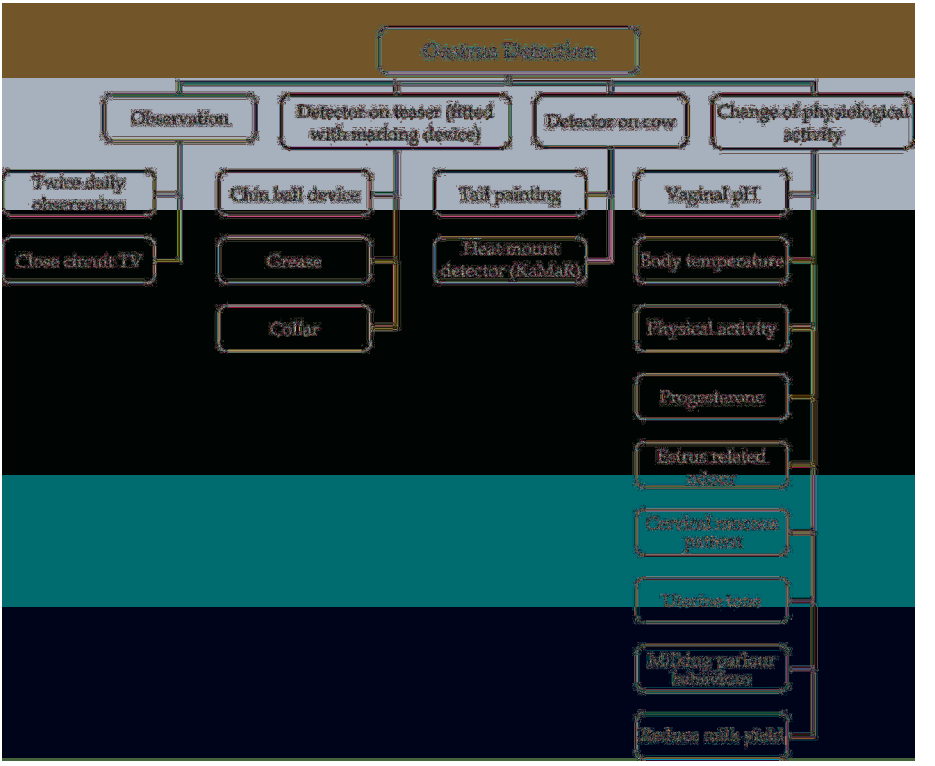


Fig. 10.1 : Various heat detection techniques

(*Source* **:** Reproduction in farm animals, 7th edition by Hafez and Hafez)

10.3.1.1. Observation

It is the easiest as well as efficient technique for detection of heat. Maximum oestrus activity occurs during night time (6PM to 6AM), during the cooler parts of the day, when cows are more active. Observation should be carried out for at least 30 minutes at a stretch, two to three times daily, especially in the early morning and late evening or night time. Mounting activity of the oestrus cow mostly found when she is not distracted by farm activities such as feeding and milking. Some large commercial farms install close circuit TV, which record all the activities of the animals throughout day and night, and the cows in oestrus can easily be identified. For this identification mark of the animals should have good visibility.

10.3.1.2. Detector on teaser

Usually bull or bullocks are used as teaser, however cows having cystic ovary treated with androstenedione may also be used. Bulls

which are surgically vasectomised or deflected penis and bullocks treated with estrogen are generally used as teaser. Some farm allow the teaser to the cow's herd only in a particular time and observers watch and note down cow number to whom the teaser mount. In medium size farm it may be possible as there will be only few animals in heat on a particular day. However, in large farm the teaser is usually fitted with some marking device and allowed to stay with the cow's herd throughout the day, so that it creates marks over the cows when mounting. Marking device is attached to the chin (chin ball mating device), brisket (grease) and collar (pad soaked in dye or grease).

Although the efficiency of heat detection by the teaser is good, however, these methods have some drawbacks like extra cost for feeding and mangemenent of the teaser animals, cost of surgery and/or drug used. Sometimes it is very much dangerous for the worker as control of teaser is difficult.

10.3.1.3. Use of detector on cows

This method is based on the standing animal allowing to be mounted by other animals. The detector is fitted over the cows, likely to be in heat. Heat mount detector (KaMaR) attached in front of the tail head. Pressure from the mounted animals releases dye from the detector. An oil or water based paint is applied to the back of a cow. Any change of colour is visible to the observer and particular animal in heat can be identified.

10.3.1.4. Change of physiological activity

Around the time of oestrus there is marked change in physiological activities of the cows. Vaginal pH decreases significantly. Body temperature increases slightly (0.5 to 0.8°C). Physical activity of the animals markedly increases which can be measured by using pedometer. Progesterone level in the blood as well as in the milk reaches to the base level. Odour developed related to oestrus can be detected by trained dogs. Typical fern pattern of the cervical mucous can be detected. Change of uterine tone can easily be palpable by rectal palpation. The oestrus cows show sudden change in parlour behaviour with more restless activity. There is marked reduction of milk yield.

10.3.2. Pregnancy Diagnosis

Detection of pregnancy in cows at earliest after breeding is directly related to the overall productivity, ultimately profitability of the dairy

farm. Main objective of pregnancy diagnosis is the identification of the non-pregnant one.

The animal owner may sometimes be misguided by the signs of pregnancy even if the cow is not pregnant. Therefore, it is important to check the cow for true pregnancy, so that better managemetal facilities can be provided to the pregnant cows. If the cow is not pregnant, she would be treated for infertility or any other reproductive disorders if present. This helps in shortening of the unproductive period of a cow. Therefore, precious time of the cow's life can be saved, otherwise wasted. If the problem is not curable, then culling of the cow is the only way. The method of pregnancy diagnosis should be inexpensive, highly accurate.

The principle of pregnancy diagnosis of dairy cattle depends upon the principle of either exhibition of sign and symptoms of pregnancy or detection of certain pregnancy related hormone.

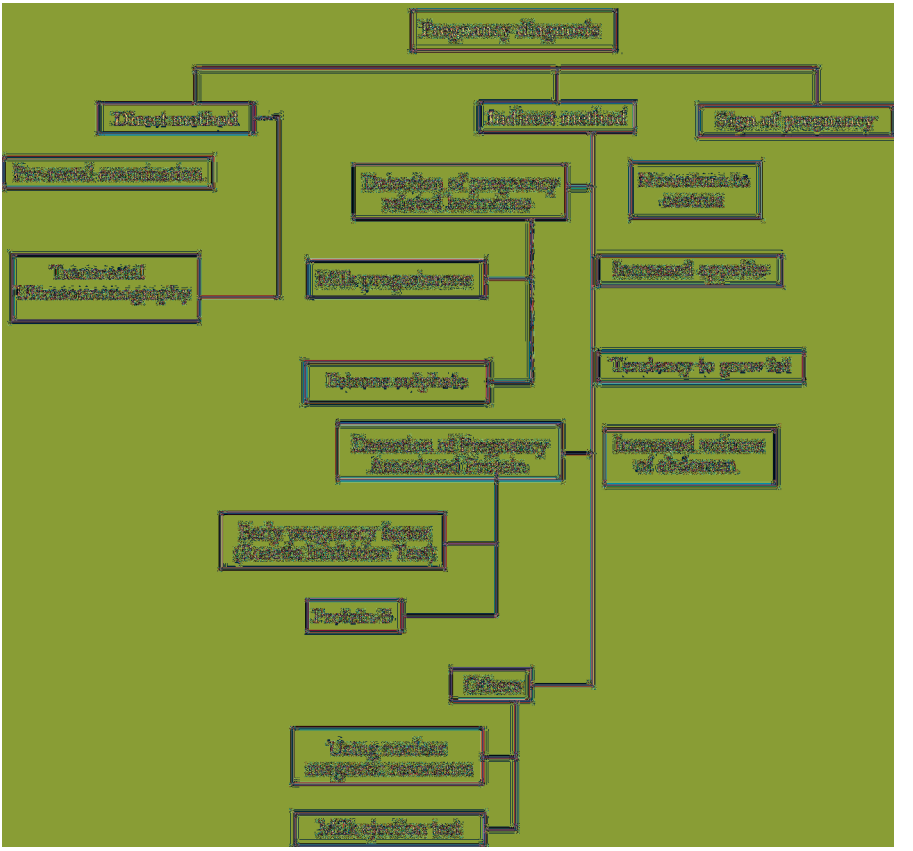


Fig. 10.2 : Various pregnancy detection techniques

A. Exhibition of sign of pregnancy

Signs of the pregnancy should be looked and judged carefully, as signs do not give clear indication of pregnancy. The signs are

a. **Non-return to oestrus:** If the cow does not exhibit oestrus 21-24 days after breeding, then it can be assumed that the cow become pregnant.

b. **Increased appetite:** Appetite of the animal increases as the pregnancy advances.

c. **Tendency to grow fat:** Pregnant animals have a tendency to grow fat.

d. **Increased volume of abdomen:** At last stage (trimester) of pregnancy there is significant increase in abdominal volume

B. Direct methods

As the name indicates, direct method involves direct detection of the tissues and/or associated fluids of the foetus either manually or via electronic instrumentation.

a. Per-rectal examination

Per-rectal palpation of the female reproductive organs is the most common, efficient and fast method of pregnancy diagnosis. It is usually performed between 35 and 42 days after breeding.

Palpation process

The animal is restrained in the service crate. Most of the people use left hand for rectal palpation, although either hand can be used. After put on full sleeve on the hand, apply some lubricant over the gloves. Then insert hand gently into the rectum of the cow. Rectal contraction prevents the hand to make the palpation. However not to fight against the contraction, rather allow the contraction to pass and then palpate the reproductive organs. Symptoms of different stages of pregnancy are given below (Table 10.1).

Table 10.1 : Symptoms of per-rectal examination of pregnancy diagnosis in cattle

Days of gestation	Position of the uterus	Palpable Structures
45	Pelvic floor	Slight enlargement of one horn (uterine asymmetry) with a fluid-filled feeling.Slipping feel of the foetal membrane (chorioallantoic membrane) by the experienced person. Corpus luteum on the ipsilateral (on the same side of the pregnant horn) ovary is palpable.

Contd...

90	Pelvic rim	Displacement of uterus from pelvic floor to pelvic rim due to ever increasing foetal weight and fluid volume.Cotyledons can be felt like marbles.Cervix is traced anterior to the pelvic rim.
150	Abdominal cavity	At this stage uterus become heavy and further displacement of uterus occurs.Cotyledons are larger.Due to the increase blood flow in the uterus, diameter of middle uterine artery increases. The vibration and pulsation of the artery become palpable which is called fremitus. Fremitus palpable in the non-gravid horn (horn do not have foetus) also. Cervix is traced anterior to the pelvic rim.
		Although per-rectal examination is quick (experienced person take 1-2 minutes), reliable and safe method of pregnancy diagnosis. However, per-rectal examination may provide error information when abnormal uterine contents (pyometra or mucometra) present in the uterus or incorrect service dates (improper record). Early or inappropriate palpation of the amniotic vesicle may damage the embryo and cause embryonic mortality or abortion.

b. Transrectal ultrasonography

Ultrasound device can be used as an alternative to per-rectal pregnancy diagnosis. A rectal probe is placed inside the rectum above the uterus. The probe produces sound that diffuses to the adjacent tissues and reflects back to the probe. Probe generates electrical pulse that is carried and the video is displayed in the monitor kept at nearby places. A black image is generated by the fluid filled placenta as the ultrasound is absorbed by the fluid. Whereas, light grey or white image is produced by dense structure like embryo which have greater reflectivity (more ecogenic) of ultrasound.

Ultrasonography has some advantages over per-rectal examination viz., early diagnosis of pregnancy (25 days after breeding), determination of embryo/fetus viability, reduce chance of error (false negatives and false positives). High cost of the instrument is the major limitation of this method.

C. Indirect method

Indirect methods include qualitative or quantitative measurement of reproductive hormones, proteins or detection of foetus specific substances in maternal body fluids as indirect indicators of the presence of a viable pregnancy.

Indirect methods of pregnancy diagnosis are catergorised as follows;

a. Detection of certain pregnancy related hormone

i. **Progesterone assay :** Corpus luteum (CL), required for the maintenance of pregnancy release progesterone which is detectable in the blood as well as in the milk in lactating animals. Progesterone can be estimated by radio immune assay (RIA) or enzyme-linked immunosorbent assay (ELISA). For detection of early pregnancy this test can be conducted around 30 days after breeding. Progesterone levels if higher than 1 and 4 ng/ml, respectively, in plasma and milk of cows, they are considered being pregnant. Nevertheless, false positive results may arise in the conditions like early embryonic death, persistent CL etc.

ii. **Estrone sulfate :** Estrone sulfate, a conjugated estrogen is produced by foetus is detectable in the whey portion of the cow milk. Detectable limit reaches at about 100 days after breeding.

b. Detection of Pregnancy Associated Proteins

i. **Protein B :** Pregnancy specific protein B (PSPB), a glycoprotein is produced by the placenta and is detected by RIA. Pregnancy can be detected as early as 30 days after breeding.

ii. **Early pregnancy factor/early conception factor :** This test is also called Rosette inhibition test. This test has been developed to detect early pregnancy factor (EPF). Pregnancy can be detected as early as within first week after breeding. Maternal lymphocytes are used for this test. Lymphocytes and sensitized erythrocytes (coated with anti-lymphocyte antibodies) forms rosettes which are inhibited by EPF. This method is time consuming as well as costly.

c. Other methods

i. **Using nuclear magnetic resonance (based in determining differences in cervical mucus) :** Vaginal smears are used for the determination of differences of cervical mucous by using nuclear magnetic resonance. This test could not get popularity because of the low accuracy.

ii. **Milk ejection test :** This test can be performed at early as two weeks after breeding. Intravenous injection of low doses (non-luteolytic) $PGF_{2á}$ induces oxytocin release from corpus luteum. This will result in an increase in the pressure in the

milk ejection and alveolar milk volume in pregnant in comparison to non-pregnant animal which is measured by a teat probe.

10.3.3. Artificial Insemination (AI)

Artificial insemination is defined as the process by which sperms are collected from male, processed, stored and artificially introduced into the female reproductive tract during oestrus to attain pregnancy.

In the year 1970, Spallanzani, an Italian scientist developed the method of AI in frog and later successfully inseminated dog. Later attempts had been made to develop AI methods in other domesticated animals. During 20th century much progress had been made due to some great achievements and discoveries like storage of semen in the ultra-low temperature (-196°C) in liquid nitrogen (LN_2). Now AI is successfully established and routinely employed in cattle.

Advantages of AI

1. Use of superior bulls for upgrading and crossbreeding purposes, thus improvement of the overall genetic merit of the herd.
2. Even several years after the death of the prized bull, the semen can be successfully used for insemination purpose.
3. Dairy farm does not require maintaining a bull round the year. Therefore managemental cost will be reduced.
4. Al helps in rapid identification of fertility problems.
5. Decrease risk of disease transmission during natural mating.
6. Increased safety of the animal handler as no aggressive males in the farm.
7. Problem of using heavy bulls on younger heifers can be eliminated.
8. Number of bulls required for breeding purposes is reduced very much.
9. Frozen semen technology facilitates cross country transport of semen instead of bulls.
10. Genetic merit of exceptional bulls can be used widely.
11. Recent advanced technologies like embryo transfer technology is possible only because of AI.

12. Activities related to AI viz., manufacturing and supply of equipments and accessories, preparation of extenders, transport and selling of semen provide opportunity for the huge employment as well as business.
13. Several research avenues are opened in recent days based on AI.

Disadvantages of AI

1. Requires skilled technician.
2. Detection of proper stage of heat is mandatory, which imposes problems to the herdsman.
3. If the desired bull is infected with some diseases (transmittable through semen), it may pose threat. If not detected, then chance of disease transmission is high.
4. Any breakage of cold chain during transport of semen, affect the success of AI.
5. Required more time than natural service.
6. Any type of human error in the process of AI may adversely affect the fertility of the animals.

10.3.3.1. Management of bull for AI

As bull contribute half of the genetic merit of the calf, therefore well managed bulls from weaning to maturity will boost their contribution to herd productivity. Cow having high reproductive efficiency produces one calf per year, whereas, one sire can produce as many as thousands calf per year. Therefore cow has very less genetic impact in the herd compare to bull.

With the objective of production of good quality semen for AI programme one should start from the basic unit like male calf. Male calves are selected at or before weaning, considering economically important characteristics, such as milk production, fat percentage and age at first calving. They are grouped based on their age. Diet should be checked on the basis of the body weight at monthly intervals. Growth should be closely monitored. Age of attainment of puberty is about 12-14 months. Yearling bull attains puberty when it is first able to produce an ejaculate containing 50 million sperm with a minimum of 10% motility (capable of motion). However, it should not be used for semen collection until attains sexual maturity.

Dairy bulls should be managed properly to produce good quality semen which includes;

Nutrition: Balanced and proper nutrition (protein, energy, minerals and vitamins) is necessary for sperm production. Severe undernourishment may cause irreversible testicular damage in young bulls and decreased sperm production in mature bulls. Young bulls should be fed more liberally than mature bulls, because of their growth requirement. Bulls must be in good condition to be fertile and sexually active. Adequate clean drinking water must be ensured.

Exercise: Fitness of the bull is essential for quality semen production. Excessive fat deposits in the scrotum may interfere with temperature regulation and low serving capacity. Regular exercise helps to get rid from excess fat deposition and prevents over growth of hooves. Bulls may be exercised through providing open area or a loafing area in the pen. In case of bulls kept in confinement, bull exerciser can be used for exercising 1-2 hours daily.

Dehorning: Before one month of age bulls should be dehorned. Dehorning helps to reduce the injury to bull attendants and other animals. However, to maintain the breed characteristics of the bulls in some breeds of animals dehorning is not recommended.

Deworming: Specific anthelmintics should be applied on the basis of worm load of the bulls. Every six months interval bulls should be dewormed. It is better not to use single anthelmintic repeatedly.

Management of hoof: Most common semen collection method is the artificial vagina (AV) method used in dairy bull. Any painful condition of the hoof interferes with mounting ability of the bull and it may reluctant to mount over dummy and thus do not ejaculate. Overgrowth of hooves is the most common problem encounter in bulls. Bulls kept in closed confinement with little chance of exercise or infrequent hoof trimming have over grown hooves. Hoof trimming can be done during the lay off period following vaccination.

