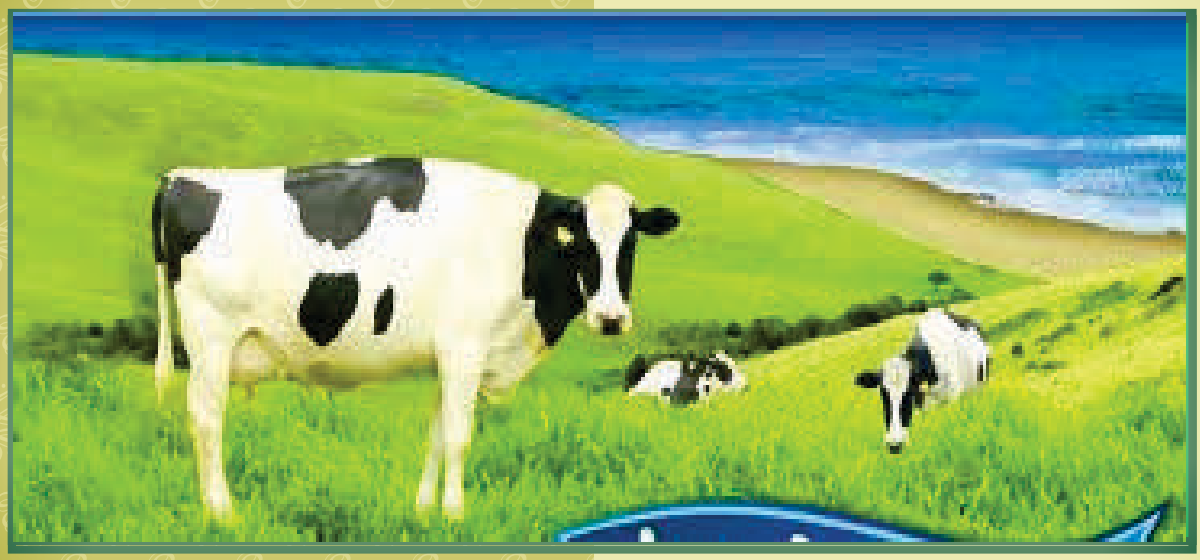
Animal Nutrition and Reproduction (Dairy Husbandry)

Textbook for Class-XI



CENTRAL BOARD OF SECONDARY EDUCATION

Shiksha Kendra, 2, Community Centre, Preet Vihar, Delhi-110 092 India

नया आगाज़

आज समय की माँग पर
आगाज़ नया इक होगा
निरंतर योग्यता के निर्णय से
परिणाम आकलन होगा।

परिवर्तन नियम जीवन का
नियम अब नया बनेगा
अब परिणामों के भय से
नहीं बालक कोई डरेगा

निरंतर योग्यता के निर्णय से
परिणाम आकलन होगा।

बदले शिक्षा का स्वरूप
नई खिले आशा की धूप
अब किसी कोमल-से मन पर
कोई बोझ न होगा

निरंतर योग्यता के निर्णय से
परिणाम आकलन होगा।
नई राह पर चलकर मंज़िल को हमें पाना है
इस नए प्रयास को हमने सफल बनाना है
बेहतर शिक्षा से बदले देश, ऐसे इसे अपनाए
शिक्षक, शिक्षा और शिक्षित
बस आगे बढते जाएँ
बस आगे बढते जाएँ
बस आगे बढते जाएँ.....

Animal Nutrition and Reproduction (Dairy Husbandry)

Student Handbook

for

CLASS XI

CENTRAL BOARD OF SECONDARY EDUCATION, DELHI
Shiksha Kendra, 2 Community Centre, Preet Vihar, Delhi-110092 India

Animal Nutrition and Reproduction (Dairy Husbandary) for Class XI

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Preface

Livestock sector is an integral component of Indian agriculture and provides livelihood support to millions of rural people having little access to land. The availability of feed and fodder to the livestock species have a significant bearing on productivity. According to Planning Commission of India and other sources, large gap exists between requirement and availability of feed and fodder in the country. The deficiency in feed and fodder is more conspicuous in arid and semi-arid regions. The shortage of dry fodder (40%), green fodder (36%) and concentrate (57%) is further increasing. For increasing milk production from the current level of 128 mt to 170 mt by 2020, 494 mt of dry fodder, 825 mt of green fodder and 54 mt concentrates will be required. Fodder which is being cultivated in only about 4% of the agricultural land is not adequate to meet the requirement of fodder in the country. The total projected milk demand in India for about 1500 million people will be about 170 mt by the year 2020. To meet this deficit successful implementation of modern bio- techniques including artificial insemination along with analytical techniques will be helpful for enhancing production and reproduction of livestock species. The course on “Animal Nutrition and Reproduction” for class XI students has been introduced with the following objectives:

- This is a basic course to equip students with knowledge and skills in the area of Animal Nutrition and Reproduction. Major topics covered in this book are anatomy of digestive system of dairy animals, anatomy of male and female reproductive system, basic concepts of animal reproduction, detection of heat in cattle and buffaloes, artificial insemination, breeding calendar and common reproductive disorders, common feed and fodders, feed processing and conservation, feeding of dairy animals, common nutritional deficiency diseases etc.
- Students will get an exposure to vocational/professional course on dairy production, which will motivate students to come up as entrepreneurs in the area of dairy production.
- This course is an effort to sensitize student in the field of dairy production. Students will get an opportunity to choose career in the area of Animal Husbandry and Dairying and they may further pursue diploma/ degree in this area.
- This course has been designed to provide entry level job skills to the students and will help to meet the human resource requirement for dairy production sector.

Vineet Joshi, IAS
Chairman
CBSE

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भारत का संविधान

उद्देशिका

हम, भारत के लोग, भारत को एक '[सम्पूर्ण प्रभुत्व-संपन्न समाजवादी पंथनिरपेक्ष लोकतंत्रात्मक गणराज्य] बनाने के लिए, तथा उसके समस्त नागरिकों को:

सामाजिक, आर्थिक और राजनैतिक न्याय,
विचार, अभिव्यक्ति, विश्वास, धर्म
और उपासना की स्वतंत्रता,
प्रतिष्ठा और अवसर की समता

प्राप्त कराने के लिए, तथा उन सब में, व्यक्ति की गरिमा और [राष्ट्र की एकता और अखण्डता] सुनिश्चित करने वाली बंधुता बढ़ाने के लिए दृढ़संकल्प होकर अपनी इस संविधान सभा में आज तारीख 26 नवम्बर, 1949 ई॰ को एतद्द्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।

1. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977) से "प्रभुत्व-संपन्न लोकतंत्रात्मक गणराज्य" के स्थान पर प्रतिस्थापित।
2. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977 से), "राष्ट्र की एकता" के स्थान पर प्रतिस्थापित।

भाग 4 क

मूल कर्त्तव्य

51 क. मूल कर्त्तव्य – भारत के प्रत्येक नागरिक का यह कर्त्तव्य होगा कि वह –

(क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्रध्वज और राष्ट्रगान का आदर करे;

(ख) स्वतंत्रता के लिए हमारे राष्ट्रीय आंदोलन को प्रेरित करने वाले उच्च आदर्शों को हृदय में संजोए रखे और उनका पालन करे;

(ग) भारत की प्रभुता, एकता और अखंडता की रक्षा करे और उसे अक्षुण्ण रखे;

(घ) देश की रक्षा करे और आह्वान किए जाने पर राष्ट्र की सेवा करे;

(ङ) भारत के सभी लोगों में समरसता और समान भ्रातृत्व की भावना का निर्माण करे जो धर्म, भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभाव से परे हों, ऐसी प्रथाओं का त्याग करे जो स्त्रियों के सम्मान के विरुद्ध हैं;

(च) हमारी सामासिक संस्कृति की गौरवशाली परंपरा का महत्त्व समझे और उसका परीक्षण करे;

(छ) प्राकृतिक पर्यावरण की जिसके अंतर्गत वन, झील, नदी, और वन्य जीव हैं, रक्षा करे और उसका संवर्धन करे तथा प्राणिमात्र के प्रति दयाभाव रखे;

(ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करे;

(झ) सार्वजनिक संपत्ति को सुरक्षित रखे और हिंसा से दूर रहे;

(ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कर्ष की ओर बढ़ने का सतत प्रयास करे जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत्न और उपलब्धि की नई उंचाइयों को छू ले।

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a [1] **SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the [2] [unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do **HEREBY TO OURSELVES THIS CONSTITUTION.**

1. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "Sovereign Democratic Republic (w.e.f. 3.1.1977)
2. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "unity of the Nation (w.e.f. 3.1.1977)

THE CONSTITUTION OF INDIA

Chapter IV A

Fundamental Duties

ARTICLE 51A

Fundamental Duties - It shall be the duty of every citizen of India-

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) To promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement.

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CHAPTER-1

Classification of Nutrients

water, carbohydrates, proteins, lipids, minerals and vitamins; role of different nutrients in animals growth, production, reproduction and health

OBJECTIVES

1. To understand the basic role of nutrients in animal body.
2. Classification of nutrients based on their role in animal system.

Introduction

Nutrition is a biological process of chemical and physiological reactions which transform feeds/ fodders into body tissues and activities of organisms. It involves ingestion and digestion food materials, absorption of various nutrients, their transport to all body tissues thereby maintaining growth, repair, production and reproduction and removal of indigestible materials from the body. Feed comprising of water, organic constituents (carbohydrate, protein, fat and vitamins) and inorganic constituents (major and macro minerals) in variable amounts and these are known as nutrients. These nutrients are required for maintenance, growth and repair, reproduction and other body functions in adequate quantity and proportions. The objective of studying the subject is to provide all essential nutrients in adequate quantity and optimum proportions to all organisms.

Every nutrient has its specific functions to play in the biological system. As we know there are six nutrients i.e., water, carbohydrate, protein, fat, minerals and vitamins and each of these have different functions, it will be discussed separately for each nutrients.

Water

Water is the ideal dispersing medium because of its solvent and ionizing powers which facilitates cell reaction and due to its high specific heat which helps to absorb the heat of these reactions with a minimum rise of temperature. Lean adult body contains about 70 percent of water, though the amount varies from embryo to mature animals. In case of animals, the water content is approximately 95 percent for the embryo shortly after conception, 75-80 percent at birth, 65-72 percent at 5 months and 40-65 percent in mature animal which indicates the importance of water in animal body. It is to be noted that India with less than 3 percent water resources harbouring more than 11 percent animals

and more than 16 percent human beings. So, we have to use water in judicious way for better future.

Water deprivation: When human is deprive of drinking water in a hot and dry environment, soon exhibits thirst. When deficiency comes to 4-5 percent of body weight there is discomfort, anorexia, when it comes to 6-10 percent, there is headache, lack in coordination, indistinct speeches, dyspnoea and cyanosis. At 12-14 percent level, eye sunken, skin becomes shriveled, there is inability to swallow and delirium occurs. Under hot environment, 12 percent deprivation is fatal to human.