Regular Screening of the animal for disease free status: Artificial insemination can be a potent source of veneral diseases if bulls are not properly checked for the disease free status. Bulls should be regularly screened for tuberculosis, paratuberculosis, brucellosis, vibriosis and infectious bovine rhinotracheitis (IBRT).

Vaccination: Bull should be regularly vaccinated against the diseases prevalent in the area viz., foot and mouth disease (FMD),

Haemorrhagic septicaemia (HS), Rinderpest (RP), Anthrax, Black Quarter (BQ). After vaccination testicular tissues starts degenerative changes and again regenerate within two to three weeks after vaccination. Therefore, two to three weeks rest should be given following vaccination.

Time and regime of semen collection: Semen should be collected from the bull in the cooler part of the day especially in the morning hours when bulls are alert and fresh. Collection of semen can be done once (single collection regime) or twice in a day (double collection regime). In single collection regime, one ejaculate is collected thrice in a week. In double collection regime, two ejaculates are collected twice in a week. Semen collection regime can be fixed according to the necessity of the farm.

Overuse: Overuse of the bulls in semen collection center should be avoided. Overuse can cause temporary infertility, which can only be overcome by rest.

Training of the young bull: Training of the young bulls for semen collection should be commenced by the age of 18 months. The training bulls can be brought for collection once a week and they have to bring to the collection area early and keeping them till the semen collection is over, so that they can familiarize with the collection procedure. Regular semen collections can be started 6 months after the initiation of training.

Dummy: Dummy can be anoestrus cows or bull. Some bulls may show refractoriness to a particular dummy due to long time use of same dummy or increase frequency of collection. Refractoriness can be corrected by

- presenting the same dummy in a new location
- presenting a new dummy
- creating a situation for competition among bulls for mounting the same dummy

10.3.3.2. Steps of AI

10.3.3.2.1. Semen collection

Several methods are employed for the collection of semen from the sexually mature breeding bull viz., artificial vagina method, electro-ejaculation method, message method, sponge method, scoop method etc. Among these, the artificial vagina (AV) method is used commonly

for semen collection as it gives nearer to the natural stimulus of copulation. Electro-ejaculator method is sometimes used in case of prized bull, not capable to mount due to physical disability.

The parts of the AV (figure-10.3) are as follows;

- outer strong rubber cylinder, having upturned rim at both the ends to provide grip to the thin inner latex rubber,
- a valve, fixed nearer to one end to admit water and air,
- a thin inner latex which is turned back over each rim of outer cylinder and tightly held by thick rubber bands,
- a latex rubber cone, mounted on the cylinder to the end nearer to the valve,
- a graduated tube, fixed to the conical end of the rubber cone,
- an insulation bag, covering the glass tube and rubber cone.

The space between outer rubber cylinder and thin inner rubber is filled with warm water and then air is pumped into it. The internal temperature of the AV should be 43-45°C; if higher than 47°C it will kill all the sperm.

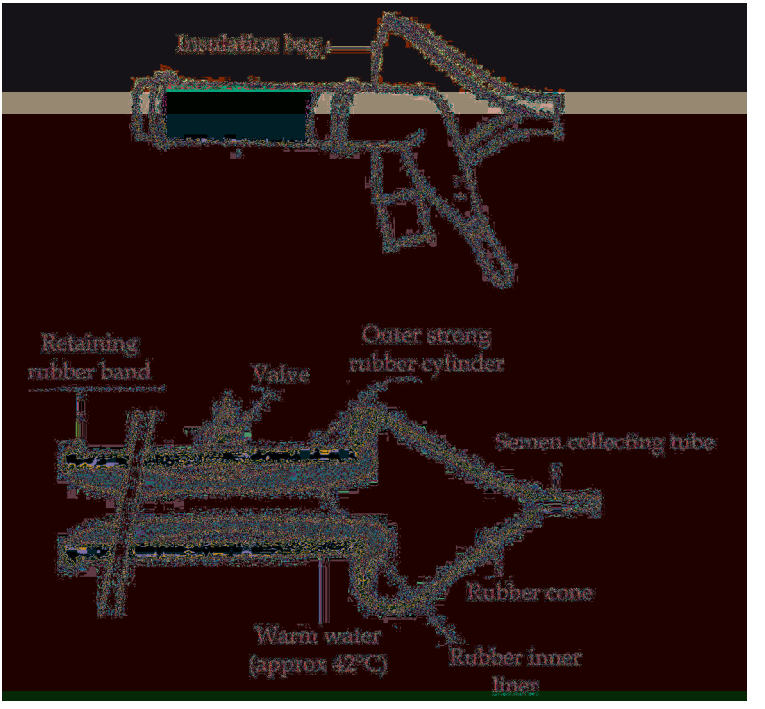


Fig. 10.3 : Parts of Artificial Vagina

Dummy is restrained in the service crate. Bull is trained in such a way that it would mount over the dummy. In the first few attempts of mounting the penis of the bull is diverted by the semen collector by holding the prepuceal sheath which is called false mounting. False mounting followed by restraining for 5-10 minutes provide more sexual stimulation to the bull. After that bull is allowed to mount again. Semen collector is ready to collect semen by holding the AV at 45° angle. At mounting, the semen collector holds the base of the penis and makes it possible to touch tip of penis with the anterior portion of the AV. This provide strong stimulus to the bull and thus, bull gives strong ejaculatory thrust to the AV. Within 1-2 seconds ejaculation takes place and it is collected in the semen collection tube attached with the cone. Semen collection tube is then detached from the AV and is transfered to the semen evaluation laboratory.

10.3.3.2.2. Semen evaluation

Semen evaluation starts with the measurement of volume and colour of the semen. In the next step, mass activity (initial gross movement) is evaluated under microscope (10X) by placing a drop of freshly collected semen over warmed slide placed on stage warmer. Then semen collection tube is placed into water bath (30°C) for further semen evaluation. After dilution of the semen sample individual motility is measured at 37°C under phase contrast microscope and sperm concentration is measured by either haemocytometer or Macler's counting chamber. Whether or not, the semen sample is eligible for freezing that initially depends upon the individual motility of the sperms. Semen sample shows more than 70 percent progressive motility is eligible for freezing. However, above 50 percent progressive motile semen sample can be used for fresh or refrigerated (at 4°C) liquid semen insemination. Other routine tests like fructolysis index, methylene blue reduction test, pH, sperm abnormality are also used for semen evaluation.

Table 10.2 : Semen characteristics of bull

Volume (ml)	5-8 ml
Colour	White, creamy, yellow
Ejaculate/week	3-4
Sperm concentration (10^8/ml)	10-12
Total sperm (10^8/ml) per ejaculate	50-90
Abnormal sperm (%)	15-20
Motile spermatozoa required at insemination (10^6/ml)	10

10.3.3.2.3. Dilution of semen

In natural mating, single cow get one whole ejaculate. However, extension or dilution of artificially collected semen assists to inseminate several hundreds (400-800) of cows from a single ejaculate. A dilutor should have the following qualities

- It should be readily available and cheap as well as non toxic to the sperm
- Provide buffering medium to sperm
- Provide nutrition to the sperm
- It should have cryostability and isotonicity to semen
- It should discourage the growth of microorganisms

In the past few decades several extenders have extensively been used for dilution and preservation of semen. Four different types of materials are used for the preparation of all the extenders. These are i) sugar- provides energy, ii) biological fluids (egg yolk or milk)- for cold shock protection (due to the presence of lecithin, proteins, lipoprotein etc.) as well as nutrients, iii) buffer (like tris, sodium citrate, phosphate etc.)- for maintaining neutral pH and an osmotic pressure equivalent to biological fluids or semen and iv) antibiotics (broad spectrum)- prevents growth of bacteria. Always add diluent to the semen (not reverse), otherwise spermatozoa get shock and ultimately reduced motility.

Commonly used extenders are

1. Tris : This extender commonly used by the semen laboratories especially for frozen semen.

Table 10.3 : Composition of tris and tris base extenders

Buffer	
Tris hydroxyl methyl amino methane	3.97 g
Citric acid	1.73 g
Fructose	1.27 g
Distilled water	Upto 100 ml
(Adjust pH to 6.8 with citric acid or NaOH)	
Extender for refrigeration	
Tris buffer	80 ml
Egg yolk	20 ml

Contd...

Penicillin	1000 I.U/ml
Streptomycin	1000 mg/ml
Extender for cryopreservation	
Tris buffer	74 ml
Egg yolk	20 ml
Glycerol	6 ml
Penicillin	1000 I.U/ml
Streptomycin	1000 mg/ml

2. Sodium citrate : This extender is very much popular for bull semen.

Table : Composition of Sodium citrate dilutor

Sodium citrate	2.9 g
Distilled water	100 ml
Egg-yolk	100 ml
Penicillin	1000 I.U/ml
Streptomycin	1000 mg/ml

3. Milk dilutor : In this dilutor, milk is used as major constituent, after boiling milk in 92-95°C for about 10 minutes to remove toxic substance (lactenin). Lactenin is an antibacterial substance present in the albumin fraction of the whole milk. Other than whole milk, skim milk, milk whey, reconstituted milk powder is also used. Soybean milk is also gaining popularity as a constituent of the dilutor.

4. Other popular dilutor : Several other dilutors after modification of the above mentioned dilutors are also used. Most of popular of this category are Cornell university extender (CUE), Illinois variable temperature extender (IVT) etc.

5. Commercial dilutor : Many commercial vegetable based dilutors are available in the market, replace animal protein source like egg or milk, because of risk of disease transmission. Biociphos is most popular in this category.

10.3.3.2.4. Preservation of semen

Opening of era of artificial insemination has demanded the compulsion of preservation of semen. Semen preservation means extension of fertilizable life of sperm with the use of suitable suspending medium (dilutor) in the range from room temperature to frozen state. The medium not only provides nutrition to the sperm, but also protect

from the possible change of pH due to accumulation of metabolic wastes from the metabolism by the sperm. As the sperm is a living cell, it continues metabolism. Long term storage of sperm (in the diluting medium) leads to exhaustion and alteration of property of the medium due to the accumulation of metabolites beyond its capability. The rate of metabolism is directly related to the storage temperature. Therefore, the principle of sperm preservation is based on the reduction of metabolic activity of the sperm (in dilutor) by preserving in a suitable temperature or by adding chemicals (like carbon dioxide which lowers metabolic activity).

Semen is commonly preserved at :

- Room temperature (about 21°C)
- Refrigerated temperature (0-4°C)
- Ultra low temperature (cryo-preserved, <-20°C)

10.3.3.2.5. When and how to inseminate

AI should be done at right time and at right place. Ovum is released from the ovary about 10-14 hours after the end of heat. The useful life of ovum is about 10-12 hours inside the uterus, thus it must be fertilised within ten hours of ovulation otherwise it will die. In contrast, spermatozoa remain viable for 24 hours in the same place. Sperm must undergo some chemical changes called capacitation inside the uterus before fertilization. Therefore, the best time to inseminate a cow is 12-18 hours after the onset of oestrus. A common rule i.e., AM-PM rule can be adopted for inseminating a cow. Under this rule a cow showing heat in the morning, should be inseminated in the same day evening and cow showing heat in the afternoon should be inseminated in the next day morning.

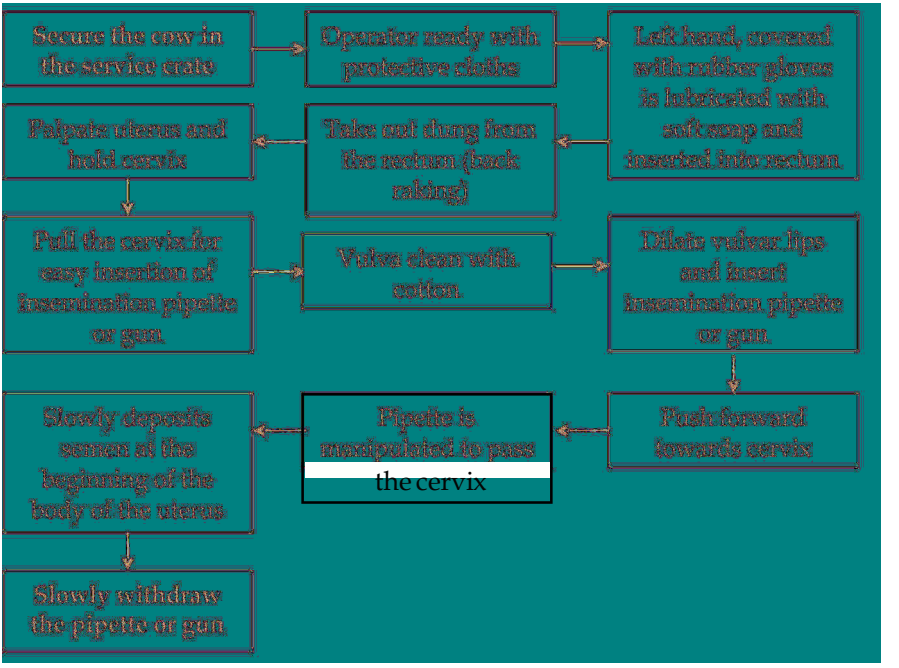
10.3.3.2.6. Insemination technique

Success of AI programme depends upon the technical skill of the inseminator as well as sanitary condition maintained during insemination. Two methods are commonly used for AI, viz., speculum method and rectovaginal method.

In speculum method, the lubricated (with paraffin) speculum is inserted into vagina for dilation. Cervix is located visually by the use of head light torch. Inseminating pipette containing diluted semen is introduced and deposited into the uterus (in front of the cervix). This method is suitable for less trained person. However, sterilization of

the vagina speculum after every AI to prevent disease transmission is not always possible.

Rectovaginal method is most widely used throughout the world as it is simple and easy to operate. Following steps are followed in this method



10.3.4. Frozen semen technology

Frozen semen technology is a benchmark method for the rapid improvement of animals through AI or embryo transfer which is shaped over the decades of marginal improvement. In the late 1930's and early 1940's many researchers found that sperm could survive freezing to temperatures below -160°C. However, survival was limited in the absence of cryoprotectant. In 1950's a landmark finding by Polge and Rowson that glycerol can act as cryoprotectant opened a new era of cryo-preservation of semen. Further optimization of the freezing procedure resulted in the wide spread application of frozen semen in the 1960s. At present worldwide breeding programme in cattle is based on the use of artificial insemination and frozen semen. Top bull (sire) can produce up to 50,000 doses of semen per year, and thus cryopreservation has allowed exploitation of superior sires and achieved rapid, large-scale genetic improvement of cattle.

The principle of frozen semen technology is to cool the diluted semen much below the freezing point of water so that the metabolic activity of the sperm is temporarily suspended and therefore, preserve the life and activity of sperm for a indefinite period.

10.3.4.1. Steps of cryo-preservation

Cryopreservation of sperms usually consist of the following major events: (i) dilutor containing cryoprotective agents (usually glycerol) is added to the semen; (ii) diluted semen is cooled to temperatures near 0°C and provide equilibration time for about 4-6 hours; (iii) then it is cooled to intermediate subzero temperatures (-130°C) at low cooling rate (about 5–10°C/min) and then plunged into liquid nitrogen at –196°C for storage; (iv) to restore their function, semen is thawed.

(a) **Extender preparation :** Fresh extender/dilutor (discussed earlier) should be prepared about one hour before semen collection and kept in water bath at 30°C.

(b) **Semen collection and evaluation :** After collection of semen (discussed earlier) it should be transferred to the laboratory (attached to the collection area) for further evaluation. Semen sample showing more than 60 percent motility is eligible for further processing. Then sperm concentration is determined through the use photoelectric colorimeter, haemocytometer or Macler's counting chember.

(c) **Initial dilution :** The dilution rate of the semen is determined based on the sperm motility, sperm concentration and capacity of straw used for packaging.

For example for calculation of dilution rate:

Volume of semen = 5 ml

Sperm concentration of raw semen = 1000 million/ml

Total sperm = 5X1000 = 5000 million

Sperm Motility = 60%

Total motile sperm = 5000X60/100= 3000 million

Desired motile sperm concentration per insemination/straw = 30 million

Total dose of semen =3000/30 =100

Volume of straw = 0.25 ml

Total volume of diluted semen=100X0.25=25 ml

Extender needed = Total volume of diluted semen - semen volume = 25ml - 5ml = 20 ml

Therefore, 5 part semen mixed with 20 parts extender will give a final extended concentration of 30 million motile sperm/straw

For initial dilution, half of the total extender required for dilution is added to the semen, kept in a flask and gently mixed. Then the flask is kept in a vessel containing water and transferred to the cold room, where it gradually cooled to 5 ^{o}C over the 45 to 60 minutes. Another flask containing rest extender (half) added with glycerol also kept in the same cold room.

(d) Glycerolisation : Final diluition of the semen is carried out with the addition of glycerolated extender (with 3-4 installments) to the initial extended semen (cooled to 5^{o}C). It has to be added slowly and mix thoroughly. All the activity should be done inside the cold chamber.

(e) Equilibration and packaging : Finally extended semen is kept for about 4-6 hours in the cold room (at 5^{o}C) before storing it in frozen temperature (-196^{o}C in liquid nitrogen). This phase is called equilibration of diluted semen. The specified time should be provided because glycerol, a cryoprotective agent permeates sperms and provides better resistance against freezing stress.

Packaging materials (ampoule, straw etc.) has to be pre-cooled at 5^{o}C. Package material (usually straw) is printed by automatic printing machine carrying all necessary records like breed, sire number and name, date of collection, etc (Figure-10.4). The straw is having two ends, one end plugged and other end opened. The plugged end is having manufacturer's plug, containing three layers viz., two layers of webbing (cotton) plug and in between them poly-vinyl alcohol plug. Open end is called laboratory end. Straw is filled with semen through the open end. Just after filling, sealing is done at the open end of the straw. Filling and sealing of the diluted semen is carried out either by manually or mechanically by automatic filling and sealing machine.

After the end of the equilibration period, the semen sample showing more than 60% pre-freeze motility are considered for freezing.