Functions of water

a. By solvent action, it serves as universal medium in which cellular reaction, ionic and other reaction takes place.

b. Lubrication: It acts as lubricant to prevent friction and drying in joints, pleura, conjunctive etc.

c. Hydrolytic action: In this process, H^+ and OH^- ions of water introduced into bigger molecules to facilitate breakdown process.

d. Cell rigidity and elasticity: The body must have a definite form which it can be retain and yet within limits it must be able to change its shape by comprising to some extent to the force applied at any particular point. This is made possible by liquid content of the cell.

e. Transport: It acts as a vehicle for transporting absorbed and reabsorbed of various food materials and excretory products to the definite organ.

f. Heat regulation: As the specific heat of water is high, it is important in heat regulation of body by conduction and distribution, heat loss through urine, feces and respiration as well as sweating.

g. Refractive medium: The aquous humor helps to keep up the shape and tension of the eye ball and acts as the refractive medium of light.

Carbohydrate

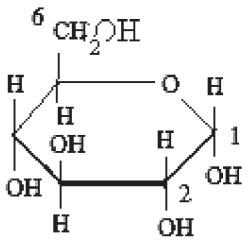
Carbohydrate may be defined as the hydrates of carbon or polyhydroxy aldehyde or polyhydroxy ketone, their polymers and on hydrolysis produces monohydroxy alcohol or ketones i.e. simple sugars. Most plants comprise 60-90 percent carbohydrate and an adult human body comprises about 300-350 g of carbohydrate. Carbohydrates may be represented with a empirical formula $C_n(H_2O)_n$.

Classification: Carbohydrate may be classified into 3 major categories- monosaccharide,

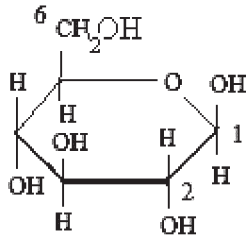
oligosaccharide and polysaccharides.

Monosaccharides: These are simple sugars which can not be broken into smaller molecules upon hydrolysis. Monosaccharides again, chemically sub classified into pentoses and hexoses. Important pentoses are arabinose (occur in gum, pectin etc.), xylose (derived from plum, cherries, grapes etc.) and ribose (found every living cell i.e. adenosine di phosphate or ADP, Adenosine tri phosphate ot ATP, riboflabin, nucleic acid of every living cell). Some important hexoses are listed below with their occurance

Glucose: It is the major end product of digestion of carbohydrates by non ruminants and is the primary form to be utilized for energy in which these nutrients circulate in the blood of mammals. Glucose exists in the form of a pyranose ring and is more accurately depicted in the Haworth perspective below. Depending on position of H and OH at C-1, this exists in two form i.e. α and β. α is the precursor of starch and glycogen while, β is the form for cellulose.



α D Glucose



α D Glucose

Fructose: It is the only keto hexose in nature and sweetest of the carbohydrate. It occurs free along with glucose and sucrose in honey, inulin is found in a number of plant where it serves as reserve polysaccharide.

Disaccharide: More than one simple sugars are bound together to form disaccharide. Important disaccharides are maltose occurs in sugar cane, sugar beet in ripe fruits and tree saps, while lactose (galactose and glucose) occurs in milk.

Polysaccharide: Large number simple sugars are polymerized to form polysaccharides which are of high in molecular weight and most of them are insoluble in water. Important polysaccharide is starch which occurs in plant as small granules. These granules are very resistant to rupture but moist heating ruptures them and make them available in gut. Cellulose is a polymer of ß-1,4 glucose. As such the 6^{th} carbon atom is in *trans* position, which results in cellulose being flat band like microfibril. It is highly stable and fibrils held firmly by H bond and makes insoluble and resistant to microbial degradation. It is the most abundant substance in plant kingdom and major cell wall component and combined with lignin. Cotton is one of the purest form of cellulose. Hemicelluloses is not, as name implies, one half of cellulose rather a complex heterogenous mixture of mumber of different polymers of monosaccharide like glucose, xylose, mannose, arabinose and galactose. It

is predominantly a xyloglucan. This is linked covalently to the pectic fraction of the cell wall and by H bonding to the cellulose microfibrils, thus adding to significant strength to cell wall. It is also a principal component of cell wall and less resistant to chemical degradation. Nutritionally, carbohydrate may be classified into two- fibrous and non fibrous. Fibrous carbohydrate includes cellulose, hemicellulose and lignin which are responsible for integrity of plants whereas non fibrous carbohydrate includes starch, pectin etc which are mostly the storage part of the plant. These fibrous carbohydrate fermented by microbes in rumen of ruminants, converts them to simpler molecules like acetate, propionate and butyrate which are utilized by the host animal. It is right place to mention that plant fibres are only digested by microbes, no host enzymes can solubilise them.

Functions:

a. It provides energy to cell for survival and activity. Glucose through glycolysis and tricarboxylic acid cycle produces 38 moles of ATP which is used for many purposes by the cell. In ruminants, propionate produced in the rumen, goes to liver where it converts to glucose for further use. Again, acetate may enter into the TCA cycle for energy production and at the same time it is required for body fat and milk synthesis. In case of high energy diet (higher amounts of maize, barley even higher cooked rice feeding) acetate level decreases which may lead to milk fat depression.

b. Fibre in ruminants diet is more important as it constitutes around 70 percent, though under tropical situation like in India, animals are raised animals on more than 90 percent roughages. This supplies fibre or cellulose, hemicelluloses for microbial fermentation resulting into production of volatile fatty acids.

c. It has protein sparing effects as intermediates of TCA cycle may produce amino acid which is essential for organisms.

d. Carbohydrates in combination of protein and lipids forms phospholipids and glycolipids which are the part of cell membrane.

e. Part of milk as milk sugar and this lactose is almost constant part of milk.

Protein

As it is the principal constituent of the organs and soft structures of animal body a liberal and continuous supply is needed in the blood throughout life for growth and repair, thus the transformation of food protein into body protein is very important part of nutrition. This is a collective one which embraces an enormous group of closely related but physiologically distinct numbers. Plant protein differ from each other and from animal protein. Each plant and animal species has its own specific protein, even in different organs it is specific one.

The elementary composition of protein is carbon 51-55 percent, hydrogen 6-7 percent, nitrogen 15.5-18.0 percent, oxygen 21-24 percent, sulphur 0.5-2.0 percent and phosphorus 0-1.5 percent. Proteins are the polymers of amino acid which vary in relative amounts and kind from protein to protein. These are the hydrolytic and enzymatic end product of protein. Amino acids are the derivatives of short chain fatty acids and contain a -NH_2 group and –COOH group. In acidic pH, it acts as cation and in basic pH, it acts as anion due to presence of NH_2 and COOH group. In the pH, a particular amino acids act as electrically neutral and called as zwitterions and the pH is termed as isoelectric point for that amino acid. Amino acids may be essential and non essential depending on the need of the organism. Amino acids may be mono amino mono carboxylic (glycine, alanine, serine, valine, leucine, isoleucine and threonine), mono amino-dicaboxylic (acidic) acid (aspertic acid and glutamic acid), diamino-monocarboxylic acid (lysine, arginine, citrulline), sulfur containing amino acid (cysteine and methionine), aromatic amino acid (tyrosine, phenyl alanine, thyroxin) and hetero cyclic amino acid (histidine and proline).

Protein are classified primarily on form, physical properties and chemical configuration.

1. Simple protein: Hydrolysis of simple protein yields amino acid or its derivatives.
2. Conjugated protein: When simple protein combined with a non- protein radical- called conjugated protein. Nucleoprotein, phospho-protein, metallo-protein etc, are the examples of conjugated protein.

    b. Structurally it can be fibrous protein which consists of long chains of polypeptide and found in collagen and keratin. Collagen found as components of connective tissue and cornea. Its insoluble and indigestible but upon heating with acid, it becomes soluble, easily digested and the mixture of polypeptides called gelatin. It contains hydroxy- proline but devoid of cysteine or cystine. Elastin, part of tendons, arteries and other elastic tissues and found to contain cystine (22 percent).

    c. Globular protein include enzymes, protein hormone and oxygen carrying proteins. These are soluble in water or aquous mixture of acids, bases or alcohol. Albumins are water soluble and are a significant part of serum protein and egg protein. Globulins are insoluble in water but solubility increases with changes in neutral fat concentration. Immuno-globulins and haemoglobulin in blood, lacto-globulins in milk, myoglobulins in muscles are some of the important examples.

Essential and non- essential amino acids:

Essential amino acids are those which are not synthesized in the body at a required rate by the body for normal functioning. Eight amino acid are dietary essential by all species and 10 are required by one or more species. These ten amino acids must be incorporated

in the diet of most of the species and these are histaidine, isoleucine, lysine, leucine methionine, arginine, phenyl alanine, theronine, tryptophan and valine. Some of amino acids are synthesized inside the body, hence not required from the dietary source are called as non essential amino acid. Tyrosine, cystine, alanine, aspartic acid, glutamic acid, citrulline, hydroxy proline etc. are the example of dispensable or nonessential amino acid.

Functions of protein

Proteins perform many different functions in the animal body. Most of body proteins are present as components of cell membrane, in muscle and supportive capacities such as in skin, hair, and hooves.

In addition, plasma proteins, enzymes, hormones and antibodies against any diseases perform specialized functions in the body even though their amount is very low. Collagen gives strength and compact structure to muscles and perhaps you have seen that due to over cooking of meat and meat from older animals becomes tough due to shrinkage as a result of higher proline and hydroxyproline content. It is insoluble in water and resistant to digestive enzymes. Actin, tropomycin B and myosin protein are the major component of muscle responsible for contraction. Blood proteins are albumin, globulins, fibrinogen, hemoglobin and apoproteins works in a variety of physiological function in the organisms. Enzymes or organic catalysts performs a specific function in the system, e.g., digestive enzymes only involves in conversion of large molecules of feed to simple molecules in the gastro-intestinal tract. There are thousands of enzyme present in the cell and performs a specific function. If there is deficiency of energy/ propionate in the circulation, fat and protein comes to play in production of ATP which is required for normal functioning of cell. Like enzymes, hormones antibodies also perform a vital role in protection of animals against specific infections. Antibodies against specific infections can be acquired (passive immunity) by placental transfer to the fetus from the blood of mother, by ingestion and absorption of antibody rich colostrums by the new born or parenteral (not through mouth) injection into the susceptible animals. Exposure of susceptible animals to a pathogen/ antigen stimulates antibody production against particular antigen, resulting in active immunity.

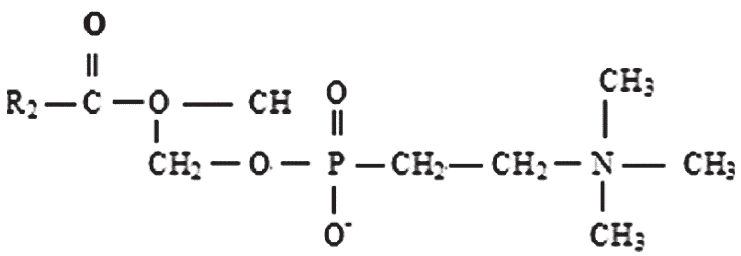
Lipids

It is defined as the substances that are insoluble in water but soluble in ether, chloroform, benzene and other organic solvents. This group includes the fat and a number of closely associated compounds. Fats or lipids play an important role in physiology and nutrition. One of the best example, we can say is cholesterol, which is the precursor of vitamin D and steroid in one hand and the infamous compound of atheromatous plaques of cardio-vascular disease on the other. It acts as the condensed reserve of the body, structural element of tissue and essentials of various reactions in intermediary metabolism.

A. Classification

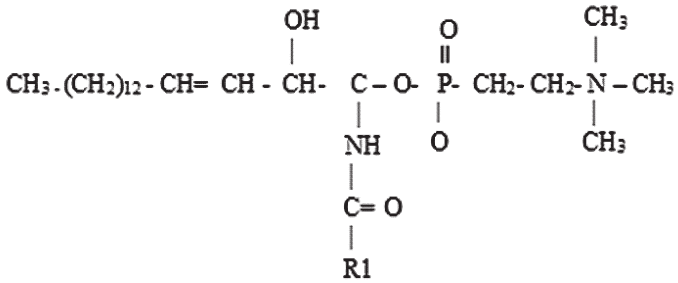
Lipids are relatively insoluble in water and relatively soluble in organic solvents and performs various important functions in animals. It is classified as the saponifiable and non saponifiable fat. Saponifiable again classified as the simple fat and waxes whereas the compound fat as the glycolipids and phospholipids. Simple fats and oils are esters of fatty acids with glycerol. Terpenes, steroids and prostaglandins are the example of nonsaponifianble lipids. Waxes are lipids resulting from combination of fatty acids and higher monohydroxy and di- hydroxy- alcohols. These have higher melting point and sufficiently difficult to saponify that these are not readily digested by animals. Common example is bee wax, a combination of palmitic acid and myricyl alcohol. Wax occurs as secretion and excretion in animals and insects and as protective coatings of plant. They are removed the in ether extract, thus, overestimates the nutritive significance of the assay.

Compound lipids: In biological system lipids contain a hydrophobic (non polar) end and a hydrophilic (polar) end which is essential for transportation. Examples of compound lipids are phospholipids, sphingolipids etc. Phospholipids consists of glycerol in which the 1 and 2 positions are esterified with long chain fatty acids. Saturated fatty acid in 1 and unsaturated fatty acid in position 2 , whereas, position 3 is esterified with phosphoric acid and turn to a nitrogen base. If the nitrogen base is choline, the phospholipids is lecithin, if it is ethnolamine, the phospholipids is cephalin. Both the lipids are component of cell membrane and involves in transport of lipid in plasma eg. chilomicrons and lipoproteins.



R2 - Fatty acid chain in the C3 position of glyceraldehydes

Shingolipids don't contain glycerol but consists of amino alcohol sphinosine to which is added a fatty acid phosphate and either choline or ethanolamine. In animals, these are found predominantly in brain and nerve tissues and called sphingomyelin. One special component of sphingolipid has the choline replaced with glucose and is called as the cerebroside, as shown below.



Prostaglandins: This group is non saponifiable and containing 20 carbon atom with cyclic structure between 8th and 12th carbon atom. These are found in almost all mammalian tissue and synthesized from linoleic acid. Their name comes from prostate gland, from where it was first identified. Though, recent advances of medical research shows that these are not confined to male genitalia but can be detected in several tissues of both sexes and are found to function as regulator of various tissue metabolism. These are often called as local hormone due to their activity within cells or nearby cells from where secreted. They work together with other established hormone to modify the chemical messages that other hormones brings to cell, though complete understanding requires research to conclude, even today.

From the standpoint of nutrition, it is the fact that main component of fat/ lipids are fatty acid. These are may be saturated and unsaturated fatty acid. Saturated fatty acids are those have no double or triple bond, on the contrary, the later have one or more double and triple bond. Polyunsaturated fatty acids have important role to play in various physiological functions.

Example of saturated fatty acids are butyrate (C4:0), palmitic (C16:0), stearate (C18:0), whereas the example of unsaturated fatty acid are oleic acid (C18: $1^{\Delta 9}$), linoleic acid (C18: $2^{\Delta 9:12}$), linolenic acid (C18: $3^{\Delta 9:12:15}$) and arachidonic acid (C20: $4^{\Delta 5:8:11:14}$).

Fat analysis and characterization

In routine feed analysis, lipids are determined as ether extract and it includes plant pigments, some essential oils thus ether extract in the feeds and fodder is not fully accurate which feed or fodder contains and available to the animal. There are some typical characteristics of food or feed fat required for routine analysis or identifying the origin of fat. Some of which are listed below.

a. **Melting point (or solidifying point)**: Number of carbon atom when increased in saturated fatty acid, melting point increased, whereas, in unsaturated fatty acid melting point decreased with increasing carbon numbers of fatty acids.

b. **Iodine number**: It is defined as the number of grams of iodine absorbed by 100 g of vegetable or animal fat to be evaluated. It readily unites with the unsaturated fat at the double bond, two moles of iodine per double bond.

c. **Saponification number**: The number of milligrams of alkali (KOH) is required to saponify 1.0 g of fat is called the saponification number of that particular fat. As one mole of K^+ reacts with each fatty acid, the larger the saponification number, the smaller the average chain length.

d. **Rancidity**: It may be of 2 type, viz., hydrolytic and oxidative depending on type of reaction with the fat. When unsaturated fat or butter are stored they become rancid due to hydrolytic activity of the microbes. These secrete lipase which splits triglyceride to mono and di- glyceride, glycerol and free fatty acid. Low molecular fatty acids give bad flavour and odour to the particular fat. This type of rancidity can be reduced by refrigeration, exclusion of water or by destroying hydrolytic microbes. In case of oxidative rancidity, hydrogen, oxygen and halogens are combined with unsaturated fatty acids. This reaction of hydrogen with fats and oils is used commercially to produce hydrogenated fats.

Functions

The functions of lipids can be listed broadly as follows

1. Supply energy for maintenance and production: Hydrolysis of triglyceride or neutral fat yields glycerol and fatty acid which serve as the source of energy. Most of the variation among fat sources in the amount of utilizable energy they contain related to their digestibility. Though high fat diet in ruminants may interfere with the rumen fermentation due to fact that fatty acids have antimicrobial activity resulting in reduction of feed intake. All the energy needed by the animals, may not require energy from fat but it is the source of essential fatty acid and fat soluble vitamins, hence fat intake must be there for every organism.

2. Serve as the source of essential fatty acids: Linoleic and linolenic acid apparently can not be synthesized by animal tissues and needs to supplement through dietary source to prevent some pathological changes. Exact mechanism is not clear how these works but assumes that they are the integral part of lipid – protein structure of of cell membrane and they appear to play an important part in the structure of several components called eicosanoids that play a role in the release of hypothalamic and pituitary hormones. Eicosanoids include thromboxane, leucotines and prostaglandins. Deficiency symptoms of essential fatty acids are dermatitis or skin lesions, growth failure, reproductive failure and deposition of tissue fluids between cells (oedema) etc.

3. Serve as the source of fat soluble vitamins: Absorption of fat soluble vitamins (A, D, E and K) is a function of digestion and absorption of fats.

4. Serve as the integral part of cell membrane.

Minerals

There are immensely important elements which require for various life processes as they are the basic component of all forms of life. Large number of elements of the periodic table has been found to be present in living cells but so far 25 minerals have been found to be dietary essential on the basis of their proven role in various metabolic function in the animal body. These are required in very small quantity as compared to carbohydrate, protein, fat, and water but deficiency may cause harmful effect in the body and some time may lead to death of the animals.

Classification

Depending on requirement of animal the minerals are classified in to two major classes viz., major or macro and micro or trace minerals. There are 7 minerals viz., Ca, P, Mg, S, Na, K and Cl which are termed as major as these are needed in relatively higher quantity (i.e. in grams) and others *viz*., Cu, Co, Zn, Fe, I, F, Mn, Ni, Si, Sn, V, Cd, Hg, Pb, Cr, As, Sc and Se are termed as trace mineral as these are needed relatively lower quantity (in microgram or even less) for large ruminants. In addition to these listed minerals there are 30 or so minerals that are needed for normal functioning of the animal body but exact role yet to be established.

Most of the minerals are distributed throughout the body where they exist in variety of functional combination and in characteristic concentrations which must be maintained within quite narrow limits if the functional and structural integrity of the tissue is to be safeguarded with the growth, health and productivity of the animal. Continued ingestion of diets, that are deficient, imbalanced or excessively high in a particular element invariably induce changes in the functioning forms, activities or concentration of that element in the body tissues or fluids. Under these circumstances, biochemical defects develop, physiological functions are affected and structural disorders may arise in ways which vary with different elements, with the degree and duration of the dietary deficiency or toxicity and with age, sex and species of animal involved. However, there is generally a varying degree of gap between the essential and apparently toxic levels of intake.

Bioavailability of minerals

Bioavailability of any mineral relates to the degree to which an ingested mineral is absorbed and so is available to the body of the animal. While minerals are present in a feed, they are not available unless the body can absorb and utilize them. The ability to absorb minerals from a diet depends on many factors. A value listed in the feed composition table is just a starting point for estimating the true contribution a feed makes to the animals' mineral needs. Bioavailability in true sense, therefore, could be defined as the proportion of an

ingested element i.e. absorbed, transported to the site of action and converted to the physiologically active species.

In the country like India, animals are fed diets consisting of dry fodders, legumes and non- leguminous fodders, tree leaves, shrubs, crop residue and cereal byproducts. In such diets mineral content is generally low and their availability is not known. Ruminant reared mostly on roughages mainly crop residues and animals need supplementation of minerals. But most of the farmers are not aware of the fact and there is immediate need to consider mineral supplementation to the dairy animals for better productivity.

General functions of minerals

Mineral nutrition is a complex one, since there is lot of interactions between the various minerals and some of them function in combination. However, a few general functions are given below.

a. Electrochemical: The elements are concerned in the maintenance of acid base balance, osmotic pressure and membrane permeability of cell in the body.

b. Catalytic: Nearly all essential elements are believed to have one or more catalytic functions in the cell as they are constituents of various enzymes and co- enzymes.

c. Structural: Large number of elements has a structural role in integrity of cell and the body as a whole. The frame work of the body (skeleton) and synthesis of structural protein are also dependant on so many minerals.