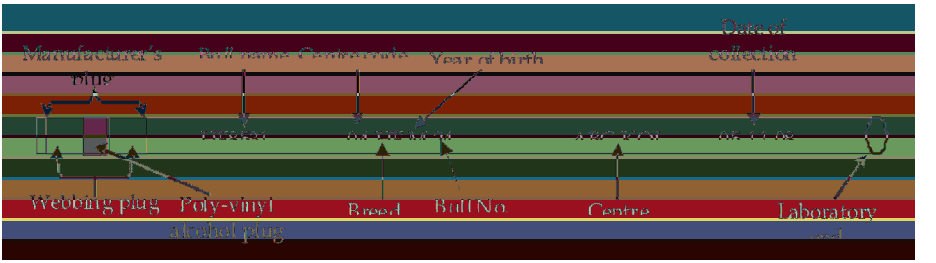


Fig. 10.4 : Straw showing identification details

(f) Freezing : Semen filled straws are arranged in the racks and the racks are kept at 4-5 cm above the level of liquid nitrogen (LN_2) in a wide mouthed LN_2 container, thereby exposing to the vapour of the LN_2. This facilitates rapid cooling of semen and within 10-15 minutes the temperature of the semen reaches to -130°C to -150°C.

(g) Storage: Liquid nitrogen (-196°C) is the commonly used storage medium throughout the world. Although other storage media like solid CO_2 (-79°C), liquid air (-190°C), liquid helium (-296°C) are also used sporadically.

After initial freezing straws are collected through pre-freezed forceps and transferred to the goblets (container to hold the straws). Goblets are immediately plunged into liquid LN_2 and stored in the frozen semen tank/can.

(h) Thawing : Thawing (melting) of frozen semen should be done just before insemination. For this, first remove the straw from the goblet using pre-cooled tweezers and shaken once or twice vigorously to remove LN_2 from the cotton plug. The straw is placed in the warm water (37-40°C) as quick as possible and leaving it there for a minimum of 30 seconds. Thawing for a longer period does not cause any harm but the straw should be used within 20 minutes of removing it from the tank. Then straw is wiped with tissue paper and loaded into insemination gun for insemination. Once thawed, straws must not be refrozen.

10.3.5. Embryo Transfer (ET)

In the year 1890, a new era of animal reproduction was opened with the contribution of Walter Heape by transferring rabbit embryos. Later progenies were produced through embryo transferred (ET) in other domesticated animals like sheep, goat, pig, cattle and buffalo.

There are about 125,000 potential "eggs" or ova in the female ovary at the time of birth. Although, the reproductive potential of a cow is enormous, only a very small fraction of it could be realized. Use of AI makes it possible to use superior bull to a greater extent, but the reproductive potential of the cow has been largely under-utilized as average cow usually have only one calf per year. In normal condition a cow produce 8-9 calves in her lifetime. Therefore, ET can increase the number of calves to a greater extent from genetically superior cows.

Advantages of embryo transfer technique

The advantages of embryo transfer are as follows:

1. More number of good genetic merit calves will be born from a valuable dam.

2. Genetically superior cows that are unable to bear pregnancy due to injury or some other reasons but fertile, can be useful through ET.

3. Too old cow, unable to bear pregnancy could provide calf through ET.

4. Genetic merit of the valuable dams can be utilized to a greater extent.

5. Generation interval can be shortened by the superovulation of prepubertal heifers and transferred embryos to mature recipients.

6. It is easier to transport embryos rather live animals.

7. Twinning can be induced by transferring two embryos in two horns of the recipient cows.

8. Through embryo freezing superior genetics merit can be preserved for future generations.

10.3.5.1. Steps of Embryo Transfer

The process of ET has the following important steps:

10.3.5.1.1. Selection of Donor Cows

The donor for ET programme should be selected based on the following criteria :

(a) genetic superiority over other herd mates

(b) completed atleast one lactation

(c) normal reproductive organ

(d) regular cycling and completed 60 days postpartum

(e) free from history of dystokia, retention of placenta or any type of reproductive irregularities

(f) no conformational or detectable genetic defects

10.3.5.1.2. Superovulation

The process of producing more than one ovum at a time by the hormonal manipulation of the cow is called superovulation. Hormonal treatment can be given 8-12 days of the oestrous cycle to stimulate the growth of additional follicles. Pregnant mare serum gonadotropin (PMSG) is given as single dose or follicle-stimulating hormone (FSH) is given twice daily for 4 days. This is followed by an injection of prostaglandin F_{2a} (PGF_{2a}) on the third day of treatment schedule for CL regression and the animal come to oestrus approximatlely 48 to 60 hours after the injection.

10.3.5.1.3. Oestrus Synchronisation

Harmonising the estrous cycle of donor and recipients to stimulate the onset of estrus (heat) is called as oestrus synchronisation. It ensures the right environment for the embryo within the recipients' reproductive tract. Oestrus of the recipients can either be natural or induced (using hormones like progesterone, oestrogen, PGF_{2a} etc.). It is advisable to bring the recipient into oestrus one day after the donor's oestrus.

Oestrus synchronization facilitates transfer of fresh embryo to the recipient. Otherwise, embryo can be cryopreserved for a longer period and transferred to the recipient as necessity arises.

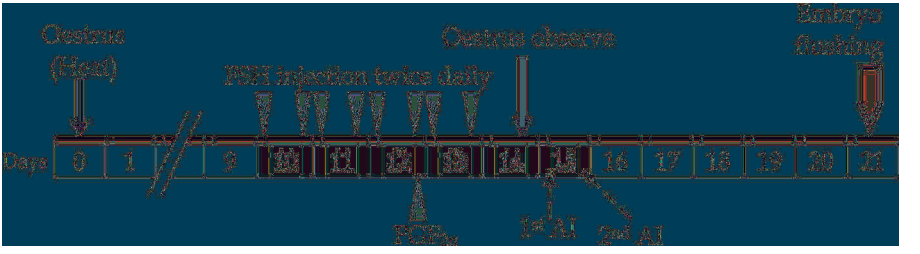


Fig. 10.5 : Important events of oestrus synchronisation and embryo transfer

10.3.5.1.4. Insemination

Insemination is done with high quality semen at 12 and 24 hours after the onset of standing heat. It is better to deposit semen in the body of the uterus.

10.3.5.1.5. Embryo collection (flushing)

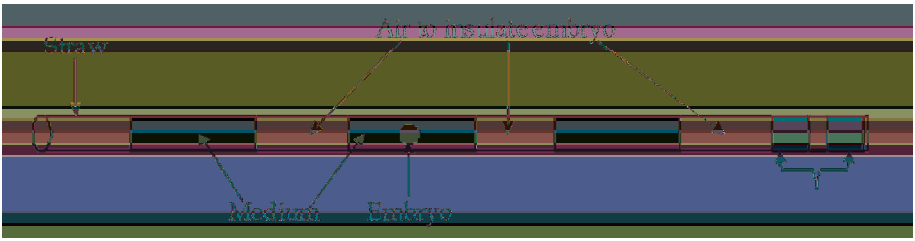
Embryo can be collected from the donor, surgically or non-surgically. However, non-surgical collection is preferred as it is simple and can be completed in a short time without any harm to the cow. Embryo recovery or flushing is done on day 7 after the onset of oestrus. Epidural anaesthesia is given to the donor. Then perineal region is washed thoroughly. A 3-way Foley catheter, with, pre-sterilized stilette (metal cervical expander) for rigidity is introduced into the uterine horn on the side of the ovary having better response. Tip of the catheter fixed about 2 inches from the utero-tubal junction. About 10-20 ml air is infused by syringe to inflate rubber balloon to prevent backward flow of introduced flushing medium (D-PBS; Dulbecco's phosphate buffer saline) through uterus-cervix-vagina. Then stilette is removed. A Y-connector with inflow and outflow tube (siliconised) is attached to the catheter. Tweezer clamps are attached to both tubes to regulate the flow of the flushing fluid. Glass bottle (1 litre) containing flushing medium hang above the height of the animal in an inverted position after fixing with inflow tube. Flushing medium is successively added and removed by gravity through outflow tube, collected in an embryo filter. This process continues until 500-600 ml medium is used. The flushing is repeated in the other horn using a separate sterile instrument set.

10.3.5.1.6. Embryo evaluation

After collection, the contents of the embryo filter are poured into petri-dishes (square marked with grids at the bottom). Petri-dish is kept under stereozoom microscope with 10× to 15× magnification. The embryos are lifted by unopette or capillary tube and transferred to a culture dish containing fresh holding medium for the evaluation of embryo. Morphologically normal embryos are selected for use in embryo transfer.

A good quality embryo at its early stage can be split by micromanipulator and the process is called as embryo splitting. Both half of the embryonic masses when transferred to the recipient it will develop identical twins.

After evaluation the embryos are loaded into the straw (0.25 ml; Fig. 10.6) and it can either be freshly transferred or stored frozen in liquid nitrogen and transferred at a later date.



Fi. 10.6 : Schematic diagram of straw containing embryo

10.3.5.1.7. Freezing:

For long term storage, embryos are frozen in liquid nitrogen. Embryo freezing and thawing process is very complicated and usually reduce about 20-30% pregnancy rates from those observed with fresh transfer.

The medium used for freezing the embryos is Dulbecco's phosphate buffered saline (D-PBS) or Ham's F-10 supplemented with blood serum or Bovine serum albumin. The protective agent are used to prevent cryo-damage viz., Dimethyl sulfoxide (DMSO), glycerol and 1,2-Propandiol.

10.3.5.1.8. Transfer of cryo-preserved embryo

Transfer of embryo can be done surgically or non-surgically. However, non-surgical transfer is preferred over surgical transfer. Recipients should be selected based on synchronization of oestrus and presence of distinct CL. Recipient is injected with epidural anaesthesia and perineal region is cleaned. Embryo transfer gun pre-loaded with straw containing embryo, covered with sheath is inserted into the uterine horn (ipsilateral to the ovary containing CL). The embryo is gently expelled and gun is withdrawn. The entire procedure should be conducted on swift hand without damaging the lining of the uterus.

10.4. SUMMARY

The adoption of various reproductive technologies has resulted in far-reaching consequences on commercial dairy herds. This has greatly improved the reproductive efficiency of dairy animals and maximum utilization of genetic potential. Various heat detection techniques have minimized the problems of heat detection in cows. This has greatly increased the conception rate of cows through the use of AI. The use of pregnancy diagnosis methods help to detect non-pregnant animals at earliest and thus, re-breeding is done without

much wastage of time and pregnant animals get opportunity for better care and management. Efficient use of these techniques has greatly improved the non-return rate in the herd and reduces the culling rate of herd due to reproductive failure. Use of embryo transfer technology along with superovulation technique makes it possible to use superior cows to a maximum extent, and this has increased the number of calves obtained from genetically superior cows. The application of all these techniques has significantly improved the reproductive as well as productive performances of the herd.

10.5. CHECK YOUR PROGRESS

(a) What is heat mount detector?

(b) What is artificial insemination (AI)?

(c) In which species AI was first done?

(d) Name the insemination techniques are applied to the cow.

(e) What is super-ovulation?

(f) What is oestrus synchronisation?

10.6. ANSWERS TO 'CHECK YOUR PROGRESS'

(a) Heat mount detector (KaMaR) is used for oestrus detection which is attached in front of the tail head and pressure from the mounted animals releases dye from the detector.

(b) Artificial insemination is defined as the process by which sperms are collected from male, processed, stored and artificially introduced into the female reproductive tract during oestrus to attain pregnancy.

(c) Dog

(d) Speculum and rectovaginal method.

(e) The process of producing more than one ovum at a time by the hormonal manipulation of the cow is called superovulation.

(f) Harmonising the estrous cycle of donor and recipients to stimulate the onset of estrus (heat) is called as oestrus synchronisation.

10.7. EXERCISES AND QUESTIONS

(a) Discuss different methods of heat detection.

(b) What are the advantages and disadvantages of artificial insemination?

(c) Write about the cryo-preservation of semen.

(d) What are the different steps of embryo transfer?

10.8. FURTHER READING

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CHAPTER - 11

Common Farm Management Techniques

11.1. INTRODUCTION

A typical dairy farm consist of different classes of dairy animals like calf, heifer, breeding heifer, pregnant, milch and dry animals and bull. The systems of management for the different classes are not same. They need some routine as well as periodical farm practices, some of which are common for all categories of animals (i.e., identification, dehorning, grooming etc.), while some categories need special farm operations (e.g., castration in males, milking etc.). Also there is need of routine disinfection of animal sheds and farm premises to prevent and control occurrence of diseases and maintaining the animals healthy. Further for proper execution of all these operations there is need of keeping farm records. Keeping in view the above points, this section deals with some important farm management practices.

11.2. OBJECTIVES

The purposes of this section are to:

- acquaint with the various farm management practices
- execute the farm management practices efficiently
- select suitable techniques for a particular farm operation based on the available technology and farm condition
- manage the dairy farm routinely and appropriately.

11.3. COMMON MANAGEMENTAL PRACTICES

The common farm management practices like identification, castration, dehorning, grooming, clipping, disinfection of the farm and keeping records are discussed as follows:

11.3.1. Identification of Dairy Cattle

Identification is the process by which the animals are marked for their individual identity. The identification of individual animal is very important for the scientific management of the animals.

11.3.1.1. Objectives

The purpose of identification is to

i. keep production, reproduction and other records of animals
ii. manage animals efficiently
iii. feed animals economically
iv. diagnose diseases and provide treatment and vaccination
v. insure animals
vi. register in milk societies
vii. make entry into herd-books of pedigree animals
viii. give license to animal owners
ix. import and export animals

11.3.1.2. Methods of identification

Various methods (Fig. 11.1) are employed for identification of animals depending upon the purpose, size of the herd, suitability and economic feasibility. The methods may be natural or artificial.

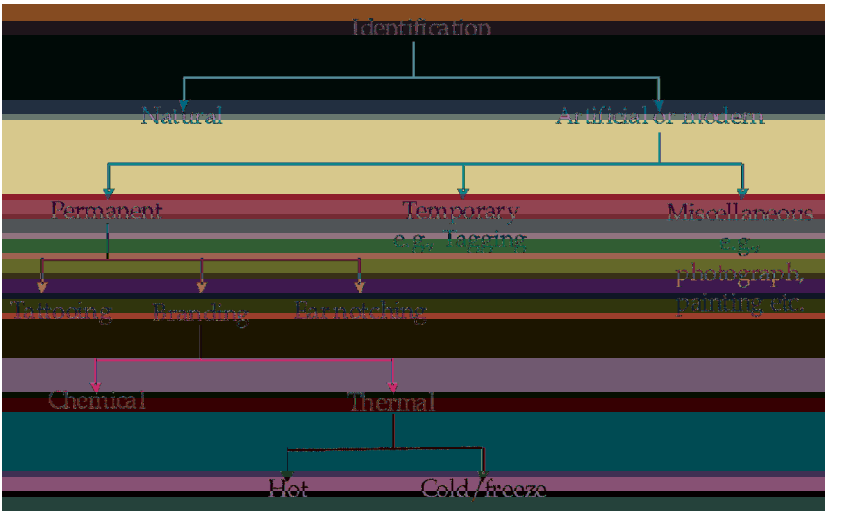


Fig. 11.1 : Identification methods

11.3.1.2.1. Natural methods

Identification by natural methods refers to the identification by external body appearances like general appearance, body size, coat colour, body markings, nature of horns, physical deformities etc. This method is suitable when the animal number is less and is commonly practiced in households having 2-3 animals.

11.3.1.2.2. Artificial or modern methods

This is the scientific method of identification by artificially marking in a part of the body of the animal by various methods.

Rules of identification: Irrespective of the methods of identification some rules for numbering the animals is required depending upon the number of animals in the farm and management systems followed. Both numbers and letters can be used for marking the animals for identification.

- Allow the first digit of the number to indicate the year of birth and rest of the digits to indicate the particular animal's sequence of birth e.g., 912 indicates 12th calf born in 2009.
- Use odd numbers for female e.g., 905, 907, 909 and so on, and even numbers for male, e.g., 906, 908, 910 and so on.

The artificial or modern methods of identification can be classified into following types.

(A) Permanent- tattooing, branding, ear notching

(B) Temporary- tagging

(C) Miscellaneous- photograph, painting etc.

(A) Permanent method

a. Tattooing: In this method letters or numbers are imprinted on the inner side of the ear by tattooing forceps smeared with inert ink so that inert pigments of the skin enter the subcutaneous tissue and creates a permanent mark in the ear lobe (Fig. 11.2).

Tattooing set: It consist of tattooing forceps, tattoo letters and numbers in the form of sharp pins and tattooing ink made of inert chemicals or pigments like insoluble carbon (black) or green pigments.

Site and its preparation: The ribs of cartilage divide the ear into top, middle and lower thirds. The tattoo should be placed in the inner side of the ear at the top third just above the upper cartilage rib avoiding the ear veins. It may also be done on the under surface of the root of tail in cattle. The site before tattooing should be scrubbed with soap and water, dried by wiping and cleaned with spirit to remove wax or grease.

Age: Tattooing can be done at any age but it is convenient to tattoo new born and younger calves.

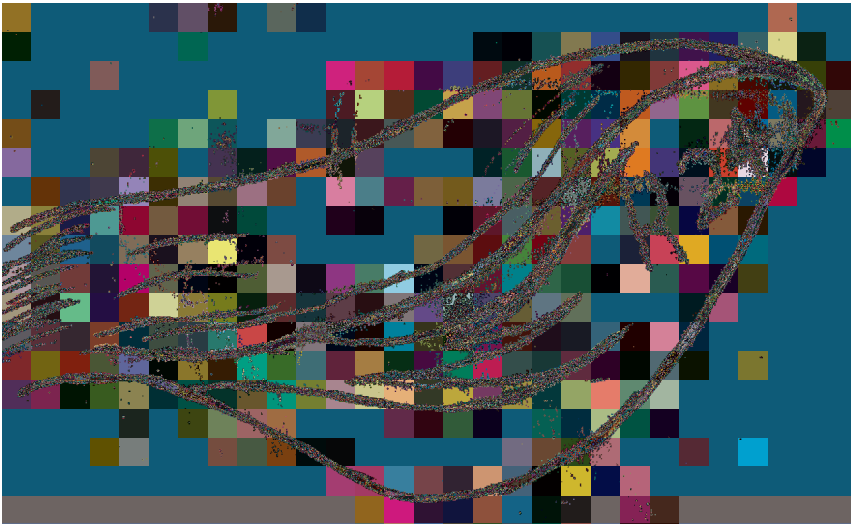
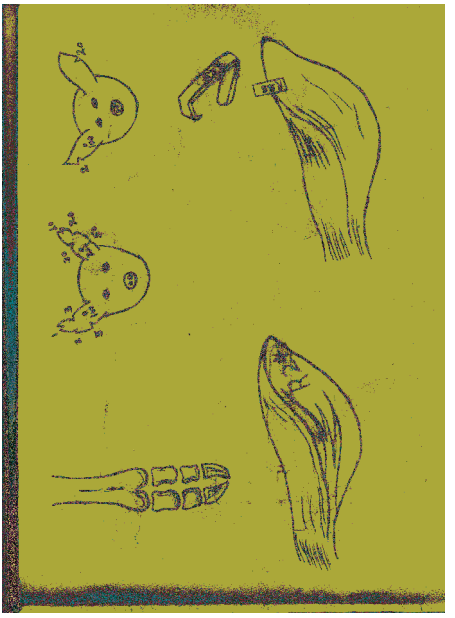


Fig. 11.2 : Tattoo mark on the ear



Procedure: The desired numbers and/or letters are fixed to the tattooing forceps and ink is applied on them. Then by pressing the jaws of the forceps firmly the numbers are placed on the skin. Some ink is applied with a swab and rubbed well into the tattooed punctures with the thumb.