A number of elements have a unique functions e.g. calcium and phosphorus besides being a major constituent of bone and teeth are involved in wide range of metabolic reactions, in gain or loss of energy and almost every form of energy exchange in the cell including the making and breaking of high energy phosphate bonds. It is also an integral part of protein molecules of the soft tissues of the body and of the nucleic acid and their derivatives that are involved in cell replication and transmission of the genetic code. Iron is the constituent of haem and play an important role in respiration. Co is a component of vitamin cyanocobalamin (B_{12}) and it is an constituent of thyroxine. Both the elements and vitamin are nevertheless concerned in a variety of metabolic processes. In ruminants, Co is necessary for the growth of certain bacteria which synthesizes vitamin B_{12} essential to the host animal.

Major elements

Calcium is the most abundant mineral in the body as its the major constituent of bone, teeth, in which almost 99 percent of total body Ca is found. It is the essential component

of all living cell and tissue fluids. Blood contains about 9-12 mg/ dl in mammals but in laying hens it is about 30-40 mg/ dl. Bone ash contains about 36 percent of Ca,17 percent of phosphorus and 1 percent of Mg. The bone or skeleton is not the stable organ chemically rather dynamic especially during growth, lactation, laying in poultry depending on nutritional status of the animal. If the animal is fed on low Ca diet, bone Ca will liberate and parathyroid hormone plays an important role in it through absorption from gut, which is a gene mediated action by formation of Ca binding protein. Deficiency symptom in young is known as rickets whereas in the adult its known as osteomalacia. Phosphorus has more known functions in the living organism than any other mineral content because of its association with Ca in bone and skeleton formation and energy metabolism. It occurs in phophoproteins, nucleic acids and phospholipids. In the bone and skeleton 80-85 percent P is found as compared to Ca (99 percent). Normal blood level is 4-9 mg/ dl in mammals. Pica or deprived appetite is noted in ruminants due to deficiency of P in their ration with the symptoms of chewing hard objects like wood, bones, rags and other solid object. Magnesium is also associated with Ca and P in formation of bone skeleton. 70 percent of total body Mg is found in skeleton whereas rests are found in body fluid and soft tissues. It is the commonest enzyme activator i.e, phosphate transferases, pyruvate carboxylase, pyruvate oxidase etc. in addition it is involved in cellular respiration and formation of AMP, ADP and ATPs. In adult ruminants a condition called hypomagnesaemic tetany with low Mg content in blood due to intake of lush, green pasture which is low in Mg content.

K, Na and Cl are associated with acid base balance in body. Failure to maintain the correct electrolyte balance within cell means that metabolic pathways are unable to work efficiently and resources are diverted to achieving homeostasis at the expense of growth. The diet is important in maintenance of correct intracellular electrolyte balance owing to the metabolizable anions and cations that it contains, which consume or generate acid during metabolism. Dietary influence in this respect may be assessed by measuring the quantity of sodium, potassium and chlorine ions per unit weight. Alteration in electrolyte balance influence the metabolism of energy, amino acid, vit D and Ca, hence it has an effect on growth and lactation.

Most of the sulphur in the animal body occurs in the proteins containing amino acids cysteine, cystine and methionine. Vitamins – biotin and thiamin; insulin hormone and coenzyme A contains sulphur. The structural compound chondroitin sulphate is a component of cartilage, bone, tendons and the walls of blood vessels. Inorganic S present in the body in small quantities and wool rich in cystine and contains about 4 percent S. The ration should contain about 10-15: 1 N to S ratio and narrower the ratio, better will be the production performance of animals. Tissue protein and milk have the N:S ratio is 15:1, whereas in wool its around 5:1. Traditionally, little attention has been given to the importance of S in animal nutrition as the intake of this element is mainly in the form of protein, and a deficiency of S would indicate the deficiency of protein.

Minor/ trace elements

Zinc

Zinc is widely distributed throughout the body and plays an essential role in many body processes. Zinc on oral supplementation or through intravenous route reaches peak concentration in the liver within a few days, but concentrations in red blood cells, muscle, bone and hair do not peak for several weeks. Zinc is present in many enzyme systems that are concerned with the metabolism of feed constituents. For example, zinc is a constituent of carbonic anhydrase, carboxy peptidase A and B, several dehydrogenase, alkaline phosphateses, ribonuclease and DNA polymerase. Zinc is required for normal protein synthesis and metabolism and it is also a component of insulin, so it functions in carbohydrate metabolism. Common sources of supplemental zinc include zinc sulfate, zinc oxide, zinc chloride, zinc carbonate and zinc chelates.

Zinc deficiency in bulls and lactasing animals results in a lack of appetite, reduced growth, impaired growth of testes, cessation of spermatogenesis and poor milk production.

Iron

Approximately two-thirds of body iron is present in hemoglobin in red blood cells and myoglobin in muscle, 20% is in labile forms in liver, spleen and other tissues with the remainder in unavailable forms in tissues such as myosin and actomysin and in metallo enzymes. In hemoglobin, which contains 0.34% iron, an atom of ferrous iron in the centre of a porphyrin ring connects heme, the prosthetic group, with globin, the protein. The iron in hemoglobin is essential for the proper function of every organ and tissue of the body. Iron also plays a role in other enzymes involved in oxygen transport and the oxidative process, including catalase, peroxidases, flavoprotein enzymes and cytochromes. Iron in blood plasma is bound in the ferric state (Fe+++) to a specific protein called transferrin. Transferrin is the carrier of iron in the blood and is saturated normally only to 30-60% of its iron binding capacity.

Anemia may occur at any stage of life due to deficiency of iron, but it is likely to occur during the suckling period, since milk is very low in iron. Iron is very low in the milk of cows, goats and sows. It varies from 0.5 to 1.0 ppm. The magnitude of growth rate imposes a greater demand on iron needs than occurs with young ruminants. There is little evidence of an iron deficiency occurring with calves, lambs and kids raised under grazing conditions, except when blood loss or disturbance in iron metabolism occurs because of parasitic infection or disease. This is because they start early to eat food other than mother's milk. Iron supplementation is needed, however, when young ruminants are fed an exclusive whole milk diet. Young nursing calves and lambs, receiving no supplemental source of iron, have responded to intra musculature injections of iron-dextran by improved hemoglobin levels and growth rate.

Copper

Copper is required for the activity of enzymes associated with iron metabolism, elastin and collagen synthesis, melanin production and the integrity of the central nervous system. It is required for normal red blood cell formation by allowing iron absorption from the small intestine and release of iron in the tissue into the blood plasma. Ceruloplasmin is the copper-containing transport protein.

Copper is required for bone formation by promoting structural integrity of bone collagen and for normal elastin formation in the cardiovascular system. Copper is required for normal myelination of brain cells and spinal cord as a component of the enzyme cytochrome oxidase which is essential for myelin formation. Maximum immune response is also dependent on copper as indicated by depressed titers in deficient animals. The process of normal hair and wool pigmentation requires copper. It is believed that copper is a component of polyphenyl oxidase which catalyzes the conversion of tyrosine to melanin and for the incorporation of disulfide groups into keratin in wool and hair. A minimum requirement for copper cannot be given with great accuracy, since copper absorption and utilization in the animal can be markedly affected by several mineral elements and other dietary factors. Zinc, iron, molybdenum, inorganic sulfate and other nutrients can reduce copper absorption.

Copper deficiency in suckling lambs results in a lack of muscular coordination, partial paralysis of the hindquarters, a swayback condition, degeneration of the myelin sheath of nerve fibers, and weak lambs at birth that may die because of their inability to nurse. Anemia, bone disorders and a lack of fertility also occur with a copper deficiency. Sheep produce ‘steely’ wool, which is lacking in crimp, tensile strength, affinity for dyes, and elasticity. Black sheep show depigmentation of the wool.

Iodine

Around 1900, scientists first recognized that iodine was required for the proper functioning of the thyroid gland and that an iodine deficiency caused goiter. Shortly thereafter, iodized salt became widely accepted as a means of preventing goiter in man and animals. The thyroid gland contains the highest concentration (0.2% to 5% on a dry weight basis) of iodine in the body; between 70% and 80% of the total body stores. Approximately 90% of the iodine which passes through the thyroid gland is captured by that organ. Iodine is then combined with tyrosine in the thyroid to form diiodotyrosine. Two molecules of this compound are then combined to form thyroxine. Approximately, 80% of the thyroxine entering the circulation is broken down through de-iodinization by the liver, kidney and other tissues. Deficiency of iodine, related to improper brain development and basal metabolism in the animal.

Cobalt

The only known animal requirement for cobalt is as a constituent of Vitamin B_{12}, which has 4% cobalt in its chemical structure. This means that a cobalt deficiency is really a vitamin B_{12} deficiency. Microorganisms in the rumen are able to synthesize vitamin B_{12} to fulfil needs of ruminants if the diet is adequate in cobalt. Normally, cobalt is not stored in the body in significant quantities. The small amount that is stored does not easily pass back into the rumen or intestinal tract where it can be used for vitamin B_{12} synthesis. Therefore, ruminants must consume cobalt frequently in the diet for adequate B_{12} synthesis. Traditionally, a breakdown in propionate metabolism at the point in the metabolic pathway where methymalony-CoA is converted to succinyl-CoA was thought to be the reason for the depression in appetite is controlled by Vit B_{12}. It has been well documented that changes in the rumen microbial population occurs in cobalt deficient ruminants. It now appears that a cobalt deficiency causes a vitamin B_{12} deficiency which inhibits propionate producing bacteria such as *Selenomonas ruminantium*.

Manganese

Manganese was first recognized as a necessary nutrient for animals in the early 1930s. Because manganese is found in many different feeds, a deficiency is less likely than with most of the other trace minerals. However, manganese deficiency does occur in sufficient magnitude to justify consideration in this text. Bone, kidney, liver, pancreas, and pituitary gland are the sites of highest manganese concentration. Relative concentration is quite low compared to the other trace minerals. For example, in humans, total body manganese is approximately 1% of the zinc and 20% of the copper. Although concentrations are low, it is a critical nutrient for several functions. Manganese is essential for chondroitin sulfate synthesis, which is critical to the organic matrix of bone. Many enzymes required for the synthesis of polysaccharides and glycoproteins need manganese to be active. Manganese is a key component of the metalloenzyme, pyruvate carboxylase, a critical enzyme in carbohydrate metabolism. Lipid metabolism is also dependent on manganese to allow the liver to convert mevalonic acid to squalene.