Advantages of tattooing :

- Permanent method of marking
- Less costly
- More humane compare to branding
- Utility in all age groups
- Does not disfigure or damage any body part of the animals

Disadvantages of tattooing :

- Animals must be caught and close inspection is required to read the identifying marks.
- Marks fade out in course of time.
- Non-suitability for black skinned animals
- Unsatisfactory marking can occur because of dirty equipments, dirty and greasy skin, bad ink, inadequate application of ink, or misapplication of the tattoo.

b. Branding: Branding refers to affixing some markings either in the form of letters or numbers on animal body with hot or cold iron or chemicals (Fig. 11.3). It causes permanent physical damage to the epidermal cells of the area imprinting particular numbers or letters in the skin. Branding is done by iron rods having numbers (1 to 9 and 0) and letters (A to Z).

Age : Heifers should be branded at or above one year of age.

Site: The usual sites for branding are shoulder, hind quarter, cheek and horns of cattle.

Advantages of branding :

- Permanent method of marking
- Can be easily seen

Disadvantages of branding :

- Suitable after one year of age and not for young animals.
- Cause damage to hide/skin. This can be minimized by branding in the lower part of the thigh which come at the marginal end of the hide and is of lesser value.

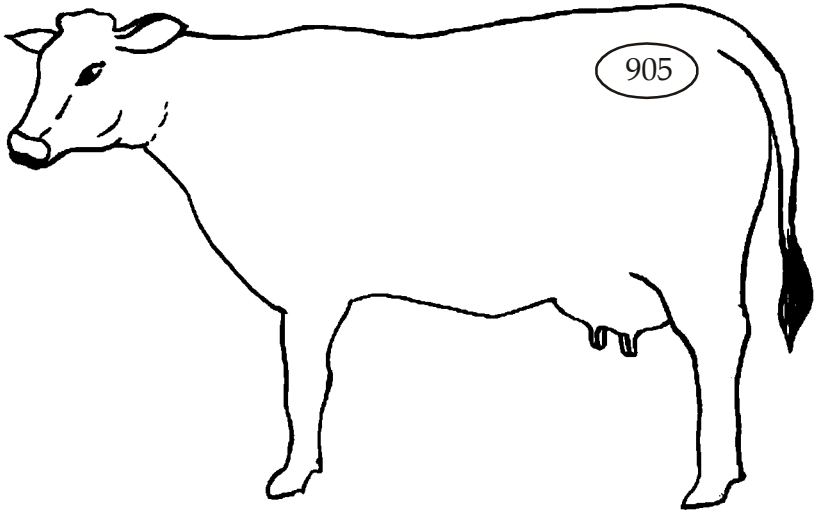


Fig. 11.3 : Branding in cow

Types: The branding can be classified into following types-

i) Thermal branding

1. Hot branding
2. Cold/freeze branding

ii) Chemical branding

i) **Thermal branding**: Thermal branding is done by employing high or low temperature. It is of two types: hot branding and cold/freeze branding

1. **Hot branding**: In this method the desired branding iron is heated to the colour of grey ashes and applied in the required site with light pressure for 2-3 seconds. It destroys hair follicles located under several layers of the skin and leaves a permanent bald scar on the skin corresponding to the letter or number selected. A little mustard oil mixed with zinc oxide may be smeared on the area for quicker healing. There will be wound formation and after healing the area will be devoid of hairs and thus forms a permanent marking.

Advantages:

- Marking permanent
- Marking can be easily seen
- Comparatively cheaper
- Suitable in all animals irrespective of coat colour

Disadvantages :

- Very painful and cruel method
- Damages skin
- Not suitable for young animals

2. **Cold/ freeze branding:** In this method the branding rod is frozen by dipping in liquid nitrogen (-196°C) or dry ice (-79°C) and is then gently pressed in the skin for about 10-15 seconds so that melanocytes (colour producing cells) are destroyed and the subsequent hairs growing in the branded area will be colourless. After branding, water soaked cloth should be applied to the branding site. The brand will be oedematous till 48 hours, scab formed will last till 3-4 weeks and new white hair will grow in 6-10 weeks. Before freeze branding the intended area has to be shaved properly as hairs act as insulator and interferes with freezing process.

Advantages:

- Marking permanent
- Marking can be easily seen
- Less painful than hot branding
- Skin and hide damage is reduced compared to hot branding
- Infection risk is eliminated

Disadvantages:

- Not suitable for young animals
- Not suitable for white or light skinned animals. But this problem can be overcome by over branding the animals for 2.5 minutes to kill the hair follicles which produce a bald brand similar to a hot brand.
- Requirement of liquid nitrogen or dry ice

ii) **Chemical branding:** Same branding irons used for thermal branding can be used for chemical branding, but branding iron with a shallow groove on the contact surface of the letter or figure is better. A caustic chemical is applied on the branding iron number or letter and is applied to the body so that due to caustic nature of the chemical used, skin of the contact area is burned and a marking is formed upon healing.

Advantages:

- Less cruel than hot branding
- Reduces skin and hide damage compared to hot branding

Disadvantages:

- Not suitable for young animals
- Less permanent
- Harmful if carried by inexperienced person

c. **Ear notching:** It refers to cutting 'V' shaped notches at specified places along the borders of ears by means of sharp scissors or pincers.

Advantages:

- Permanent method

- Can be seen from distance and no need for handling of animals

Disadvantages:

- Deformed ears

(B) Temporary method

Tagging: In this method tags made up of light metal or strong plastic with letters or numbers engraved on them, are affixed on the ear lobe (Fig. 11.4a,b).

Types of tags: There are two types of tags i) non-piercing tag- a hole must first be made with a tag punch or pen knife on the ear for fixing the tag, ii) self-piercing tag- having sharp ends and can be directly fixed to the ear with forceps.

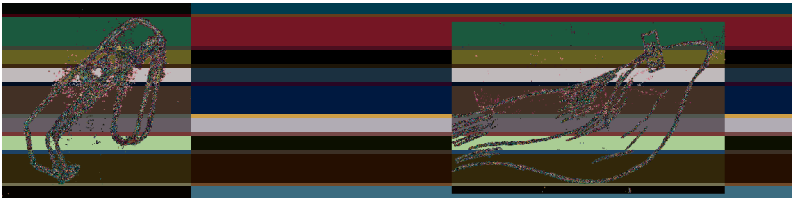


Fig. 11.4a : Ear tag **Fig.11.4b :** Application of ear tag

Procedure :

(i) **Non-piercing tag**: A hole is made on the upper edge of the ear close to head with help of tag punch or pen knife sterilized with spirit. The tag is placed through the hole with numbered side on the back of the ear and locked in position with pincers. The tag should be fixed not tight or too loose, leaving enough space for growth of ear. Some antiseptic should be applied on the wound to prevent infection and for speedy healing.

(ii) **Self-piercing tag**: The tag is fixed directly with the help of forceps and locked keeping the number visible outside the upper edge of the ear. The tag is kept neither tight nor swinging loose on the ear. Some antiseptic should be applied on the wound to prevent infection and for speedy healing.

Advantages:

- Number can be seen from distance without handling the animal.
- Less costly

- Suitable for all types of animal
- Insecticide-impregnated ear tags can be used to control ectoparasites, insects and other purposes.

Disadvantages:

- Temporary method of marking
- Body part of animal partly deformed
- Chance of tag loss

(C) Miscellaneous methods:

a. Electronic tags or tag chips: Electronic tagging is done with the help of a syringe which is used to push the chips just under the skin of the animal. Electronic chips in the form of capsule can be fed to the animals and it will remain inside the rumen due to its weight. The chips bear specific numbers and necessary information which is read by a scanner. The full information regarding the animals can be kept in a national data base centre.

Advantages:

- Quick and painless
- More humane and ethical than other methods
- No injury to the animals
- Little chance of getting lost

Disadvantages:

- Costly method

b. Different coloured neck chains or ropes and tags or leather neck straps tied to the chains.

c. Painting on horns

d. Animal owners having one or two animals call by their names

e. Photographs and sketches

11.3.2. Castration

Castration means depriving animals of its gonadal function either by removal or disfunctioning of essential reproductive organs in males.

11.3.2.1. Objectives

The purpose of castration is to

i. prevent uncontrolled breeding
ii. deposit fat in castrates more than in intact males
iii. prevent injury in animals as intact males tend to fight
iv. make animals more docile and easy to handle
v. have a positive effect on meat quality in terms of palatability, colour and self life due to presence of muscle glycogen, which get depleted due to fighting in intact males
vi. remove hides easily than in intact bulls

11.3.2.2. Age of castration

Males can be castrated at any time during their lives, but it is better to castrate at less than 3 months old to minimize stress.

11.3.2.3. Season

The best seasons to castrate are spring and autumn. Rainy season should be avoided to augment healing and prevent fly and maggot infestation and infection.

11.3.2.4. Methods

There are two methods of castration

i. Surgical or open method
ii. Bloodless method
    a. Burdizzo's castrator or emasculatome method
    b. Rubber ring method

11.3.2.4.1. Surgical methods

In this method the testicles are removed by severing the spermatic cord after incising the scrotum. This is the most common and safe method. Castration by this method can be done at any age. Precaution should be taken regarding drainage and wound healing.

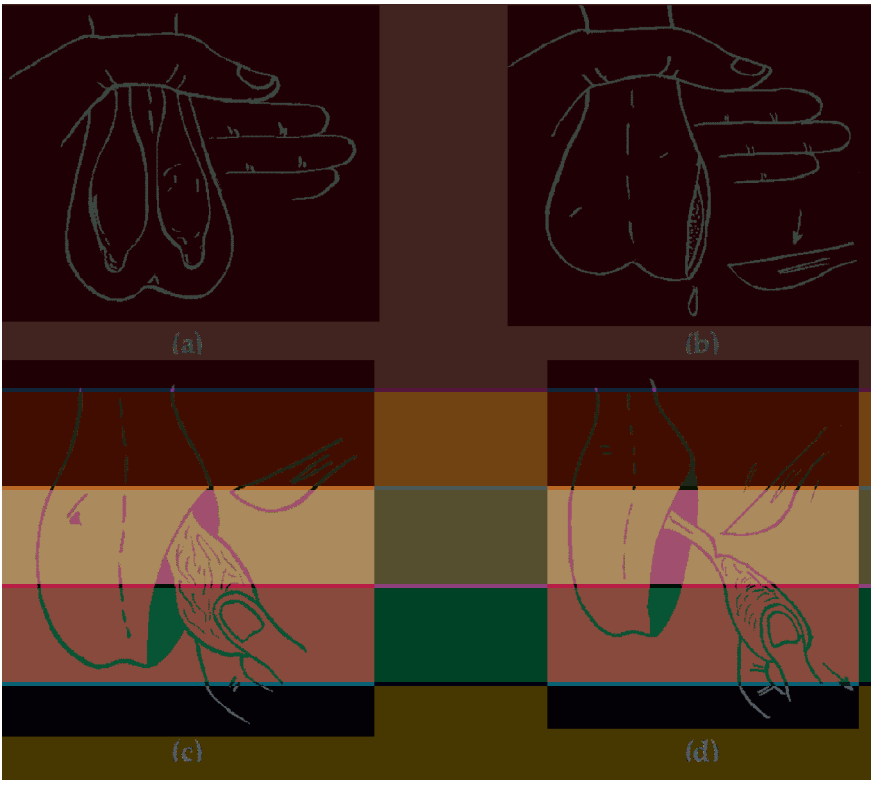


Fig. 11.5 : Surgical method of castration (a= Testicles are pushed into the bottom of the scrotum, b= an incision is made from the base of the scrotum up the side, c= Testicle is pushed through the opening, d= Exposed spermatic cord is severed with a scraping motion)

Procedure:

Animal is restrained

↓

Hands of the operator are washed, instruments are sterilized and scrotum disinfected

↓

Testicles are pushed into the bottom of the scrotum (Fig. 11.5 a)

↓

An incision is made from the base of the scrotum up the side (approximately 2.5 cm) (Fig. 11.5 b)

↓

Testicle is pushed through the opening (Fig. 11.5 c)

Contd.

↓

Connective tissue is removed from around the testicle

↓

The exposed spermatic cord is severed high above the testicle with a scraping motion (allowing quicker blood clotting and therefore reducing blood loss) (Fig. 11.5-d)

↓

The operation is repeated for the other testicle

↓

Close the opening of the scrotum

↓

Release the animal

Alternate surgical method:

Restrain the animal

↓

Washing hands of the operator, instruments are sterilized and scrotum disinfected

↓

Force both the testicles upward in the scrotum

↓

Cut off the lower 1/3rd length of the scrotum horizontally with a sharp knife or scalpel blade

↓

Testicles are exposed and freed of their connective tissues

↓

Exposed spermatic cords are severed high above the testicle with a scraping motion (allowing quicker blood clotting and therefore reducing blood loss)

↓

Close the opening of the scrotum

↓

Release the animal

11.3.2.4.2. Bloodless methods

i. Burdizzo's castrator or emasculatome method

This is a bloodless method of castration. The emasculatome (Fig. 11.6) crushes the spermatic cord and the associated blood vessels without disturbing the central septum of the scrotum. The scrotum remains intact and gets blood supply through the central area. There will be cutting of blood supply to the testicles causing cell death of the testicular tissues resulting in degeneration of testicular tissues.

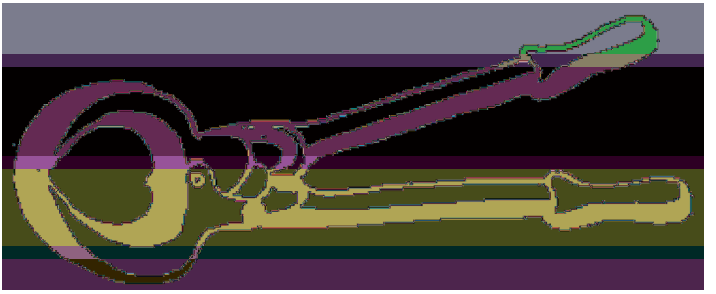


Fig. 11.6: Burdizzo's castrator or emasculatome

Suitable age: The best time to castrate by applying emasculatome is as soon as the spermatic cords can be felt, i.e., 3-4 weeks after birth. In older animals above 4 months it is difficult as the connective tissues in the spermatic cord thicken with age which prevent crushing of the cord by the instrument.

Advantages :

i. Bloodless method

ii. Can be done at any time of the season

iii. Quick method

iv. Less chance of getting infection

Disadvantage :

i. Inexperienced person may miss the cord completely and the animal is not castrated

ii. Not suitable in old animals

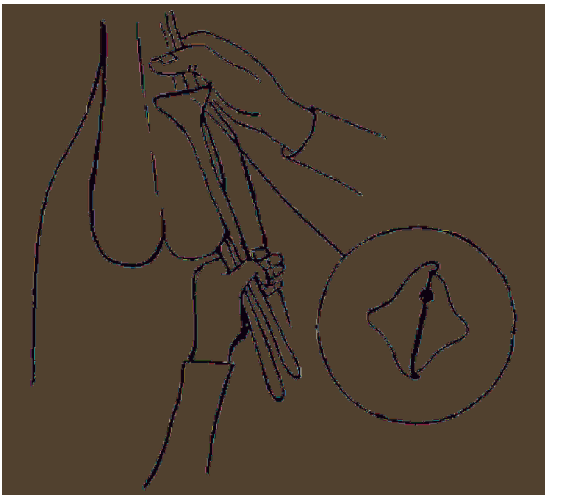


Fig. 11.7 : Application of Burdizzo's castrator or emasculatome

Procedure:

Restrain the animal

↓

Locate the testicle and spermatic cord

↓

Move a spermatic cord to the side of the scrotal sac

↓

Position the open emasculatome (sterilised) approximately 2" above the tip of the testicle with care that the spermatic cord is within the jaws of the emasculatome (Fig. 11.7)

↓

Close completely the handles of the emasculatome and keep for approximately 30 seconds

↓

Release the emasculatome and the procedure is repeated on the other cord by positioning the emasculatome approximately ¼" to ½" below the original clamping site

↓

Release the animal

With successful castration, after a day the testicles are swollen. The testicles within a period of weeks will shrivel up and are replaced with connective tissues.

ii. Rubber ring method

The rubber (elastrator) rings are applied on the scrotum between the animal's body and the testicles with the help of an elastrator (Fig. 11.8). The rubber rings cut off blood circulation of the testicles and lower scrotum, which atrophy and slough off in 3-4 weeks. The ring is applied as close as possible to the testicles for better blood vessel constriction and major portion of the scrotum is left.

Age: This method works best on calves less than 1-2 months of age. As the testicles become larger with age, the rings become more difficult to apply and may not always cut off blood supply effectively.

Advantages:

i. Bloodless method

ii. Can be done at any time of the year

Disadvantages:

i. Tetanus and infection are problems as the scrotum atrophies and sloughs off. When this method is used tetanus antitoxin should be administered at the time of applying.

ii. Elastrator band can break and castration may not occur

iii. Not suitable in old animals

Fig. 11.8 : Application of rubber ring for castration

Procedure:

Assemble the elastrator and rubber rings
↓
Restrain the calf
↓
Place one rubber ring over the four prongs of elastrator
↓
The ring is stretched and placed over the scrotum
↓
The testicles are pushed into the scrotum below the rubber ring
↓
The rubber ring is released and elastrator removed
↓
Check that both the testicles are present below the rubber ring
↓
Release the calf

Failure of the method occurs if the rubber ring breaks or not applied properly

Short scrotum method:

Where high growth rate associated with intact males is given priority rather than fat deposition short scrotum castration can be done. The elastrator ring is applied to the scrotum distal (away from the body) to the testicles after the testicles are pushed up against the body of the bull in a manner that will keep the testicles firmly in contact with the body and thereby keeping teticles temperature nearer to the body temperature. In this condition, the testicles continue to produce hormones but do not produce sperm. Such a bull is sterile, grows well and fat deposition is same as in intact bull.

11.3.3. Dehorning

Dehorning is the process of removal of horn or preventing its growth. Dehorning removes the horn and horn producing tissues after horn have formed from the bud.

Disbudding means destroying or removing horn buds and the horn producing cells around the horn bud at an early age. Disbudding can be done upto 6 months of age.

Objectives: The purpose of dehorning is to

i. reduce injury due to fighting
ii. minimize damage and bruising of hides which reduces value of carcass
iii. handle easily without any danger to the attendant
iv. keep more number of animals in a less space and less feeding area
v. transport the animals without any injury
vi. feed the animals in group with less interference from dominant animals

Horns and their growth: Horns are the pairs of hard, bone like, permanent growths projecting from the heads of cattle. They grow from a unique area of skin cells, the horn buds or buttons at the base of the horn. The horn bud starts to form during the first two months of life. During this time it is free floating in the skin layer above the skull. After about 2 months, the horn bud attaches to the skull and the horn starts to grow from the horn forming tissues in the horn bud.

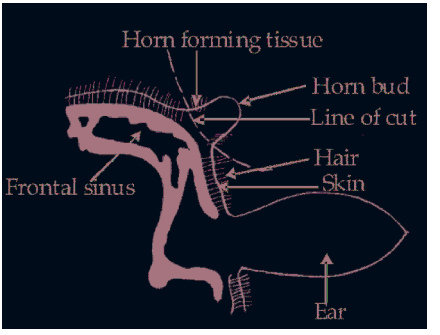


Fig. 11.9a : Diagram of horn showing position of cutting

Fig. 11.9b : Diagram showing removal of horn

Age of dehorning: Cattle should be dehorned before 6 months of age, but the ideal is before 3 months of age. This is because at three months of age the horn buds are not firmly attached to the skull. The animals suffer less stress, can be easily handled, cause little or no bleeding, heal quickly and do not result in any significant setbacks.

Key to successful dehorning:

i. Whatever the dehorning method is used it is essential that whole horn bud is removed. It is essential to remove or destroy a complete ring of skin atleast one cm in diameter around the horn base (Fig. 11.9a,b). This is important as the horn grows from the skin around its base.

ii. Good hygiene and dressing of the wound for quick healing.

11.3.3.1. Dehorning methods

Dehorning can be done by various methods depending on the age of the animals.

1. Physical methods
   a. Hot iron
   b. Dehorning knife or spoon (gouge) or tube
   c. Barnes type dehorner
   d. Dehorning clippers and saws
   e. Rubber bands
2. Chemical method

11.3.3.1.1. Physical methods

1. Hot iron : Various hot iron dehorning tools are available including fire, gas or electric heated (Fig. 11.10a, b). This method is best suited to calves below 2 months of age. It can be carried out at any time of the year. If carried out properly, there is no loss of blood and no wound to become infected.

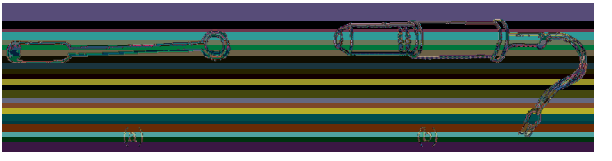


Fig. 11.10 : Dehorning iron (a= iron rod and b= electrical dehorner)

Procedure:

Restrain the calf

↓

Iron rod heated to a cherry red colour

↓

Apply the heated iron firmly over the emerging horn bud

↓

Roll the hot iron over the horn bud several times in a circular manner for about 10 seconds so that a ring of tissue about 1 cm around the bud is burnt through the full thickness of the skin

↓

Finally a ring of copper coloured hide appears around the horn base

Release the calf

In case of electrically heated iron the temperature of the iron is about 1000°F or 538°C. The horn bud will slough off in 4-6 weeks, leaving a relatively smooth area devoid of hair.

2. Dehorning knife or spoon (gouge) or tube : This method involves the actual cutting out and removing of the small horn buds. This method works best on young calves below 2 months of age.

Procedure:

Assemble and sterilized the necessary equipments

↓

Restrain the calf

↓

Clean the horn and area around horn with soapy water or a disinfectant

↓

Place the cutting edge of the instrument on the skin around the base of the horn

↓

Tube: Place the tube over the base of the horn so that approximately 1/8" of skin around the base of the horn is included within the tube. Push and twist the tube inward and downward (towards the jaw) so that the cutting edge of the tube cuts under the area of horn button to spoon it out.

Or

Knife or spoon (gouge): Position the knife or spoon around the skin at the base of the horn and cut around and under the horn taking about 1/8" of skin around the base of the horn and go about ¼" to ½" below the surface of skin. This will slice off horn level with the skull and remove an elliptical piece of skin with the horn at the centre. Make sure that no horn forming tissue is left.

↓

Repeat the same procedure in the other horn

↓

Apply an antiseptic solution to the horn area to prevent infection

↓

Release the calf

3. Barnes type dehorner : It is used for dehorning older cattle 4-12 months old. It leads the horns out by the roots and crushes the blood vessels for minimum bleeding.

Procedure :

Assemble and sterilize the necessary equipments

↓

Restrain the animal

↓

Place the dehorner with handles together over the horn close enough that a ring of hair and skin ¼" to ½" wide is removed with the horn

↓

Spread the handles apart quickly which will close the knife and remove the horn

↓

After the horn is removed bleeding will occur (because the artery is exposed). Bleeding can be reduced by picking up the main artery on the underside of the cut, twisting and pulling the artery out of its position until it breaks off within the soft tissue by using forceps. The broken artery will retract into the soft tissue, clotting occurs and bleeding will be stopped.

↓

Treat the wound with an antiseptic spray or solution to prevent infection

Place a thin layer of cotton over the exposed sinus cavity to prevent foreign particles from entering the sinus and thus, minimise infection

↓

Repeat the same procedure in other horn

↓

Release the calf

4. Dehorning clippers and saws : These are used for dehorning cattle of 1-2 years of age. Dehorning saws can be used to tip (cut ends off) horns or to remove entire horn. The saw may be a simple wood cutting saw (Fig. 11.11) or wire saw (Fig. 11.12). The use of saw is necessary when the horn base is too large for clippers or when abnormal horn growth prevents the use of clippers.

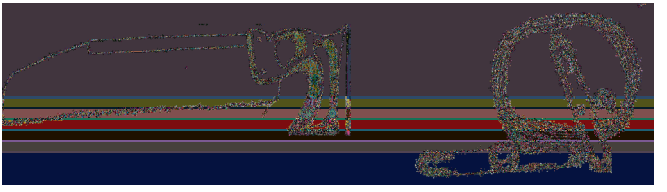


Fig. 11.11 : Wood cutting saw **Fig. 11.12 :** Wire saw

Procedure:

Assemble and sterilize the necessary equipments

↓

Restrain the animal

↓

Administer local anesthesia around the base of the horn

↓

Apply the dehorning clippers over the horn or place the saw at the base of the horn

↓

Cut deep enough to remove a ring of skin along with the horn. The deep cut destroys the modified skin cells from which the horn grows

↓

More bleeding occurs in mature than in younger cattle. Bleeding can be reduced by picking up the main artery on the underside of the cut, twisting and pulling the artery out of its position until it breaks

off within the soft tissue by using forceps. The broken artery will retract into the soft tissue, clotting occurs and bleeding will be stopped. Use of the saw results in less bleeding because the action of the saw blade lacerates the blood vessels instead of making a clean cut, but the wound produced by the saw take longer to heal

↓

Treat the wound with an antiseptic spray or solution to prevent infection

↓

Place a thin layer of cotton over the exposed sinus cavity to prevent foreign particles from entering the sinus and thus, minimise infection

↓

Repeat the same procedure in other horn

↓

Release the animal

5. Rubber bands : Rubber band acts by shutting of blood circulation around the horn which results in gradual sloughing off horn. It is effective in older animals. It is bloodless without any open wound but the method is neither satisfactory nor dependable.

Procedure :

Assemble and sterilize the necessary equipments

↓

Restrain the animal

↓

Make a shallow groove around the base of the horn forming a ring

↓

Using elastrator slip a tight rubber band over the horn and fix into the groove

↓

Repeat the same procedure in other horn

↓

Release the animal

After few days the horn will dry and fall off because of stoppage of blood supply to the horn.

11.3.3.1.2. Chemical method (caustic stick or paste method)

This method of dehorning is used for very young calves (about 1or 2 weeks of age) in which the horn has grown very little. The method involves destroying the tissues of horn bud by applying a caustic paste or stick.

Fig. 11.13 : Application of chemical caustic stick for disbudding

Procedure:

Assemble petroleum jelly and caustic paste or stick

↓

Restrain the calf

↓

Clip hairs around the base of horn bud

↓

Clip off the end of horn bud with a sharp pocket knife so that the dehorning chemical can penetrate the horn for action. When the horn bud is under skin in very young calves, nick the skin over the horn bud with a pocket knife so that the chemical can penetrate

↓

Apply a ring of petroleum jelly or Vaseline around the base of the horn bud

↓

Apply the dehorning chemical. Dampen the caustic stick with a moist paper towel or cotton to increase its effectiveness. Apply the caustic stick in a circular motion on top of the horn bud and the area immediately around the horn until blood appears (Fig. 11.13). If paste is used, apply it to the horn until it is approximately to the thickness of a coin over the top of the horn bud.

↓

Repeat the same procedure in other horn

↓

Release the calf

After a few days a scab will appear over each horn bud. This will drop off in about 1-2 weeks and leave a smooth spot of skin

Precautions

- The caustic stick or paste should be applied exactly according to the label direction. If too much solution is used or if the chemicals flows out of the horn bud site it can cause a serious scar. If the solution is used in less amount stub horn can result.
- Calf should be protected from rain after treatment because the caustic solution can run down and cause damage to calf's face. When the calf suckles, it can even damage cow's udder.

11.3.4. Grooming

Grooming is the process of cleaning body coat of animal. This can be done either by electrically operated apparatus having rotating brushes or manually with hand massage, which is better than the former.

11.3.4.1. Objectives

The purposes of grooming are to:

- clean the body of the animal regularly
- remove dust, dirt and loose hairs from the animal body
- produce clean milk
- stimulate cutaneous blood circulation
- keep skin glossy and pliable
- make animal docile

- promote overall improvement of general health
- make animal good looking and appearance

11.3.4.2. Procedure

Assemble the necessary equipments
↓
Restrain the animal
↓
Remove sticking dirt and dry dung with curry comb
↓
Start brushing from neck towards the hind quarters with body brush along the direction of hairs
↓
Scrap the brush on the curry comb after every 4-5 strokes for cleaning it
↓
Release the animal

11.3.4.3. Precautions

- Movement of brush should be along the direction of hair.
- Grooming should be done one hour before milking so that fine dust particles and hairs suspended in air may settle down.

11.3.5. Clipping of Hairs

The clipping of hairs of a dairy cows is an important prerequisite of clean milk production. The loose hairs and dirt, cow dung etc. attached to the hairs may fall on milk during milking and contaminate it. The animals are to be clipped twice in a year. The udder should be clipped to prepare for milking by washing and drying and it is easier to keep clean. The flanks and underline (belly and brisket) should also be clipped to keep the cow clean. This will prevent manure and mud from sticking to the body hairs. Cutting off the end of switch will also prevent manure and mud sticking to it. A good time to clip the animal is just before calving. The clipping is done by clippers.

11.3.5.1. Objectives

The animals are clipped for the following purposes:

- clean milk production

- elimination of parasitic infestation
- improvement of general appearance
- sale purpose
- cattle shows/exhibitions

11.3.5.2. Procedure

Assemble the necessary equipments

↓

Restrain the animal

↓

Groom the animal to remove dirt, manure etc. attached to hairs

↓

Start clipping against the lay of hairs, move the clippers slowly and gently

↓

Udder is clipped by starting at the bottom of the udder and moving towards the body against the lay of hairs

↓

Clip the udder by stretching the skin to facilitate closer clipping and avoid nicking. The whole udder is clipped closely and smoothly.

↓

Clip the flanks starting at the front udder attachment, moving up and on an angle towards the pin bones. The areas below this line on the flank and thigh are clipped.

↓

The underline is clipped in the same manner starting at the front udder attachment moving towards front legs. The brisket is also clipped. Clipping is usually limited to the underline and body above the underline is not clipped.

↓

Clip off the switch about one foot above the floor.

↓

The topline may also be clipped starting at the tail head and moving forward to the neck

↓

Release the animal

11.3.6. Disinfection and hygiene of dairy farm

Many micro-organisms live and multiply outside the animal body in the surrounding environment and infect the animals causing disease outbreak. The number of organisms in the environment and incidence of disease outbreak can be reduced by ensuring bio-security measures. Bio-security measures refer to the protection of livestock from exposure to disease causing organisms. Bio-securtity helps in disease prevention by excluding disease causing organisms from the animal's environment. The bio-security measures can be enhanced through disinfection and sanitation of dairy farm. These include providing the animals clean, dry, well-ventilated housing and proper use of antiseptics and disinfectants.

11.3.6.1. Objectives

The purposes of disinfection and sanitation are to:

- minimize the number of infectious organisms in the environment.
- reduce the incidence of disease outbreaks.
- maintain animals healthy.
- maintain optimum production of animals
- reduce treatment cost
- reduce transmission of infection to human.

11.3.6.2. Terminologies associated with disinfection

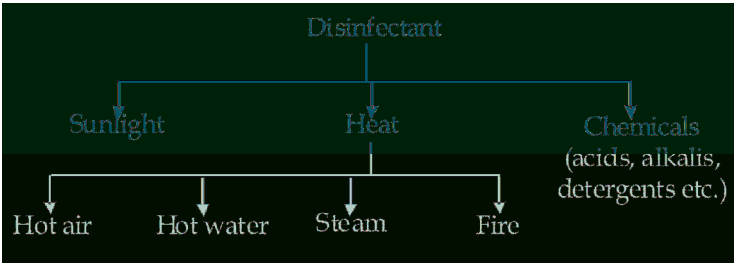
Antiseptics: Antiseptics are substances that kill or prevent the growth of microorganisms on living tissue.

Disinfectants: Disinfectants are substances that prevent infection by destruction of pathogenic microorganisms in inanimate objects.

Sanitiser: Sanitiser is an agent that reduces the number of microbial contaminants to a safe level i.e., below 25 microbes/sq. inch or 4 microbes/sq. cm.

Sterilization: Sterilisation means complete destruction of all forms of life, especially microorganisms. It may be further defined by specific terms like bactericide (destroys bacteria), viricide (destroys viruses) and fungicide (destroys fungi).

11.3.6.3. Classification of disinfectants



11.3.6.3.1. Sunlight

The ultra-violet (UV) rays of sunlight are responsible for its disinfecting action. The effective wave length range for this action is between 2800 A° and 2400 A°.

11.3.6.3.2. Heat

Heat destroys microorganisms by denaturation of their cellular proteins through oxidation. Moist heat is more effective than dry heat as the former destroys microorganisms by denaturing their cellular proteins as well as DNA and RNA. Heat is applied in the following forms:

I. **Hot air**: It is an effective means of disinfection, but due to its high cost its use is limited to laboratories.

II. **Hot water**: It is a good means of disinfecting utensils by immersion in boiling water for 5 minutes.

III. **Steam**: Steam at a pressure of 15 lbs is a good disinfectant. Steam exerts its action on following ways:

   a. High latent heat released immediately on its contact with the materials.

   b. Its condensation on microorganisms present in contaminated materials.

   c. Its high penetrating power than water due to its lower specific gravity.

IV. **Fire**: Fire totally destroys bacteria and spores and sterilizes utensils. It is the best means of disposing infected carcass and associated materials.

11.3.6.3.3. Chemicals

Various chemicals are used as disinfectants. They are cheap and have broad spectrum activity.

Mode of action: The chemical disinfectants act on proteins, enzymes, nucleic acids, lipids, cell membranes and other cell constituents of microorganisms. They act through following mechanisms :

(a) **Oxidation**: Hydrogen peroxide (H_2O_2), potassium permanganate ($KMnO_4$), chlorine, ozone etc.

(b) **Reduction**: Formaldehyde, sulphur dioxide etc.

(c) **Coagulation**: Metallic compounds like mercury, silver nitrate etc.

(d) **Ionisation:** Radiation

(e) **Hydrolysis:** Boric acid, alkali etc.

(f) **Molecular action:** Mercury compounds and other heavy metals

(g) **Mutagenesis:** Ethylene oxide, nitrous oxide etc.

Types of chemical disinfectants: Various chemical disinfectants are available in the market and most of them fall into one of the major categories discussed below:

i. **Acids:** Strong acids like hydrochloric acid (HCl), nitric acid (HNO_3) and sulphuric acid (H_2SO_4) must not be used on living tissues. Dilute acid can be used for disinfecting drains, floors, walls and other cement structures. They are especially useful in disinfecting farm buildings contaminated with excessive organic matter. Organic acids are most frequently used as food preservatives because they prohibit growth of many microorganisms such as acetic acid, lactic acid etc. Boric acid (4-6%) is a mild acid which may be used for washing skin and wound and also floors.

ii. **Alkali:** Alkalis having a pH of 9 or higher is detrimental to the survival of most of the microorganisms. But care should be taken while applying as this group of compounds is very irritating to living tissues.

Sodium hydroxide (NaOH) is the most widely used alkali of this group. NaOH (1%, 2% and 5%) is available as lye for

disinfection of animal houses particularly after an outbreak of disease. A higher concentration is required if the organic matter is more. In lower concentration about 0.5% it can be used for disinfecting equipments. In stronger solution (at or above 5% concentration), it is used to kill many of the more resistant bacteria and viruses like anthrax on floors, stalls and pens.

Calcium hydroxide (slaked lime) is formed when unslaked lime (quick lime) is added to water. It is used as disinfectant in white washing floors and walls of animal houses, and in certain equipments. Quick lime (Calcium oxide) is used as disinfectant agent by spreading in farm premises and to cover carcasses when burying them.