Selenium

Selenium is present in all cells of the body, but the concentration is normally less than 1 ppm. Toxic concentrations in liver and kidney are normally between 5 and 10 ppm. Selenium is an important part of the enzyme glutathione peroxidase. This enzyme destroys peroxides before they can damage cell membrane. Vitamin E is also effective as an antioxidant. Therefore, both selenium and vitamin E prevent peroxide damage to body cells. This aids the defense mechanisms against stress. Most feeds contain compounds that can form peroxides. Unsaturated fatty acids are a good example. Rancidity in feeds

causes formation of peroxides that destroy nutrients. Vitamin E for example, is easily destroyed by rancidity. Selenium spares vitamin E by its antioxidant effect as a constituent of glutathione peroxidase. Selenium and vitamin E are interrelated in metabolic action. Both are needed by animals and both have metabolic roles in the body in addition to an antioxidant effect. In some instances, vitamin E will substitute in varying degrees for selenium, or vice versa. However, there are deficiency symptoms that respond only to selenium or vitamin E. Although selenium cannot replace vitamin E in nutrition, it reduces the amount of vitamin E required and delays the onset of E deficiency symptoms.

Selenium plays a critical role in increasing the immune response in animals. Selenium is important in sulfur containing amino acid synthesis. Sulfur containing amino acids protect animals against several diseases associated with low intakes of selenium and vitamin E. This protection is believed to be due to the antioxidant activity of selenium and vitamin E. Therefore, the sulfur containing amino acids, methionine and cystine, can spare vitamin E and selenium through their antioxidant role. Selenium can be added to diets of all food animals. Either sodium selenite or sodium selenate can be used. Selenium is added to feed as follows: Up to 0.1 ppm in complete feed for ruminants and poultry.

Vitamins

Vitamins are usually defined as the organic compounds which are required in small quantity compared to other nutrients for normal functioning and the physiological processes of body. The term vitamin is derived from 'vital amines' as it was thought that some food factors which contain amine nitrogen are essential for normal health. Later on it was known that certain vitamins contain amines. Many of the vitamins are not very stable and are destroyed by oxidation which is speeded up by certain metals, heat and light. These are the important things to be remembered during the formulation of ration and processing of feeds for animal. Most of the commercial companies are marketing the vitamins claiming to be stabilized. Though there are almost 15 vitamins known to be essential but not all of them are not dietary essential for dairy animals as some of them are synthesized by the microbes in rumen and available to the host animals.

Classification

The vitamins are classified into fat soluble and water soluble vitamins on the basis of solubility in a particular solvent. Fat soluble vitamins are A, D_2, D_3, E and K whereas the water soluble vitamins are thiamin (B_1), riboflbin (B_2), niacin, pyridoxine (B_6), pantothenic acid, biotin, folic acid, chlorine, cyanocobalamin (B_{12}) and ascorbic acid or Vitamin C.

General functions of different vitamins

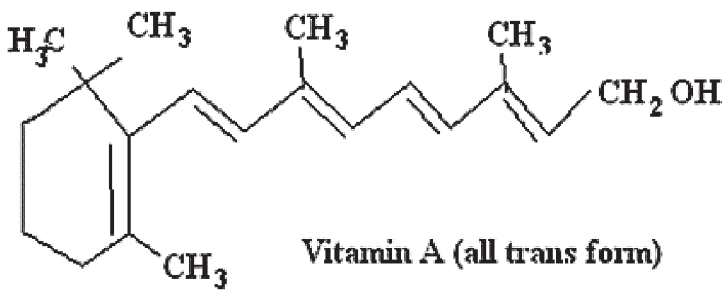
There are number of vital functions in the system regulated by vitamins which are summarized in the following table (Table 1.1).

Table 1.1. General functions of vitamins and deficiency symptoms

Name of the vitamin	Chemical name	Metabolic activity
Vitamin A	Retinol Retinal Retonoic acid	Oxidation- reduction cycle, visual cycle. Necessary for chondroitin sulphate. Maintenance of placenta in 2nd trimester
Vitamin D_2 Vitamin D_3	Ergocalcipherol Cholecalcipherol	Absorption of Ca, P from gut. Necessary for calcification of bone matrix
Vitamin E	α Tocopherol	Acts as antioxidant. Normal phosphorylation of ATP
Vitamin K	Phylloquinone	Blood coagulation
Water soluble vitamins	Not required by the ruminants as these are synthesized in rumen and indirectly the requirement fulfils.	

Vitamin A

Vitamin A is chemically known as retinol is an unsaturated monohydric alcohol with the following formula.



Vitamin A (all trans form)

The vitamin is yellow crystalline solid, insoluble in water which is readily destroyed by oxidation on exposure to air and light. A related compound with two hydrogen molecule less originally found in fish, has been designated as vitamin A_2. Vitamin does not exist in plant, but is present as precursor or provitamins of vitamin A. At least 600 naturally occurring carotenoids are known but only few of those are precursors of vitamin A. Carotenoids have yellow, orange or red colour and are responsible for many varied and

natural colours which occur in carotenoids, insects, birds and fishes. They are also found in egg yolk, butterfat and body fat of cattle and horses but not in pig and sheep. They also occur in plants, but their colour is frequently masked by the green colour pigment chlorophyll. Conversion of carotenoids to vitamin can occur in liver but usually takes place in intestinal mucosa. Theoretically, one molecule of ß carotene yields two molecules of vitamin A (retinol).

Function: Vitamin A appears to play two different roles in the body according to whether it is acting in the eye and or in the general system. In the retinal cells of the eye, vitamin A (all trans retinol) is oxidized to aldehyde (all trans retinaldehyde) which is converted into 11 cis isomer. The later then combines with the protein opsin to form rhodopsin (visual purple) which is the photo receptor for vision at low light intension or dim light vision. Deficiency symptoms involve night blindness, softening and cloudness of cornea and development of xerophthalmia

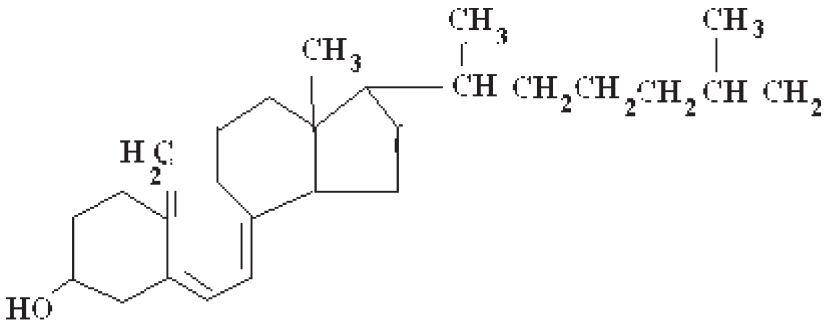
In its second role, it is involve in the formation and protection of epithelial tissues and mucus membranes. Deficiency disorder causes rough skin or toad skin, reproductive failure etc. In breeding animal vitamin A deficiency leads to infertility and in pregnant animals it leads to abortion or still birth.

Sources: Vitamin A accumulates in liver, hence this organ is likely to be a good source, the amount present varies greatly. Oils from livers of certain fish especially cod and halibut have long been used as an important dietary source of the vitamin. Egg yolk and milk fat are also rich source of vitamin A.

Vitamin D

A number of forms of vitamin D are known, although not all these are naturally occurring compounds. The two most important forms are ergocalcipherol (D_2) and cholecalcipherol (D_3). This vitamin is insoluble in water but sulphate derivatives in milk are water soluble. Both D_2 and D_3 are resistant to oxidation.

Ergosterol and 7 dehydrocholesterol, are the precursors of vitamin D_2 and D_3, respectively. The provitamins, as such have no vitamin value and must be converted to calcipherols before they are of any use to the animals. For this conversion it is necessary to impart a definite quantity of energy to the sterol molecule and this can be brought about by the ultra violet light present in the sunlight, by artificially produced radiant energy or by certain kind of physical treatment. The chemical transformation occurs in the skin and also in the skin secretions, which are known to contain the precursor. Absorption of the vitamin can take place from the skin, since deficiency can be treated successfully by rubbing codliver oil on the skin. Most biologically active form of the vitamin is 1, 25- dihydroxycholecalcipherol. This compound is transported in the blood to various target tissues, intestine, bones. The



Cholecalcipherol

compound acts in a similar way to a steroid hormone, regulating DNA transcription in the intestinal microvilli, including the synthesis of specific messenger RNA, which is responsible for the synthesis of Ca binding protein. This protein is involved in the absorption of Ca from the intestinal lumen.

The amount of 1,25- dihydroxycholecalcipherol produced in the kidney is controlled by parathyroid hormone. When the level of Ca in the blood is low, the parathyroid gland is stimulated to secrete more parathyroid hormone, which induces the kidney to produce 1, 25 dihydroxy cholecalcipherol which in turn enhances the intestinal absorption of calcium. In addition to increasing intestinal absorption of Ca, 1, 25 dihydroxycholecalcipherol increases the absorption of phosphorus from the intestine and also enhances calcium and phosphorus reabsorption from the kidney and bone.

Deficiency symptoms: A deficiency of vitamin D in the young animals results in rickets a disease if growing bone in which the deposition of Ca and P is disturbed, as a result the bones are weak and fragile and legs may be bowed. In young animals, the symptoms like swollen knee and hocks and arching the back. In older animals, deficiency causes osteomalacia in which there is reabsorption of bones already laid down. Although the similar condition may be seen in pregnant and lactating animals and thus require more vitamin D or Ca and phosphorus.

Sources: The vitamins are limited in distribution. They rarely occur in plants except in sun dried roughages and the dead leaves of growing plants. In the animal kingdom vitamin occurs in small amounts and in certain tissues and is abundant only in some fishes. Egg yolk is also a good source of the vitamin, but cow milk is generally a poor source, though colostrum is 6-10 times richer than ordinary milk.

Vitamin E

Vitamin E is a group name which includes a number of closely related active compounds. Eight naturally occurring forms are available of vitamin E, among which α, β, γ, Δ are important and most active form is the 1st one. This vitamin act as biological antioxidant, in association with Se containing enzyme glutathione peroxidase, protects cell against

damage caused by free radicals. Free radicals formed during cell metabolism and as they are capable of damaging cell membranes, enzymes and cell nuclear materials, they must be converted in to less reactive substances if the animal is to survive. This protection is essential in preventing the oxidation of polyunsaturated fatty acids which functions as primary constituent of subcellular membrane and precursor of prostaglandins. Oxidation of poly-unsaturated fatty acid (PUFA) produces hydro-peroxides which also damage the cell and tissues, so preventing such oxidation is highly essential for life process. There are two main defense line against these oxidation process, first is free radical is scavenged by vitamin E and second, glutathione peroxidase destroys any peroxidides formed before they can damage the cell. Vitamin E also plays an important role in development and function of immune system.

Deficiency symptoms: Deficiency of vitamin E is known as muscular degeration or myopathy, nutritionally also known as muscular dystrophy. The disease found in calves when turned out in to dry grasses suddenly. Symptoms are manifested by weak leg muscle, difficulty in standing and after standing trembling and staggering gait. Eventually the animals are unable to rise and weakness in neck muscle prevents them from raising their head. This condition is also known as white muscle disease. Heart muscle is also affected and death may occur.