Ammonia is useful disinfectant for destroying coccidial oocytes in 10 % aqueous solution.

Sodium bicarbonate (washing soda) as a hot 4% solution is an effective disinfectant.

iii. **Aldehyde:** The most common aldehyde used is formaldehyde. Its 40% solution is known as formalin. Formalin is used in 5-10% concentration for washing floors and buildings following outbreak of diseases. It is used in 1% aqueous solution for disinfecting utensils, medical equipments and surgical instruments.

Glutaraldehyde is another disinfectant of this group. It has added advantages that it is effective even in presence of organic matter and less toxic than formaldehyde.

iv. **Detergents and soaps:** Detergents and soaps are surfactants. Surfactants are substances that are soluble in but are able to dissolve lipids. In this way they increase the solubility of lipids in water solutions and penetrate lipid surfaces.

Soaps are sodium or potassium salts of fatty acid. Soaps are alkaline (pH>7). They exert antimicrobial effects in two ways- by harming bacteria that are sensitive to high pH and by removing the pathogens from surfaces by cleaning the surface i.e., degerming.

Detergents are synthetic surfactants. They may be cationic (positively charged) or anionic (negatively charged). Cationic detergents are better at killing bacteria than anionic

detergents. They can be used for disinfecting equipments and utensils. Anionic detergents are more suitable for bandages and clothings.

v. **Dyes :** A large number of dyes are used as antiseptics like crystal violet (0.5% aqueous solution) and brilliant green (0.05-0.1% aqueous solution) is effective against many organisms. Acridin dye (1:1000 aqueous solutions) can be used if the materials contain some amount of organic matter.

vi. **Halogens:** This group of disinfectants is widely used. They cause destruction of pathogens by oxidation.

Chlorine in different forms is used as disinfectants like gaseous chlorine, hypochlorites and organic chloramines. Sodium hypochlorite and chlorinated lime (calcium hypochlorite, bleaching powder) are very effective for washing dairy utensils, glasswares and equipments.

Iodine is an effective antiseptics for skin. Iodine is used in two forms-tincture of iodine (2 or 7%) and iodophors. Tinctures (7%) are used for navel cord treatment in calves. Iodine as 0.2% aqueous solution (Lugol's solution) is used for vaginal and uterine washing.

vii. **Metallic compounds:** Various metals and metal salts prevent microbial growth or kill microbes. Mercuric chloride and iodide as 0.1% solution can be used as skin disinfectant. Silver nitrate is used as cauterizing and disinfecting agent for wounds. Copper sulphate is used in cattle and sheep dips, snail destruction on wet lands and plankton control in lakes and ponds.

viii. **Oxidizing agents:** H_2O_2 in 3-6% aqueous solution is used mostly for washing and cleansing wounds. $KMnO_4$ in a concentration of 1:1000 to 1:10,000 is used as antiseptic for wound washing and disinfecting instruments. $KMnO_4$ (1-2mg/litre) can be used to disinfect well and tank waters.

ix. **Phenols and related compounds:** Phenol (carbolic acid) is one of the most efficient disinfectants. Phenol and its derivatives (called phenolics) are especially useful in presence of organic matter. Phenol for better effectiveness must be applied at a temperatures greater than 60°F. But care should be taken as high concentration is toxic to skin.

Cresol is used to disinfect animal houses, vehicles etc. It is more active than phenol and is toxic to living tissue.

Orthophenylphenol is often used instead of phenol particularly in dairy barns as it is odourless and less corrosive.

Chloroxylenol is the principle ingredient in dettol, a household disinfectant and antiseptic.

Lysol is used for washing floors, walls, stalls, mangers, water trough etc. Lysol is saponated cresol solution.

Thymol, derived from the herb thyme, is less soluble in water but a good antiseptic and is often used for oral washing.

x. **Alcohols**: Alcohols are poor disinfectants but are commonly used as antiseptics. The most commonly used alcohols are ethanol and isopropanol. Ethanol is ethyl rubbing alcohol containing 70% ethanol by weight. It is not very effective. Isopropanol is isopropyl rubbing alcohol containing 70% isopropanol by weight. It is slightly more germicidal than ethanol in undiluted form.

Alcohols have limited residual activity due to evaporation, which results in brief contact times, and have a limited activity in presence of organic materials. Alcohols are more effective combined with purified water (in 70-99% mixtures) than pure alcohol. The higher water content allows for greater diffusion through the cell membrane.

11.3.6.4. Steps for disinfecting animal house

i. **Cleaning and removal of organic matters**: The first step is cleaning and removal of organic matters from the animal house. Organic matter provides nutrients to the micro-organisms and prevents disinfectants from coming in contact with them. This should be done by removing cobwebs, dung and other organic matters by thorough sweeping, scrubbing and scrapping with warm water and wire brush. Sprayers applying soap and water at high pressure can be applied at last.

ii. **Selection of disinfectant**: The disinfectant should be selected considering certain factors like

- Place of use
- Effectiveness

- Availability
- Solubility
- Cost
- Toxicity to tissues
- Action on materials like metals, wood, cement floor etc.
- Effects on animals if taken internally
- Stability in solution
- Odour, colour etc.

iii. **Method of application of disinfectant**: The method of application depends on the type of disinfectant. The solution should be applied on the entire surface to be disinfected. On a limited surface it can be used with brush, splashing etc. and on a large surface can be sprayed.

iv. **Precautionary measures**: Persons applying the disinfectant must be aware of toxicities if any and should take precautionary measures accordingly. Eyes, nose and mouth must be protected by wearing goggles, gloved etc. Care also should be taken to prevent licking and ingestion of the disinfecting agents by the animals.

11.3.7. Record keeping

The basic unit of a dairy farm is cow, which is a living creature. It needs time to time care and management with sensible planning of all the necessary inputs in harmony in due time. For every single farm operation herdsman need data on the basis of which he can take correct decisions in time. The operations can be regular like feeding, milking etc. or periodical like selection and culling, vaccination etc. Data are maintained in the form of record. The records include purchase of inputs, sale of products, price per unit and total value of the different items, animals. The input records may be of feeds, fertilizers, equipment, hired labour, veterinary service, A.I. etc. Among the animal records, most important records are regarding production and reproduction records such as milk yield, oestrus, services, pregnancy, births, diseases, treatments etc. Records also include harvests and yields of fodder crops, amount and type of feeds given to the animals. Herdsman or manager can evaluate, plan, coordinate and execute the particular operations on the basis of the available facts from the records. Therefore, decision making of a farm along with its profitability and viability mainly depends upon the available records.

How to maintain the records

The data are recorded periodically. The period depends upon the frequency of occurrence of the particular events. The records are to be maintained in the simplest form, so that it can be traced out easily by anybody. Usually records are maintained in the register. However, large commercial herds and government farms maintain records in the computer, which enables recording more data in a limited period and retrieval of data is also very much easy.

Use of records

The records may be used broadly in two purposes like on-farm use and off-farm use.

On-farm use: This can be facilitated for the following purposes:

- Individual animal is identified and monitored on the basis of its production performances.
- Feed can be provided according to the requirement.
- Economic feeding is possible through selection of cheap feed resources.
- Animal can be bred in due time.
- Prevention of disease is possible
- Selection and culling can be possible with the helps of production, reproduction and performance records.
- Marketing of animals can be possible on the basis of available record.
- Annual financial statement can be prepared from the records.
- Based on the financial implications the expansion of dairy farm depends.

Off-farm use: This can be facilitated for the following purposes:

- Implementation of herd and breed registration programme is possible.
- Based on the records, different breeds within the herd can be assessed as well as in different herds can be compared.
- Best bull can be traced out and wide use of the bull is possible through artificial insemination.

- Best female cow can be identified and embryo can be used for embryo transfer technology.

Types of records

Some important records are as follows:

- History and pedigree sheet
- Breeding record
- Calving record
- Calf record
- Growth record of young calf
- Immunization record
- Herd health record
- Daily feeding record
- Daily milk yield record
- Month-wise lactation record
- Daily livestock register

11.4. SUMMARY

The routine farm management practices are essential for the success of a dairy farm. The first step of managing the animals is to identify the animals. The animals can be identified by different methods such as natural or artificial (branding, tagging, tattooing, ear notching etc.). This will also help in keeping different records of the animals for day to day or future use. The male animals should be castrated as early as possible before attaining maturity to prevent uncontrolled breeding, get good quality meat, make them docile etc. Castration can be done by different methods, e.g., surgical or bloodless method. The animals are dehorned or disbudded by different methods to prevent injury to themselves as well as the attendants, keep and feed more numbers animals together etc. The animals should regularly be groomed and clipped for better health and clean milk production. To prevent and control occurrence of diseases in animal regular and routine disinfection of animal houses, farm premises and equipments are essential. The dairy farm operations can smoothly be carried out by keeping various farm records.

11.5. CHECK YOUR PROGRESS

(a) What is identification of animals?

(b) What is branding?

(c) What is castration?

(d) What is disbudding?

(e) What is grooming?

11.6. ANSWERS TO 'CHECK YOUR PROGRESS'

(a) Identification is the process by which the animals are marked for their individual identity.

(b) Branding refers to affixing some markings either in the form of letters or numbers on animal body with hot or cold iron or chemicals.

(c) Castration means depriving animals of its gonadal function either by removal or disfunctioning of essential reproductive organs in males.

(d) Disbudding means destroying or removing horn buds and the horn producing cells around the horn bud at an early age.

(e) Grooming is the process of cleaning the body coat of the animal which can be done either by electrically operated apparatus having rotating brushes or manually with hand massage

11.7. EXERCISES AND QUESTIONS

(a) What are the various methods of identification?

(b) Discuss surgical method of castration.

(c) What are the various methods of dehorning?

(d) How you can classify disinfectants?

(e) What are the different steps of disinfecting animal house?

11.8. FURTHER READING

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CHAPTER - 12

Milking Management

12.1. INTRODUCTION

Milking is the crucial operation in a dairy farm, as milk is the main source of revenue of a dairy farm. Milking is a labour intensive operation. About 50-60 percent of the total time of farm operation is required for milking and allied activities. Milking is an art which requires skill, patience, efficiency and experience. It should be handled quietly, quickly, gently, cleanly and completely, by avoiding any type of pain, annoyance or inconvenience to the animals. Possession of high yielding animals or good managemental conditions will not generate profit if the milking operation is inefficient.

12.2. OBJECTIVES

The major objectives of milking management are as follows

- To harvest maximum amount of milk from the animals within the lactation as well as in subsequent lactation.
- To obtain milk without causing injury to udder or teats.
- To obtain clean milk.
- To reduce chance of udder infection through complete milking as incomplete milking increases the chance of diseases like mastitis (disease of mammary gland causes heavy loss to the animals) and develops a tendency of early dry off (stop milking).

12.3. UDDER OF COW

Milk is produced by a system of glands grouped together in an organ called udder (Fig. 12.1). Mammary glands or udder is a modified sweat (sudoriferous) gland. Udder is usually covered by fine hairs, however teats devoid of hair. Udder is divided into two halves (left and right). Each half is again divided into two quarter (fore and hind quarter). Each quarter is an independent unit and attached with a teat. The size of the two fore quarters is smaller than two hind quarters and contains less secretary tissues. Therefore, fore quarters produce about 40 percent and hind quarter produce 60 percent of the total milk.

The milk secretion takes place inside the alveoli containing monolayer (single layer) epithelial cells. Then milk is drained to the small duct called "terminal duct". A group of alveoli is surrounded by a thin layer of connective tissue is called lobule. A group of lobule again surrounded by a thick layer of connective tissue termed as lobe. Terminal ducts are joined together to form intralobular duct. These ducts unite successively to form larger ducts called interlobular, intralobar, and interlobar ducts. Interlobar ducts join to form galactophores that empty into a reservoir called as gland cistern or milk cistern. Milk cistern connected to another reservoir termed as teat cistern. Teat cistern joins with the streak canal which is directly connected to the outside environment. The streak canal is surrounded by muscle sphincter which prevents drainage of milk until milking process start. Therefore, streak canal along with sphincter prevent entry of bacteria and other contaminants into the teat (Banerjee, 1998).

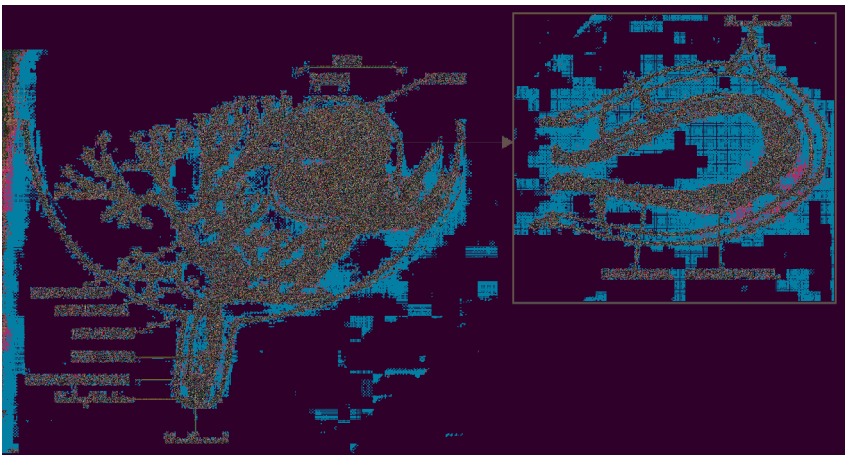


Fig. 12.1 : Internal structure of mammary gland

Milk secretion is a continuous process, within the cells of the alveolus. After milk synthesis only a small portion is stored in the large ducts and cistern. Smaller ducts and alveoli store major portion of the milk. Capillary pressure of the ducts prevents the drainage of the milk. Increase of intramammary pressure is required to remove the milk form udder. Sudden increase of intramammary pressure occurs due to the action of oxytocin hormone, which causes let down of milk. Udder is highly vascualrised gland, supplied with large number of large and smaller blood vessels. It has been estimated that for synthesis of 1 ml milk, 500 ml blood flow is required through the udder.

12.4. MILK LET DOWN MECHANISM

Milk let down is a neuro-hormonal reflex (Fig. 12.2) process which is initiated by one or more stimuli initiated at the time of milking. The stimuli are either natural (like sucking by calves) or conditioned (learned through experience). The conditioned stimuli are preparation of udder (touch, pressure or warmth provided by the milkers), washing of animals, feeding etc. The stimulation is carried to the hypothalamus (in brain) by the nerves. Hypothalamus gives signal to the posterior pituitary gland for the release of oxytocin hormone. Oxytocin is transported to the udder via blood. It not only contracts myoepithelium cells (small muscle cells surrounding the alveoli) but also relax smooth muscle of larger ducts and cisterns for the accommodation of milk released from the smaller ducts and alveoli. The pressure thus created forces the milk out of the alveoli and smaller ducts as fast as it can be removed from the teat. This ejection of milk from the teat is called as "let down" of milk.

Prior to milking or during milking any type of stress in the form of pain, fear etc. may inhibit the ejection of milk due to the release of adrenal hormone, epinephrine. Epinephrine causes constriction of the blood vessels and thereby prevents entry of oxytocin to the udder. Therefore, during milking special care should be taken to avoid any stressful conditions.

Fig. 12.2 : Milk let-down mechanism

Milk let down starts within half to one minutes after stimulation given. The effective level of oxytocin is very much limited (about 6-8 minutes). Therefore, the milking process should be so fast that the milking process would be completed within 7-8 minutes.

12.5. RESIDUAL MILK

The residual milk is the amount of milk retained in the udder of the animals after normal milking. Re-milking the animal or injection of oxytocin is the way to obtain the residual milk. Higher residual milk is found in low yielding animals in comparison to high yielding animals. First calved heifer has less residual milk than older cow. Residual milk usually contains more fat than normal milk.

12.6. MILKING MANAGEMENT

The profit of a dairy farm solely depends upon its effective milking practices. Milking is a labour intensive process and it requires skill as well as experience. Cleanliness should be maintained throughout the milking operation. Thus, milk remains wholesome for longer time and organism (harmful for consumption) free. Precaution should be taken during milking so that animals remain comfortable, milking should be complete and therefore, chance of residual milk remain low. Following points discussed below should be considered for efficient milking operation.

12.6.1. Frequency of Milking and Milking Interval

Milking should be done at least twice daily in the morning and evening with equal milking interval. Unequal milking intervals like 9 and 15 hours or 8 and 16 hours produced less daily milk compare to milking done at 12 hours interval. Three or four times daily milking with equal interval increases overall daily milk production without changing composition of milk. Thrice daily milking increases 15-25 percent daily milk yield over twice daily milking, however, about 10 percent of the price of milk will be required to cover the feeding and managemental costs.

12.6.2. Clean of Milking Pail

Milking pail may be a mammoth source of infection to the milk. Shape of the milking pail should be dome shaped top (Fig. 12.3), instead of open buckets or vessels. Dome shaped top prevents inclusion of dirt and filth from the animal body as well as from the environment into the freshly drawn milk. After each milking, the milking pail should first be washed with warm water containing suitable dairy sanitizer. Then immediately rinse with clean cold water. After thorough cleaning, the milking pail should be stacked in racks with upside down, until next milking.

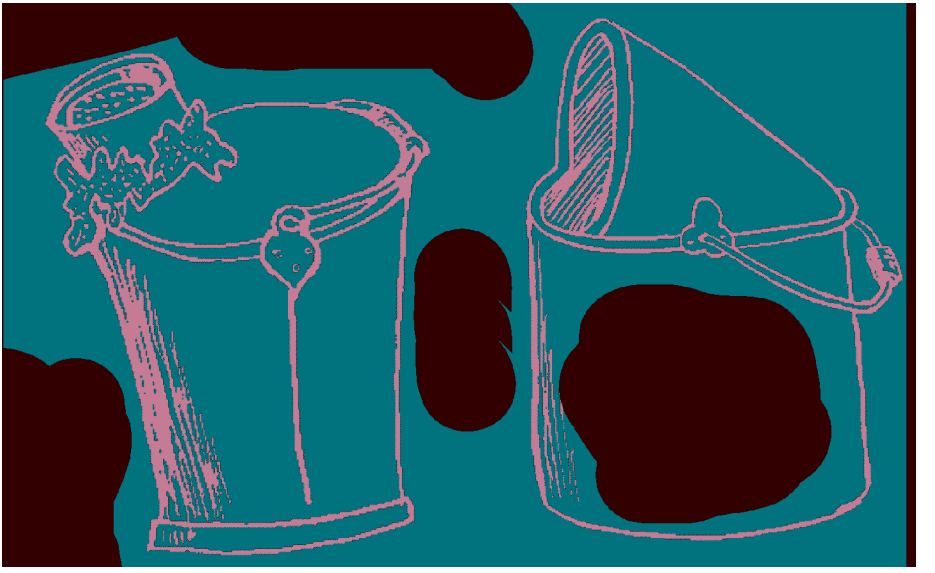


Fig. 12.3 : Milking pails

12.6.3. Feeding During Milking

It is usual practice to provide concentrate mixture to the cows at the time of milking. It helps to keep busy cows at the time of milking. Try to provide less dusty feed at the time of milking.