Sources: Vitamin E is not stored in animal body in larger quantity. Fortunately it is distributed in feeds. Green fodders and young grasses are rich source of tocopherols. Mature herbage is poor source of this vitamin and leaves contain 20-30 times as much vitamin E as stems. Losses during hay making as high as 90 percent but losses during ensiling and artificial drying is very low. Cereals are good sources of vitamin E. wheat and barley contains a tocopherols but maize contains in addition to α tocopherol and γ tocopherols. Animal products are relatively poor sources of the vitamin.

Vitamin K

During the time when discovered this vitamin called as 'Koagulation Factor', knowing its role in blood coagulation. Chemically the vitamin K is known as phylloquinone, vitamin K_1 or 2 methyl, 3 phytyl, 1-4 naphthoquinone. The compound is originally isolated from purified fishmeal and designated as vitamin K_2 is now known to be only of a series of K vitamins with unsaturated side chain synthesized by bacteria and referred to as menaquinones. Vitamin K is necessary for synthesis of prothrombin in liver which is a inactive precursor of thrombin, an enzyme that converts fibrinogen to fibrin (insoluble fibrous protein that holds clots together). Prothrombin normally binds to Ca ions before it can be activated. If the supply of the vitamin is inadequate prothrombin molecule is deficient in γ carboxyglutamic acid, a specific amino acid responsible for Ca binding. Proteins containing this amino acid,

dependent on vitamin K for their formation are also present in bone, kidney and other tissues.

Sources: Phylloquinone is present in most leafy vegetables, lucerne, cabbage and kale being good sources. Egg yolk, liver and fishmeal are good sources of this vitamin. Other feed materials are moderate source of the vitamin. Menaquinones are synthesized by bacteria in the digestive tract of animals.

Water soluble vitamins

Vitamin B complex

All the vitamins are soluble in water and not stored in body (except cyanocobalamin), hence exogenous supply is essential on regular basis. In dairy animals, all the water soluble vitamins are synthesized by the microbes in rumen and provides the satisfactory amount of vitamin required for animals.

Thiamin: This is a complex nitrogenous base containing a pyrimidine ring joined to a thiazole ring. Because of the presence of hydroxyl group at the end of the side chain, thiamin can form esters. Thiamin pyrophosphate is coenzyme involved in the oxidative decarboxylation of pyruvate to acetyl coenzyme A and α keto glutarate to succinyl CoA, in TCA cycle. Under some circumstances, bacterial thiaminase destroys the vitamin, resulting in deficiency symptoms called as cerebrocortical necrosis. This condition is characterized by circling movement, head pressing, blindness, muscular tremor etc. Thiaminase activity of bracken fern and some carp fish have been established and needs careful attention in case of deficiency.

Source: It is concentrated in outer layers of seeds, germ, in the growing areas of roots, leaves and shoots. Fermentation products like brewers' yeast are rich source of thiamin. Animal source is also rich in thiamin.

Riboflavin: Its yellow crystalline compound, which has a yellowish green fluorescence in aquous solution. It is heat stable, acid and neutral solutions but destroyed in alkali, sparingly soluble in water. It is the important component of flavin mononeucliotide and flavin adnine dineucleotide. There are several other flavoproteins which are involved in reaction of transport of hydrogen. The vitamin is synthesized in rumen and deficiencies in fully functional ruminants are unlikely to occur. However, young calves and lambs have been demonstrated with riboflavin deficiency. The symptoms are loss appetite, diarrhoea and lesions in the corner of mouth.

Sources: Rich sources of riboflavin are yeast, liver, milk (whey), green leafy crops. Cereal grains are poor sources of riboflavin.

Nicotinamide: It is a stable vitamin which is not easily destroyed by heat, acid, alkali or oxidation. It is functions as active group of two coenzymes, nocotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP). These are involved in hydrogen transfer in ATP production. Requirement of the vitamin is being fulfilled by rumen microbes and deficiency symptoms not seen in dairy aniamls under normal condition.

Sources: It can be synthesized from tryptophan in the body tissues and since, animals can convert the acid to the amide containing coenzymes, it follows that if the diet is adequately supplied with protein sources rich in tryptophan, dietary requirement will be low. Rich sources are liver, yeast, groundnut, sunflower meals. Although the cereals containing this vitamin but due to bound form, it is not available to the animal. Milk and egg are almost devoid of the vitamin, although, they contain the precursor of the vitamin.

Vitamin B_6: The vitamin exists in three form which are inter-convertible in the body tissue. The parent substance is pyridoxine, corresponding to aldehyde derivative pyridoxal and amine is pyridoxamine. All three forms describes the vitamin B_6. The amine and aldehyde derivatives are less stable than pyridoxamine and are destroyed by heat. It plays the central role as a coenzyme in reactions by which a cell transforms nutrient amino acid into mixture of amino acids and other nitrogenous compounds required for its own metabolism. These reactions involve activities of transaminase and decarboxylases. The lesions primarily of amino acid metabolism and growth rate will hamper.

Sources: The vitamin present as pyridoxine in plants, whereas in the animal products it is available as pyridoxal and pyridoxamine. Pyridoxine and its derivatives are widely distributed in yeast, cereal grains, liver and milk.

Pantothenic acid: It is an amide of pantoic acid and b alanine and is a precursor of coenzyme A which is important coenzyme of acyl transfer. In addition to the component of coenzyme A, pantothenic acid is also a structural component of acyl carrier protein, involved in cytoplasmic synthesis of fatty acid.

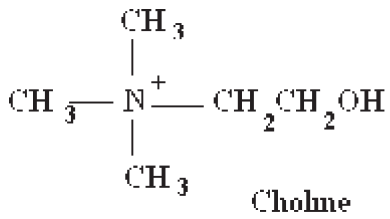
Folic acid: Chemically folic acid is pteroylmonoglutamic acid and made up of three moieties: p- aminobenzoic acid, glutamic acid and a pteridine nucleus. Several active derivatives of the vitamin are known to occur, these containing upto 11 glutamate residues in the molecule. It is reasonably stable in food stored under dry conditions but it is readily degraded by moisture, particularly at high temperature. It is destroyed by ultraviolet light. Folic acid is converted into tetrahydrofolic acid after absorption which functions as a coenzyme in the mobilization and utilization of single carbon groups that are added to, or removed from, such metabolites as histidine, serine, glycine, methionine and purines.

Source: Folic acid widely distributed in nature, green leafy vegetables, cereals and extracted oilseed meals are good source of the vitamin.

Biotin: A part of the vitamin B complex, biotin is chemically 2-keto 3, 4 imidazolido-2 tetrahydrothiophen-n- valeric acid. Biotin serves as the prosthetic group of several enzymes which catalyze the transfer of carbon dioxide from one substrate to another. In animals there are three biotin dependent enzymes of particular importance: pyruvate carboxilase, acetyl coenzyme A carboxilase and propinyl coenzyme A carboxilase. In ruminants, like other B complex vitamins, it is synthesized by the gut mocosa, hence not required.

Source: It is widely distributed in foods; liver, milk, yeast, oilseeds and vegetables are rich sources. However, in some feeds much of the bound vitamin may not be released during digestion and hence is unavailable.

Choline: Chemically the structure is given below:



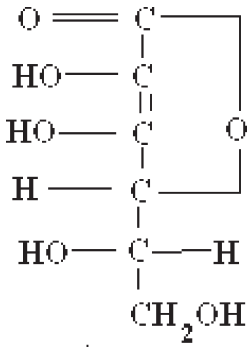
Choline

Unlike the other B vitamins, it is not a metabolic catalyst but forms an essential structural component of body tissues. It is a component of lecithins which play role in cellular structure and activity. It also plays an important role in lipid metabolism in the liver by preventing the accumulation of fat in this organ. It serves as a donor of methyl group in trans-methylation reaction and is a component of acetylcholine which is responsible for transmission of nerve impulses. Choline can be synthesized in liver from methionine and the exogenous requirement for this vitamin is therefore influences by the methionine in the diet.

Vitamin B_{12}: It is also known as cyanocobalamin and has the complex structure of all vitamins. The basic unit is corrin nucleus which consists of a ring structure comprising four five membered rings containing nitrogen. In the active centre of the nucleus is a cobalt atom. A cyano group is usually attached to the cobalt as an artifact of isolation and, as this is the most stable form of the vitamin, it is the form in which the vitamin is commercially produced. Before vitamin B_{12} can be absorbed from the intestine it must be bound to a highly specific glycoprotein, termed intrinsic factor, which is secreted by the gastric mucosa. In man, intrinsic factor may be lacking which leads to poor absorption of the vitamin and results in a condition known as percinious anaemia. The coenzyme forms of vitamin B_{12} function in several important enzyme system. These include isomerases, dehydrases and coenzymes involved in biosynthesis of methionine from homocysteine. Of special interest in ruminant nutrition is the role of vitamin B_{12} in the metabolism of propionic acid into succinic acid. In this pathway, the vitamin is necessary for the conversion of methyl malonyl CoA into succinyl CoA.

Vitamin C

Chemically this is L- ascorbic acid and has the following formula:



L-Ascorbic acid

It involves in various oxidation reduction mechanism in living cell. It is necessary for maintenance of normal collagen metabolism. It also plays an important role in the transport of iron ions from transferrin, found in the plasma, to ferritin which acts as store of iron in the bone marrow, liver and spleen. It also acts as antioxidant like vitamin E and glutathione peroxidase. In the ruminants it not dietary essential but under climatic stress poultry needs to be supplemented with this vitamin.

Review Questions

1. Why water is necessary for animals?
2. What is antioxidant and which nutrient plays the role of antioxidant.
3. Why water soluble vitamins not required through diet by the ruminants?
4. What is essential fatty acid and importance of it in human nutrition.
5. Role of forage in dairy animals. What is the precursor of glucose in dairy animals?
6. Role of cyanocobalamin in animals?

CHAPTER 2

Anatomy of Digestive System of Dairy Animals:

digestion, absorption and utilization of different nutrients

OBJECTIVE

1. To study the different organs and their role in digestion and absorption in ruminants.

INTRODUCTION

Ruminants are the mammals that digests forages by softening it within its first compartment of the stomach, principally through bacterial actions, then regurgitating the semi-digested mass, now known as cud, and chewing it again. The process of rechewing the cud to further break down plant matter and stimulate digestion is called “ruminating”. There are about 150 species of ruminants which include both domestic and wild species. Ruminating mammals including cattle, goat, sheep, giraffes, yak, deer, camels, llamas, antelope.

ANATOMY OF DIGESTIVE SYSTEM

The cow’s digestive tract consists of the mouth, esophagus, a complex four-compartment stomach, small intestine and large intestine. The stomach includes the rumen or paunch, reticulum or “honeycomb,” the omasum or “manyplies,” and the abomasum or “true stomach.”

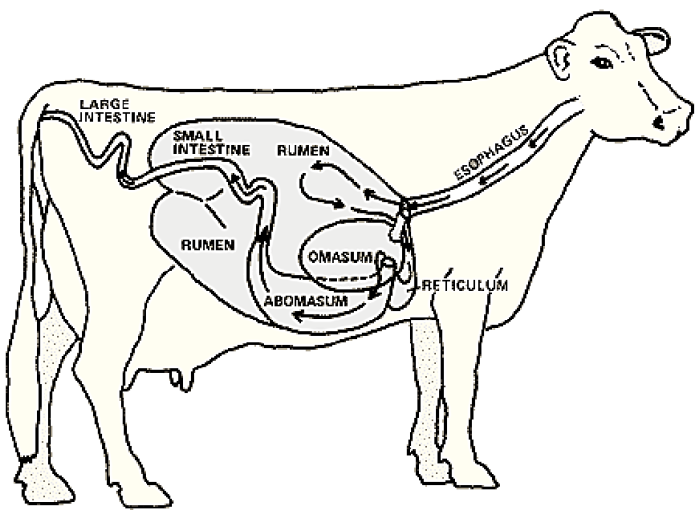


Fig: Anatomy of the adult digestive tract.

The Rumen

The rumen (on the left side of the animal) is the largest of four compartments and is divided into several sacs. It can hold 25 gallons or more of material, depending on the size of the cow. Because of its size, the rumen acts as a storage or holding vat for feed. It is also a fermentation vat. A microbial population in the rumen digests or ferments feed eaten by the animal. Conditions within the rumen favor the growth of microbes. The rumen absorbs most of the volatile fatty acids produced from fermentation of feedstuffs by rumen microbes. Absorption of volatile fatty acids and some other products of digestion is enhanced by a good blood supply to the walls of the rumen. Tiny projections called papillae increase the surface area and the absorption capacity of the rumen.

Fig.: The interior surface of the rumen forms numerous papillae that vary in shape and size from short and pointed to long and foliate.

The Reticulum

The reticulum is a pouch-like structure in the forward area of the body cavity. The tissues are arranged in a network resembling a honeycomb. A small fold of tissue lies between the reticulum and the rumen, but the two are not actually separate compartments. Collectively they are called the rumino-reticulum. Heavy or dense feed and metal objects eaten by the cow generally drop into this compartment. The reticulum lies close to the heart. Nails and other sharp objects may work into the tissue and cause “hardware disease.” If not prevented by a magnet or corrected by surgery, infection may occur and the animal may die.

Fig: Reticular epithelium is thrown into folds that form polygonal cells that give it a reticular, honey-combed appearance. Numerous small papillae stud the interior floors of these cells

The Omasum

This globe-shaped structure (also called the "manyplies") contains leaves of tissue (like pages in a book). The omasum absorbs water and other substances from digestive contents. Feed material (ingesta) between the leaves will be drier than that found in the other compartments.

The Abomasum

This is the only compartment (also called the true stomach) with a glandular lining. Hydrochloric acid and digestive enzymes, needed for the breakdown of feeds, are secreted into the abomasum. The abomasum is comparable to the stomach of the non-ruminant.

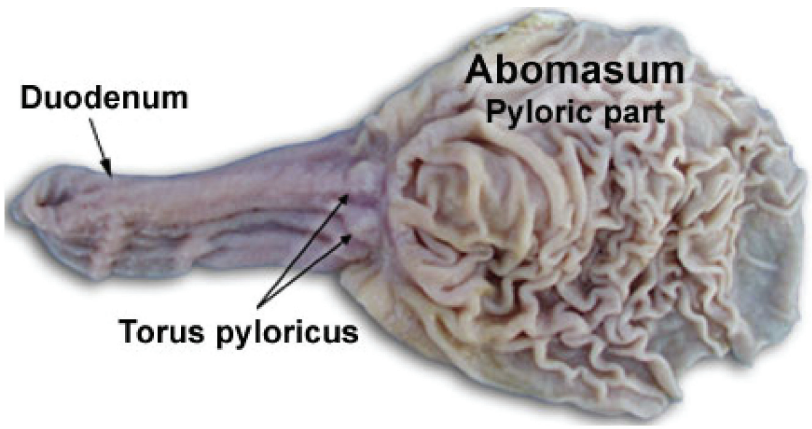


Fig: Showing different parts of abomasums

The Small Intestine

The small intestine measures about 20 times the length of the animal. It is composed of three sections: the duodenum, jejunum, and ileum. The small intestine receives the secretions of the pancreas and the gallbladder, which aid digestion. Most of the digestive process is completed here, and many nutrients are absorbed through the villi (small finger-like projections) into the blood and lymphatic systems.

Cecum

The cecum is the large area located at the junction of the small and large intestine, where some previously undigested fiber may be broken down. The exact significance of the cecum has not been established.

Large Intestine

This is the last segment of the tract through which undigested feedstuffs pass. Some bacterial digestion of undigested feed occurs, but absorption of water is the primary digestive activity occurring in the large intestine.

The anatomic features described above are exemplified by cattle, sheep and goats. Certain other animals are also generally called ruminants, but have slightly different forestomach anatomy. Camelids (camels, llamas, alpacas, vicunas) have a reticulum with areas of gland-like cells, and an omasum that is tubular and almost indistinct. These animals are occasionally referred to as pseudoruminants or as having “three stomachs” rather than four.

Calf Digestive System

At birth and during the first few weeks of life, the rumen, reticulum, and omasum are undeveloped. In contrast to the mature cow, in the calf, the abomasum is the largest compartment of the stomach. At this stage of life, the rumen is nonfunctional and some feeds digested by the adult cannot be used by the calf. During suckling milk, milk bypasses the rumen via the esophageal groove and passes directly into the abomasum. Reflex action closes the groove to form a tube-like structure which prevents milk or milk replacer from entering the rumen. When milk is consumed very rapidly, some may overflow into the rumen.

As long as the calf remains on milk, the rumen remains undeveloped. When calves begin consuming grain and forage, a microbial population becomes established in the rumen and reticulum. End products of microbial fermentation are responsible for the development of the rumen. This occurs as early as 3 weeks of age with most feeding programs. Cud

inoculation is not necessary to initiate rumen development. If grain feeding with or without forage is started during the first few weeks of life, the rumen will become larger and heavier with papillae development, and will begin functioning like the adult's when the calf is about 3 months of age.

Digestion

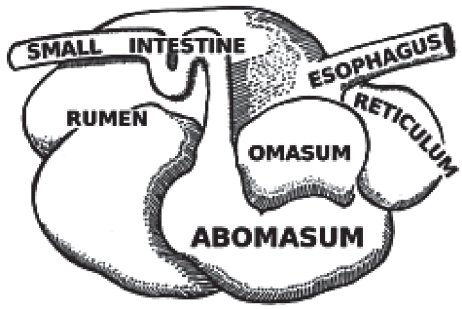


Fig: Showing different parts of ruminant stomach including esophagus and small intestine.

The rumen is a fermentation vat *par excellance*, providing an anaerobic environment, constant temperature and pH, and good mixing. Well-masticated substrates are delivered through the esophagus on a regular schedule, and fermentation products are either absorbed in the rumen itself or flow out for further digestion and absorption downstream.

Feed, water and saliva are delivered to the reticulorumen through the esophageal orifice. Heavy objects (grain, rocks, nails) fall into the reticulum, while lighter material (grass, hay) enters the rumen proper. Added to this mixture are voluminous quantities of gas produced during fermentation.

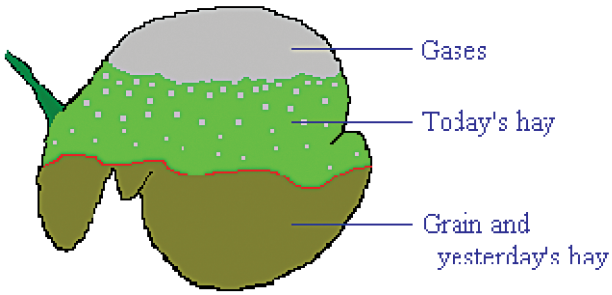
Ruminants produce prodigious quantities of saliva. Adult cows are in the range of 100 to 150 liters of saliva per day. Aside from its normal lubricating qualities, saliva serves at least two very important functions in the ruminant:

- provision of fluid for the fermentation vat
- alkaline buffering - saliva is rich in bicarbonate, which buffers the large quanitity of acid produced in the rumen and is probably critical for maintainance of rumen pH.

All these materials within the rumen partition into three primary zones based on their specific gravity. Gas rises to fill the upper regions, grain and fluid-saturated roughage ("yesterday's hay") sink to the bottom, and newly arrived roughage floats in a middle layer.

The rate of flow of solid material through the rumen is quite slow and dependent on its size and density. Water flows through the rumen rapidly and appears to be critical in flushing particulate matter downstream.

As fermentation proceeds, feedstuffs are reduced to smaller and smaller sizes and microbes



constantly proliferate. Ruminal contractions constantly flush lighter solids back into the rumen. The smaller and more dense material tends to be pushed into the reticulum and cranial sac of the rumen, from which it is ejected with microbe-laden liquid through the reticulo-omasal orifice into the omasum.

The function of the omasum is rather poorly understood. It may function to absorb residual volatile fatty acids and bicarbonate. The tendency is for fluid to pass rapidly through the omasal canal, but for particulate matter to be retained between omasal leaves. Periodic contractions of the omasum knocks flakes of material out of the leaves for passage into the abomasum.

The abomasum is a true, glandular stomach which secretes acid and otherwise functions very similarly to the stomach of a monogastric. One fascinating specialization of this organ relates to its need to process large masses of bacteria. In contrast to the stomach of non-ruminants, the abomasum secretes lysozyme, an enzyme that efficiently breaks down bacterial cell walls.

The processes described above apply to adult ruminants. For the first month or so of life, the ruminant is functionally a monogastric. The forestomach are formed, but are not yet fully developed. If milk is introduced into such a rumen, it basically rots rather than being fermented. To avoid this problem in such young ruminants, suckling causes a reflex closure of muscular folds that form a channel from the esophageal orifice toward the omasum (the esophageal groove), shunting milk away from the rumen and straight toward the stomach where it can be curdled by rennin and eventually digested enzymatically.

Digestion of Different Nutrient

Digestion of energy feeds in the rumen

Simple and complex carbohydrates (fiber) are digested by rumen microbes and converted into volatile fatty acids. The volatile fatty acids, which consist mainly of acetic, propionic, and butyric acids, are the primary energy source for ruminants. When large amounts of forage are fed, the formation of acetic acid predominates (60 to 70 percent of total) with lesser amounts of propionic (15 to 20 percent) and butyric (5 to 15 percent) acids

occurring. However, when grain feeding is increased or when finely ground forages are fed, the proportion of acetic acid may decrease to 40 percent, while the amount of propionic acid may increase to 40 percent. Approximately 30 to 50 percent of the cellulose and hemicellulose is digested in the rumen by the microbial population. Sixty percent or more of the starch is degraded, depending on the amount fed and how fast ingested materials move through the rumen. Most sugars are 100 percent digested within the rumen.