12.6.4. Order of Milking Cows

The cows should be milked in an order so that there will be minimum chance spread of mastitis from infected animals to the healthy animals. Mastitis is a dreadful disease of dairy animals which causes substantial losses to the dairy farm. Therefore, it is customary to milk disease free cow first. The appropriate milking order should be

- First calved cows free from mastitis
- Older cows free from mastitis
- Cows having history of mastitis, but at present normal
- Cows showing symptoms of mastitis (abnormal milk ejection from one or more teats).

12.6.5. Preventing Cows From Kicking

A few freshly calved heifers have a tendency to kick especially at the time of milking. This habit can be eliminated, if pregnant heifer is groomed and handled properly. Kicking can be prevented by using anti-cow-kicker or milk man's rope.

12.6.6. Clean of surrounding

In small dairy farm, there is no separate milking barn. However, large farms usually have separate milking barn. The animal house should be specially designed so as to provide comfortable and healthy housing for the cows and at the same time to enable them to be milked in clean condition. Not only the animal house, but also surrounding the animals should be cleaned properly which will prevent the fly and insect nuisance.

12.6.7. Cleanliness of Milker

Milker's hygiene also plays an important role in the clean milk production. Milker's nail should be well trimmed. They should wear clean dress. Keep clean their hands and disinfected between each milking by washing in antiseptic solution. Milker, suffering from

communicable diseases or having filthy habits like spitting, blowing nose, smoking at the time of milking etc. should not be engaged in milking operation.

12.6.8. Cleaning of Animals

Before putting the cows in the milking barn the cow should be washed and cleaned thoroughly. Udder and teats are washed with warm water and wiped with clean cloth. Addition of hypochlorite (500ppm) or quaternary ammonium compound (200 to 400ppm) can be added to the warm water to disinfect the udder.

12.6.9. Milking Methods

Milking can be done either through hand or machine. Hand milking is widely practiced for low yielding animals throughout the world. However, machine milking is gaining popularity due to overall improvement of genetic make up of the dairy animal as well commercialization of dairy farming.

It is usual practice to milk the cow from its left side. The hand of the milker should remain clean and dry during hand milking. Some milker use oil, water, or ghee to their fingers to moisten and soften the teats which is a harmful habit and the ill-practice of the milker should be checked. Full hand milking method is preferred over the other methods (detail discussed in the section 11.7.1.1).

In case of machine milking the machine should be designed in such a way that would create pleasant sensation to the animals, chance of damage of teat and udder remain nadir.

12.6.10. Mastitis Check (Strip Cup Test)

It is customary to check the health condition of the udder. Therefore, before initiation of actual milking process first few streams of milk from each teat are milked into the cup of the strip cup. Strip cup (Fig. 12.4) is having four cups and each cup is mentioned for a particular teat. If any form of milk clots, blood tinge or abnormalities is found in the cups, the cow as well as teat should be identified and marked for immediate attention. This process is also helpful to dispose off the milk of teat canal which has high concentration of organisms.

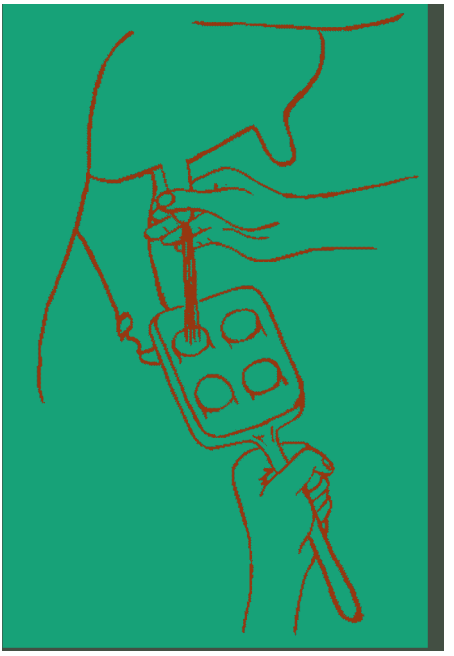


Fig. 12.4 : Strip cup test

12.6.11. Straining and Collection of Milk

Straining of milk removes all visible particles from it. For straining, a muslin cloth is tied on the mouth of the milk collecting vessel. Then milk is poured on the vessel or milk can.

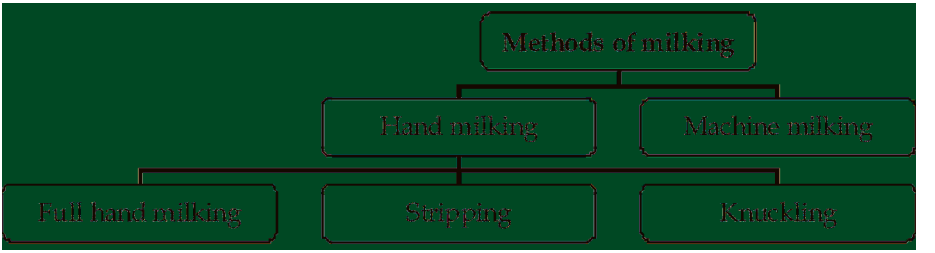
12.6.12. Cooling and Storage of Milk

Milk is a perfect medium for innumerable microorganisms. At the time of milking, milk remains nearly sterile condition. As time passes milk is contaminated with microorganisms from the environment and proliferated rapidly at the environmental temperature. Therefore, milk should immediately be chilled to 4°C just after milking which prevents further proliferation of microorganism.

12.7. MILKING METHODS

Milking methods are developed based on the calf's suckling techniques. Calf has the ability to evacuate the udder so fast that any of the manual or mechanical method can do. Method of milking depends on the socioeconomic condition of the farmer as well as the productivity of the animals. In developing countries where labour is

relatively cheap, hand milking is adopted widely. Only few advanced dairy farmers and some government organization install milking machine for milking only high yielding animals. One should adopt anyone of the methods which is possible as well as practicable.



12.7.1. Hand Milking

Hand milking is most commonly practiced in India and other developing countries. Low to medium yielding animals is suitable for hand milking. Whereas very high yielding animals are not suitable for hand milking. After let-down of milk, the milker starts milking usually from the left side of the animals. The teats are milked crosswise or first preference may be given to the most distended teats or fore quarters together or hind quarters together.

Among the three hand-milking methods full hand milking and stripping are most commonly used. However, knuckling is a faulty milking practice.

12.7.1.1. Full hand milking

Full hand milking (Fig. 12.5) is best suitable for those animals, having large teats. This method gives suckling (of calf) stimulus to the cow. This method starts with holding teats in the hand, fingers encircling the teat. The base of the teat is blocked by the fore finger and thumb which form a ring. Thus, milk trap in the teat cistern and milk may not return back to the gland cistern. Concurrently, teat is squeezed between middle, ring and little fingers and the hollow palm, thus forcing milk out. Immediately after squeeze there will be complete relaxation of teat to draw the milk within the teat cistern, however the position of the hand over the teat remains same. The alternate manner of compression and relaxation of two teats (by using two hands) at quick succession take out milk at very faster rate and it sounds like a continuous stream.

Fig. 12.5 : Full hand milking

12.7.1.2. Stripping

Stripping (Fig. 12.6) is preferred in conditions like i) too small teats and it not at all possible to evacuate milk through full hand milking, 2) at the end of milking when the udder contain very low amount of milk and which has to be removed completely. In this method, the teat is squeezed firmly at the base with thumb and fore finger. Then, drawing them down the entire length of the teat pressing it simultaneously to cause the milk to flow down in a stream. Both hands are used to milk for two different teats at the same time, but they usually strip alternate way. The process is repeated at very quick succession. This may sometimes create discomfort to the animals. As stripping requires changing of position of hand each time, the loss of time is more than full hand milking. Thus, full hand milking removes more milk.

Fig. 12.6 : Striping

12.7.1.3. Knuckling

Knuckling (Fig. 12.7) is a faulty method of milking. In this method milker bend his/her hand against the teat. Chance of injury to the teat is very high in this method.

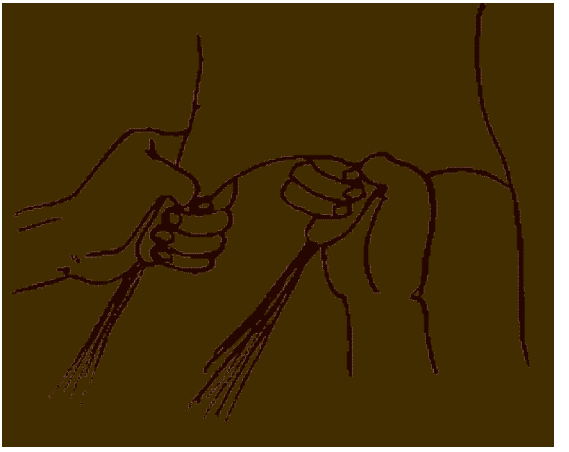


Fig. 12.7 : Knuckling

12.7.2. Machine Milking

Ever increasing labour cost encourages the use of milking machine especially in the developed countries. The milking machine reduces the hard work during hand milking. The principles of machine milking are

- to pull out milk from the teat through the application of negative pressure at the teat end
- to apply periodic message to the teat which prevents congestion of blood and lymph in the teat.

12.7.2.1. Parts of milking machine and their functions

i. Vacuum pump

The function of vacuum pump is to extract air from confined space (shell and teat cup liners, and reserve tank). Inspite of varying air usage a steady vacuum is maintained through vacuum regulator which is fitted into the main vacuum pipeline near to the milking units.

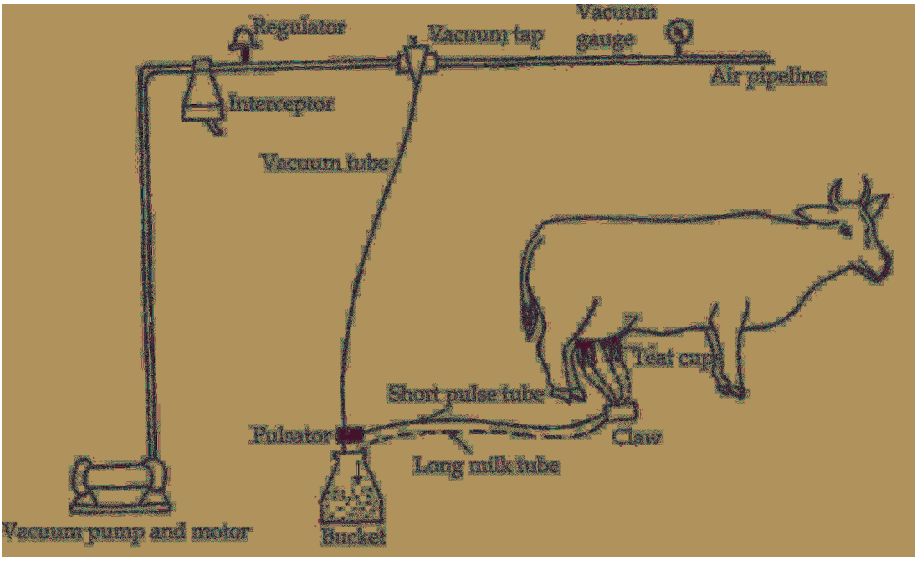


Fig. 12.8 : Parts of milking machine

ii. Pulsator

Pulsator is a valve which is automatically controlled, usually fixed on the milking bucket lid. It alternatively directs/admits atmospheric air pressure (rest/message phase) and then draws a vacuum (milk phase) into the space between the teat cup line and metal cup shell (Fig. 12.9). In the **milk phase**, the vacuum is created between shell and teat cup liner, under the control of pulsator and this creates a constant negative pressure at the teat end. Influence of internal milk pressure inside the udder and negative pressure at the teat end causes release of milk into the space between the liners. In rest/message phase, the vacuum is removed by admitting air inside the space between shell and teat cup liner (develop atmospheric pressure), thus liner collapse around the teat. The collapsing pressure provides messaging action to the teat and maintains blood flow. As the name indicts there is no milk flow during this phase.

If prolonged vacuum is applied to the teat end, blood and lymph would accumulate at the teat end which could develop trauma to the teat. Therefore, alternate vacuum and atmospheric pressure (called pulsation) is essential to maintain healthy milking practice. The pulsator is activated either by a vacuum or an electrical signal from a pulsator controller. One resting and one milking phase are jointly called one pulsation. The pulsation rate refers to the number of pulsation per

minute and which is usually 48 to 72 cycles per minute. Pulsation ratio is ratio of time taken for milking phase and resting phase. It is usually varies from 1:1 to 2.5:1.

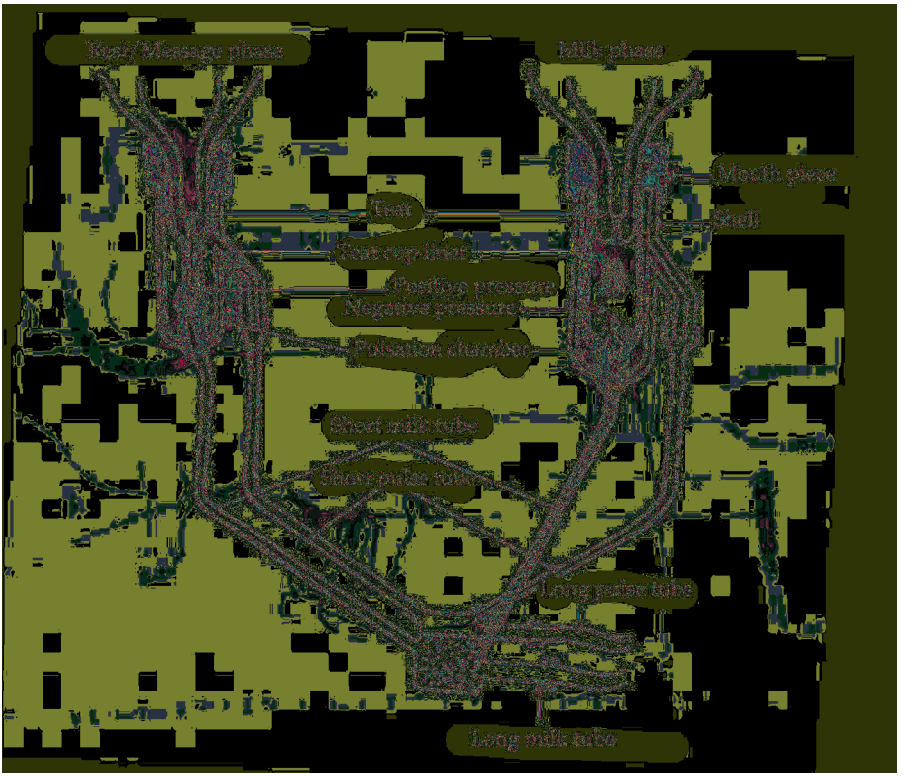


Fig. 12.9 : Basic operation of milking machine

iii. Clusture

Clusture is the terminal part of the milking machine which consists of four teat cups, one claw, one milk tube and one pulse tube. Teat cup comprises a shell, a rubber liner, a short milk tube and a short pulse tube. Teat cup shell is usually made up of stainless steel. However, plastic alone or combination of plastic and metal are also used. The liner is made-up of natural, synthetic or silicone rubber and consists of a head, a barrel and a short integrated milk tube. The liner is the only part of the milking machine which has direct contact with the teat. Shell and rubber liner (placed inside the shell) creates an annular space (pulsation chamber). Pulsation chamber is connected with the short pulse tube, which ultimately joined with the long pulse tube at claw. Teat cup rubber liner is attached with short milk tube, which either

joined with the long milk tube in pipe line milking unit or evacuate to the bucket.

12.7.2.2. Machine milking procedure

Machine milking is performed with the following steps:

- After preparation of the animals for milking at the milking parlour, teats and udder are stimulated by washing with clean warm water containing some disinfectant like quaternary ammonium compound (QAC) or hypochlorite. Udder and teats are wiped with dry towel.
- Strip a few streams of milk from each teat.
- Apply four teat cups to the teats within one minute after udder washing. Milking process will be completed within 3-5 minutes depending upon the productivity of the cow.
- Allow the milking machine few seconds for stripping last milk.
- Detach teat cups from the teat as soon as milk flow stops by breaking vacuum.
- Immediately after removal of the teat cups, the teats are disinfected with dipping solution.

12.8. SUMMARY

Milk production is the key operation of a dairy farm. Production of maximum quantities of high-quality milk is the ultimate goal of a dairy farm. It plays significant role in the profitability of dairy farm. Therefore, milking must be managed effectively to ensure efficiency and prevention of udder diseases like mastitis through complete milk removal from the udder. Method of milking should be selected according suitability of the animals as well as dairy farm. Milking frequency should be twice or thrice daily for effective milk production. Machine milking is preferable where per animal milk production is very high and capital is not a problem. The milk should be from clean, healthy cows, milked by clean, healthy milkers in clean utensils, in a clean environment, and subsequently kept clean and cold until processed or consumed.

12.9. CHECK YOUR PROGRESS

a) What type of gland is called mammary gland?

b) Where milk secretion takes place within the mammary gland?

c) What is residual milk?

d) Name the hormone responsible for milk let down.

e) Which is the best method of hand milking?

f) What is pulsation rate?

g) What is pulsation ratio?

12.10. ANSWERS TO 'CHECK YOUR PROGRESS'

a) Mammary glands or udder is a modified sweat (sudoriferous) gland.

b) The milk secretion takes place inside the alveoli containing monolayer (single layer) epithelial cells.

c) The residual milk is the amount of milk retained in the udder of the animals after normal milking.

d) Oxytocin.

e) Full hand milking.

f) The pulsation rate refers to the number of pulsation per minute and which is usually 48 to 72 cycles per minute.

g) Pulsation ratio is ratio of time taken for milking phase and resting phase. It is usually varies from 1:1 to 2.5:1.

12.11. EXERCISES AND QUESTIONS

a) Discuss milk let down mechanism.

b) What are the different methods of milking.

c) Write in detail about the milking management of cow for clean milk production.

d) What are the different parts of milking machine? Discuss with suitable diagram.

12.12. FURTHER READING

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CHAPTER - 13

Prevention and Control of Diseases of Dairy Cattle

13.1. INTRODUCTION

Diseases of dairy cattle cause huge economic losses. The losses are associated with lower productive and reproductive performances as well as mortality of the valuable animals. The high producing animals are susceptible to various infectious and contagious diseases. The diseases may permanently affect the performance of the animal e.g., mastitis may permanently damage the quarter(s) of the udder. Thus the culling rate of the herd may increase which affects the profitability of the farm. The occurrence of diseases in cattle is preventable. So, steps are needed to prevent the occurrence of diseases as prevention is better than cure. A number of factors are associated with the occurrence of diseases in animals. Disease prevention and control involves measures designed to prevent or reduce as much as possible the incidence, prevalence and consequences of the disease. These measures can be applied to control the reservoir of infection, break route of transmission or reduce the numbers of susceptible. Various new and environment friendly methods have been developed by modification or refinement of the old methods of disease control and prevention.

13.2. OBJECTIVES

The objectives of disease prevention and control are to:

- prevent outbreaks of disease

- prevent introduction and/or spread of diseases
- minimise loss of production
- prevent morbidity and mortality of valuable animals
- reduce expenses on health ground
- increase profit of the farm

13.3. STRATEGIES

The following strategies should be considered to prevent the introduction of disease in a farm and/or control the spread of diseases amongst the animals in the farm:

1. Management of new arrivals to prevent introduction of disease in a farm
2. Regulation of farm traffic to prevent spread of diseases
3. Housing management to prevent spread of diseases
4. Sanitation and disinfection to prevent spread of diseases
5. Prevent entry of foreign animal diseases through border control
6. Vector control
7. Early diagnosis
8. Genetic improvement
9. Proper nutrition
10. Epidemiological diagnosis
11. Health education
12. Vaccination

13.3.1. Management of New Arrivals to Prevent Introduction of Disease in a Farm

The healthy animals in a dairy farm may become infected by getting infection from new arrivals in the farm. The following points should be considered to control this type of disease introduction.

13.3.1.1. Maintain close herd

This is the best method to prevent the introduction of disease in a herd. It is better not to purchase but to grow animals for replacement

within the farm. Further, animals of the farm should not be brought in contact with outside animals in exhibitions, cattle fair, shows etc. Restrict the entry of visitors in the farm who can carry infection and transmit to the farm animals.

13.3.1.2. Isolation of new arrivals

The new arrivals of a farm should be quarantined. Herd animals should be prevented from coming in contact with the new arrivals. This can be achieved by following ways:

i. Keep newly arrived animals separately in an isolated (quarantine) shed
ii. Feed them separately
iii. Prevent them coming in contact with other cattle
iv. Prevent movement of manure, bedding and other materials from the isolation area to the rest of the herd.
v. If possible keep separate attendant for the new arrivals.
vi. Regular screening of the new arrivals for early detection of any disease.
vii. Milk the isolated cows separately.
viii. Test for diseases just prior to addition to the main herd.
ix. Isolate for a period of minimum 30 days as incubation period of most of the diseases fall within this period (except rabies).

13.3.1.3. Knowledge of source of purchase

The animals if purchased should be done from disease free herds or from herds with no history of previous disease occurrence. This should be confirmed through laboratory testing.

13.3.1.4. Vaccination

The newly arrived animals should be vaccinated during the 30 days isolation period.

13.3.2. Regulation of Farm Traffic to Prevent Spread of Diseases

The disease can spread between farms by a number of means like visitors, workers, birds, rodents, equipments, vehicles etc. So, their movement in the farm should be regulated by taking following steps;

13.3.2.1. People

Visitors and workers in the farm can spread disease through contaminated materials in their clothes, foot-wears, hands etc. Following measures should be taken to control these.

i. Provide a foot bath, at the entrance containing disinfectant solution.
ii. Visitors and workers should change their dresses and foot-wears with clean dresses and foot-wears provided by the farm.
iii. Discourage visitors from entering animal sheds, feeding and milking areas.
iv. Discourage visitors from touching the animals.
v. Workers must wash their hands with antiseptic solution before doing routine works with the animals.
vi. Designate a specific visitor area for minimizing contact with the animals.

13.3.2.2. Birds

Birds carry infectious agents through feeds and droppings. They should be prevented from entering into animal houses, milking barn and stores. The open spaces in animal houses are to be netted, holes and other opening to be covered. They should not be allowed to sit in the farm premises.

13.3.2.3. Rodents

Rodents contaminate feeds. They also carry disease agents in their feet and fur. To control them it is necessary to construct rodent proof buildings, eliminate safe hiding place and nesting sides, and destroy existing rodent population by trapping, poisoning etc.

13.3.2.4. Stray animals

The stray cattle, dogs, cats etc. should not be allowed to enter the farm premises and come in contact with the herd animals. They can transmit disease to the herd.

13.3.2.5. Vehicles

Vehicles can spread disease through carrying contaminated materials in tyres and its body parts. To prevent spread of contaminants by vehicles following measures can be taken:

i. Provide a bath/spray with disinfectant solution to wash the tyres at the entrance of the farm.

ii. Route of entry of vehicles should not be contaminated with manure.

iii. Allow separate route for movement of cattle so that they not come across route of the vehicles.

13.3.2.6. Feeds and other materials

Ensure that feeds and other materials purchased from outside are free from any type of contamination. Care is needed to protect feeds from getting contaminated during storage in the farm.

13.3.2.7. Equipments

The equipments used in the farm should be free from contaminants and it can be achieved by the following measures:

i. Sanitise nursing bottles and buckets after each calf feeding.

ii. Maintain clean manger and water trough.

iii. Disinfect dehorners, hoof knives, trimmers, castrators etc. after using in each animal.

iv. Avoid using manure handling equipments for handling feeds and fodders, and if necessary use after thorough washing.

v. Clean and sanitise equipments used for handling dead stock.

vi. Use a disposable needle for administering medicines or vaccine to each animal.

13.3.3. Housing management to prevent spread of diseases

Disease can spread between different categories of cattle in a farm. So, the different categories of cattle like calves, heifers, dry and milch animals, bulls should be housed separately. For example many diseases are transmitted from old to young animals like *E. coli* scours, coccidiosis, sulmonellosis etc. (Table-13.1)

Table 13.1 : Common diseases transmitted from older to younger cattle

Disease	Transmitted through
E. coli scours	Faeces
Coccidiosis	Faeces (oocyst)
Salmonellosis	Faeces
Leptospirosis	Urine, uterine discharge, aborted foetus
Jhones disease	Faeces
Bovine viral diarrhea	Body fluids of sick and carrier animals
Gastrointestinal parasites	Faeces (eggs)

To prevent these menace following measures can be taken :

i. House calves upto 8 weeks of age in individual pen or hutch.

ii. House after 8 weeks of age according to age groups like 2-4 months, 4-6 months and so on.

iii. Heifers are grouped and housed seperatly according to their age.

iv. Separate housing arrangement should be made for yearling and breeding heifers.

v. Dry and milch cows are housed separately.

vi. Provide adequate floor space to avoid overcrowding.

vii. Provide adequate manger and water trough space.

viii. Provide sick animal shed to keep the diseased animals separated from healthy one.

13.3.4. Sanitation and Disinfection to Prevent Spread of Diseases

Sanitation and disinfection removes the infectious agents from the farm and prevent spread of disease. Some common management steps for effective sanitation and disinfection in a farm are discussed below;

13.3.4.1. Disposal of carcasses

Proper and quick disposal of carcass is necessary to prevent spread of disease to the healthy animals. The carcass along with its secretions and excretions, bedding materials, left-over feeds etc. should be properly disposed-off either by burning or burial. This will prevent scavenging

by stray animals like dogs, cats, foxes, birds etc. The area where the animal died should be washed and disinfected if made of cement concrete. In case of mud floor, top 10-15 cm of soil should be removed and disposed along with the carcass. Care should be taken that the secretions and excretions of the carcass do not fall on the ground while carrying the carcass. The carcass should not be dragged on ground but should be carried in a vehicle or trolley to the site of disposal.

13.3.4.2. Disposal of excreta

The infected animals excrets infectious agents through their excretions like faeces, urine which can spread infection directly to other animals, or indirectly through feed and water. The cow-dung should be frequently removed from the shed and disposed into a manure pit or bio-gas plant. The manure pit should be located at a distance from animal houses. The cattle sheds are to be provided with drains to dispose off urine and wash water into a storage tank away from the animal houses.

13.3.4.3. Fly and parasite control

The flies and insects act as intermediate host and can spread infections. The proper disposal of excreta reduce fly and parasite population as they will not get breeding place and thus, prevent completion of their life cycle. Also control fly population by using traps, baits, insecticides, biological predators or combination of control measures.

13.3.4.4. Sanitizing and disinfecting animal shed

The regular disinfection of animal sheds is essential to destroy infectious agents. This can be effected by regular cleaning and washing of animal sheds with suitable disinfectants. The open areas should also be spread with suitable disinfectants like lime. Feeding and watering trough should be cleaned and disinfected daily.

13.3.5. Prevent Entry of Foreign Animal Diseases through Border Control

The importing and exporting animals are to be quarantined at the ports for preventing entry of new diseases. Separate import and export quarantine stations should be constructed at the ports. The animals imported from a country should bear certificate of not having any disease from that country. The animals are to be quarantined for

a minimum period of 30 days. During this period they should be regularly screened for presence of any disease.

13.3.6. Vector Control

Invertebrate vectors spread many diseases like malaria, Q-fever, Japanese encephalitis, trypanosomiasis, leishmaniasis etc. Vector control is less direct approach of disease prevention or control with little or no involvement of livestock owners or the affected population. Vector control requires an integrated approach consisting of following activities.

13.3.6.1. Environmental measures

These refer to elimination of breeding places of the vectors through proper disposal of excreta and other waste, water management, filling and drainage operations etc.

13.3.6.2. Chemical measures

A wide range of insecticides belonging to organochlorine, organophosphate and carbamate groups are available for vector control. Highly persistent compounds like DDT etc. are being replaced by readily biodegradable and less toxic compounds such as methoxychlor, abate and others.

The insecticides are classified as

A. Contact poisons:
   a. Natural-pyrethrum, rotenone, mineral oils etc.
   b. Synthetic :
      i. Organochlorines- DDT, lindane etc.
      ii. Organophosphates-chlorthion, dichlorovos etc.
      iii. Carbamates- carbaryl etc.

B. Stomach poisons: paris green, sodium fluoride etc.

C. Fumigants: hydrogen cyanide, sulphur dioxide etc.

13.3.6.3. Biological measures

Indiscriminate use of chemical insecticides resulted in development of insecticide resistance vectors, danger of environment contamination. To prevent this, biological control is designed to make use of natural

predators and parasites to control unwanted species. Biological measures have also other advantages like low cost, low operator risk, low environmental impact, more selective killing of target insects etc.

Biological measures include use of biological agents like virus, bacteria, fungi, nematodes and predators. These agents (entomogenous) grow/develop in/on the insect vectors and lead to their destruction (entomophagous).

i. Fishes: *Gambusia affinis* against anopheles mosquito etc.

ii. Fungi: Coelomomyces etc.

iii. Protozoa: Nosema, Vorticella etc.

iv. Bacteria: *Bacillus thuringiensis* etc.

13.3.6.4. Genetic manipulation

i. **Transgenic technology**: The controlled manipulation of genome of an insect by direct introduction of DNA through transgenic technology can increase vulnerability to subsequent control measures, e.g., by inducing insecticide susceptibility and temperature susceptibility or altering the ability of the insect to transmit disease causing organisms. The disease resistant transgenic animal can also be developed.

ii. **Sterilized male**: The insect vector can be controlled by releasing massive numbers of sterilised males of this species. The copulation of females with infertile males will not result in any offspring.

iii. **Genetic engineering**: New strains of bacteria can be produced by genetic engineering methods like rDNA technology and transposable elements which are lethal to insects. The technique is also designed to produce microbial metabolic products which would kill unwanted insect vectors of diseases.

13.3.7. Early Diagnosis

Early diagnosis can help in early treatment and cure and also prevent spread of the disease by identifying the causative agents. Regular screening of the animals through blood, faeces and urine examination can help in early detection of diseases. The development of various immunological and molecular techniques such as enzyme linked immunosorbent assay (ELISA), radio-immuno assay (RIA), DNA

probes, restriction fragment length polymorphism (RFLP), polymerase chain reaction (PCR), agglutination tests etc. have revolutionized diagnostic procedures with their wide acceptability. Development of ready to use test kits like mastitis detection kits may be a practical approach for early detection of infection at farm level and their eventual control.

13.3.8. Genetic improvement

The genetically resistant animals to diseases can be evolved through selective breeding and crossbreeding. Crossbreeding includes the disease resistance capability of indigenous breeds.

13.3.9. Proper nutrition

Adequate nutrients should be supplied to the animals through feed. This will help in strengthening immunity against diseases and facilitates development of strong immune response resulting in high level of productivity. It will also reduce cost of treatment of a farm.

13.3.10. Epidemiological diagnosis

Epidemiology is the major contributor to the success of the disease control and prevention. In epidemiological diagnosis, frequency and patterns of the disease occurrence are quantified with their possible determinants. It involves two principal components, epidemiological surveillance and epidemiological analysis. Regular surveillance provides information about cases of disease and suspected outbreaks of disease including frequency of disease, its time and place of occurrence and associated factors or circumstances. The information are analysed to determine immediate and long term needs for purposeful action against the disease.

13.3.11. Health education

Health education is one of the most effective preventive devices to control and/or prevent animal diseases through education of owners and associated community. The health education makes the community aware of the cause and mode of disease transmission, prevention and treatment of disease and the role of community in combating diseases. It brings cooperation and participation of the public for disease management. Health education through mass media such as newspapers, radio, cinema, T.V., wall slogans, posters etc. can be very effective. The various social and voluntary organizations can be involved for the purpose.

13.3.12. Vaccination

The strengthening of the host defense by vaccination is an integral part of disease management. The animals should be regularly vaccinated (Table 13.2) against diseases occurring in a particular area or herd. The mass administration of vaccine can be done by various methods like the use of disposable and multiple dose syringes, aerosol vaccination, oral vaccination via water supply or food. Immunization of a group of individual in confined quarters via the lungs by nebulisation or atomization of vaccine is another approach.

Table 13.2 : Vaccination schedule* in Cattle

Disease	Age	Interval
Infectious bovine rhinotracheitis (IBR)	4 months and above	Annual
Bovine viral diarrahoea (BVD)	4 months and above	Annual
Parainflenza-3 (PI3)	4 months and above	Annual
Bovine respiratory syncytial virus (BRSV)	4 months and above	Annual
Foot & Mouth disease (F.M.D)	4 months and above (booster dose at after 4 months)	Annual (Twice in prevalent areas)
Haemorrhagic Septicemia (H.S.)	6 months and above	Annual before monsoon (Twice in prevalent areas)
Black quarter (B.Q.)	6 months and above	Annual before monsoon (Twice in prevalent areas)
Anthrax	6 months and above	Annual (Only in prevalent areas)
Brucellosis	4-8 months	Once only (in affected herds for female calves only)

* Vaccination schedules depends on the prevalence of a disease in a particular herd and/or area

13.4. SUMMARY

Diseases cause mortality, but more often results in morbidity which causes loss through reduced milk production which results a setback to the economy of the dairy farm. The losses due to diseases can be avoided by application of effective disease control and prevention measures. The motto should be “Prevention is better than cure”. The incidence of disease occurrence in a farm can be minimized by taking

various effective measures like preventing introduction of disease in a farm, regulation of farm traffic, housing management, regular sanitation and disinfection, vector control, early diagnosis, proper nutrition etc. Epidemiological surveillance is an important aspect to study the occurrence and factors associated with the disease occurrence. Cooperation of the farming community by educating them is a necessary prerequisite for the success of any disease prevention programme. Keeping in view the prevalence of disease outbreaks in a particular area or herd, a schedule of vaccination must be prepared.

13.5. CHECK YOUR PROGRESS

(a) What are the components of epidemiological diagnosis?

(b) How mass administration of vaccine can be done?

(c) What is the motto of disease prevention?

(d) What is a close herd?

(e) What is biological measure to control vectors?

13.6. ANSWERS TO 'CHECK YOUR PROGRESS'

(a) Epidemiological diagnosis involves two principal components, epidemiological surveillance and epidemiological analysis.

(b) The mass administration of vaccine can be done by various methods like the use of disposable and multiple dose syringes, aerosol vaccination, oral vaccination via water supply or food.

(c) The motto of disease prevention is "Prevention is better than cure".

(d) The close herd refers to grow animals for replacement within the farm and not to purchase from outside.

(e) Biological measure refers to control unwanted species of vectors by use of natural predators and parasites.

13.7. EXERCISES AND QUESTIONS

(a) How you will manage new arrivals in a farm to prevent introduction of disease?

(b) How you will do regulate farm traffic to prevent spread of diseases in a farm?

(c) Discuss housing management to prevent spread of diseases in a farm.

(d) Discuss the various measures of vector control.

13.8. FURTHER READING

Banerjee, G.C. (1998) A Textbook of Animal Husbandry – 8th edition. Oxford & IBH Publishing Co.

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READERSHIP :
THE BOOK IS MEANT FOR STUDENTS, RESEARCHERS AND ALL THOSE RELATED TO DAIRY ANIMAL PRODUCTION, LPT AND LPM.

DAIRY ANIMAL PRODUCTION

This book deals specifically with basic managemental aspects of dairy animal in the context of Indian subcontinent. The informations are carefully presented in concise manner and to the point. The entire book has been prepared in most simple, clear and talking language for easy understanding.

In this book, an attempt has been made to introduce both the science and practice of dairy animal production for the students, teachers, progressive farmers and extension workers. Any book which attempt to cover the needs of much a wide range of people must have their limitations as far as any one group of persons is concerned. It is hoped however that all those who read these books will find some guidance and instruction which will enable them to improve their knowledge and understanding of the management and production of dairy animals.

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