The volatile fatty acids are absorbed from the rumen into the blood stream and transported to body tissues, including the udder, where they are used as sources of energy for maintenance, growth, reproduction, and milk production. The cow derives 50 to 70 percent of its energy from the volatile fatty acids produced in the rumen.

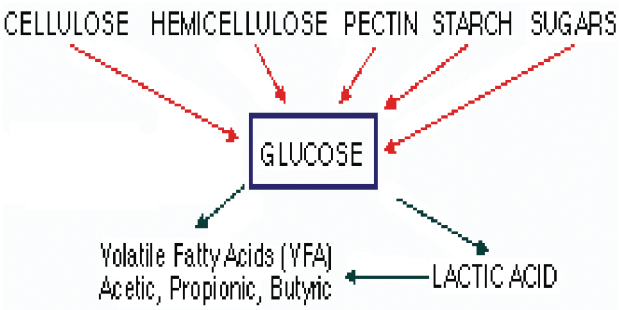


Fig: Microbial digestion of feed carbohydrate in the rumen.

Protein and nonprotein nitrogen utilization in the rumen.

Some of the protein consumed by the cow is escapes breakdown in the rumen. Protein undergoing fermentation is converted to ammonia, organic acids, amino acids, and other products. Approximately 40 to 75 percent of the natural protein in feed is broken down. The extent of breakdown depends on many factors including solubility of the protein, resistance to breakdown, rate of feed passage through the rumen, and others. Many rumen micro-organisms require ammonia (breakdown product of protein) for growth and synthesis of microbial protein. Ammonia also may be provided from NPN sources such as urea, ammonium salts, nitrates, and other compounds. Rumen microbes convert the ammonia and organic acids into amino acids that are assembled into microbial protein. Excess ammonia is mostly absorbed from the rumen into the blood stream, but small amounts may pass into the lower digestive tract and be absorbed. Feed protein (that escapes breakdown in the rumen) and microbial protein pass to the abomasum and small intestine for digestion and absorption.

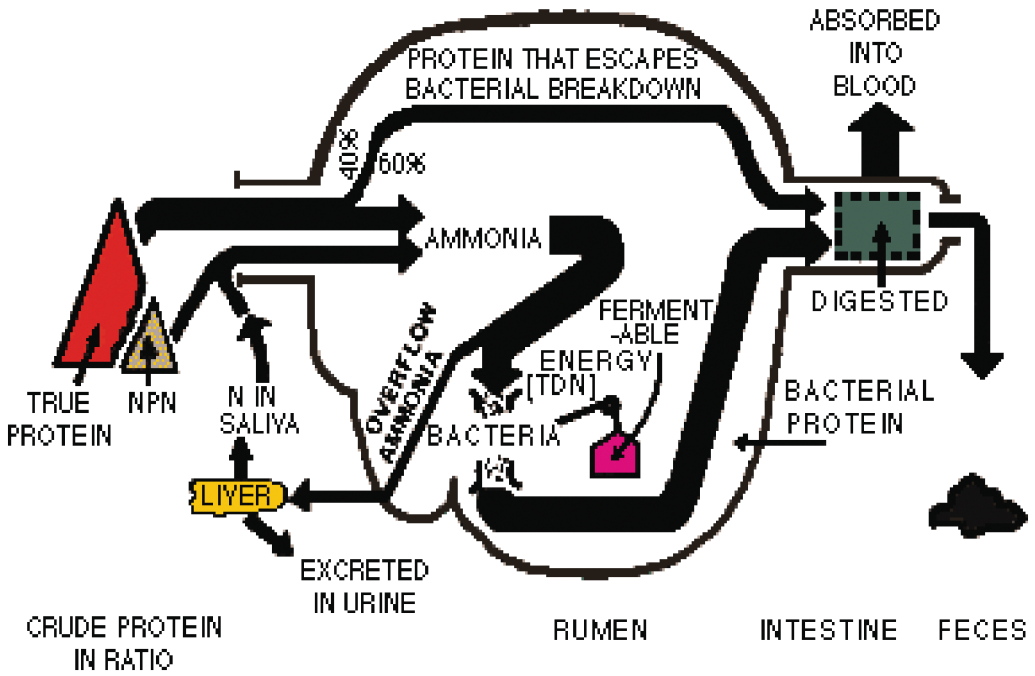


Fig: Schematic summary of nitrogen utilization by the ruminant

Vitamin synthesis

The rumen micro-organisms manufacture all of the B vitamins and vitamin K. Vitamin synthesis in the rumen is sufficient for growth and maintenance. Under most conditions, cattle with functioning rumens do not require supplemental B vitamins or vitamin K in the diet. Niacin (B3) and thiamine (B1) may be needed under stress conditions.

Fat digestion:

Most of the digestion and absorption of fat occurs in the small intestine. Rumen micro-organisms change unsaturated fatty acids to saturated acids through the addition of hydrogen molecules. Thus, more saturated fat is absorbed by cows than by simple-stomach animals. Feeding large quantities of unsaturated fatty acids can be toxic to rumen bacteria, depress fiber digestion, and lower rumen pH.

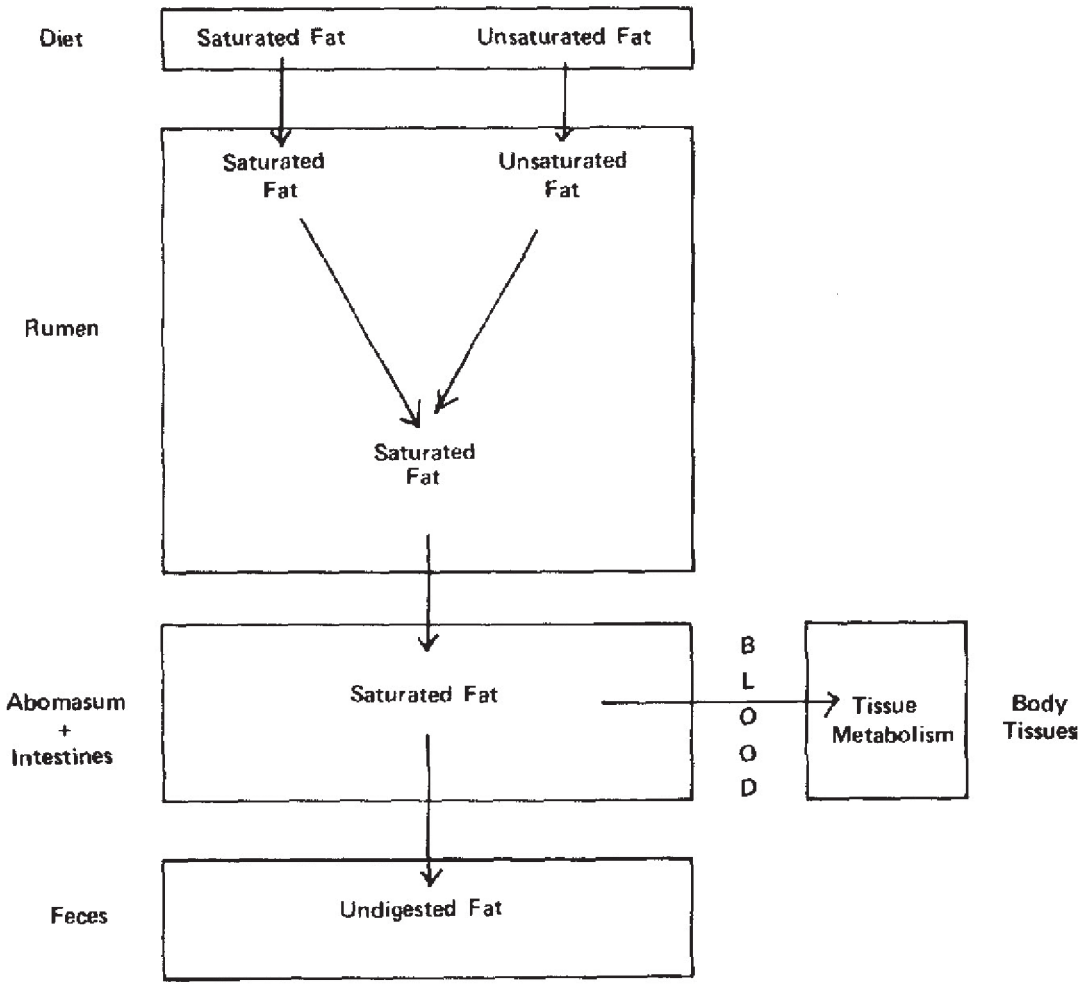


Fig: Digestion utilization of fat by cow

Nutrient Absorption and Utilization in Ruminant

Volatile fatty acids (VFA) are produced in large amounts through ruminal fermentation and are of paramount importance in that they provide greater than 70% of the ruminant's energy supply. Virtually all of the acetic, proprionic and butyric acids formed in the rumen are absorbed across the ruminal epithelium, from which they are carried by ruminal veins to the portal vein and hence through the liver. Continuous removal of VFA from the rumen is important not only for distribution, but to prevent excessive and damaging drops in pH of rumen fluid. The rumen is lined with stratified squamous epithelium similar to skin, which is generally not noted for efficient absorption. Nonetheless, this squamous epithelium has a structure which functions similarly to the columnar epithelium in the small gut and performs efficient absorption of VFA, as well as lactic acid, electrolytes and water. Recall also, that the epithelial surface is expanded greatly by formation of well-vascularized papillae. It is of considerable practical importance that the size and length of ruminal papillae respond to concentrations of VFA in the rumen. Animals that have been on a high

plane of nutrition, with abundant VFA production, have long, luxuriant papillae well suited to promote absorption. In contrast, animals which have been under nutritional deprivation have small, blunted papillae, and require time on a high quality diet to allow for development of their papillae and absorptive capacity. All the VFA appear to be absorbed by the same mechanism, which is diffusion through the epithelium, down a concentration gradient. As they pass through the epithelium, the different VFA undergo different degrees of metabolism. Acetate and proprionate pass through the epithelium largely unchanged, but almost all of the butyric acid is metabolized in the epithelium to beta-hydroxybutyric acid, a type of ketone body.

The three major VFA absorbed from the rumen have somewhat distinctive metabolic fates:

- **Acetic acid** is utilized minimally in the liver, and is oxidized throughout most of the body to generate ATP. Another important use of acetate is as the major source of acetyl CoA for synthesis of lipids.
- **Proprionic acid** is almost completely removed from portal blood by the liver. Within the liver, proprionate serves as a major substrate for gluconeogenesis, which is absolutely critical to the ruminant because almost no glucose reaches the small intestine for absorption.
- **Butyric acid**, most of which comes out of the rumen as the ketone beta-hydroxybutyric acid, is oxidized in many tissues for energy production.

THE DIGESTION AND UTILIZATION OF PROTEIN AND CARBOHYDRATES ARE SHOWN BELOW:

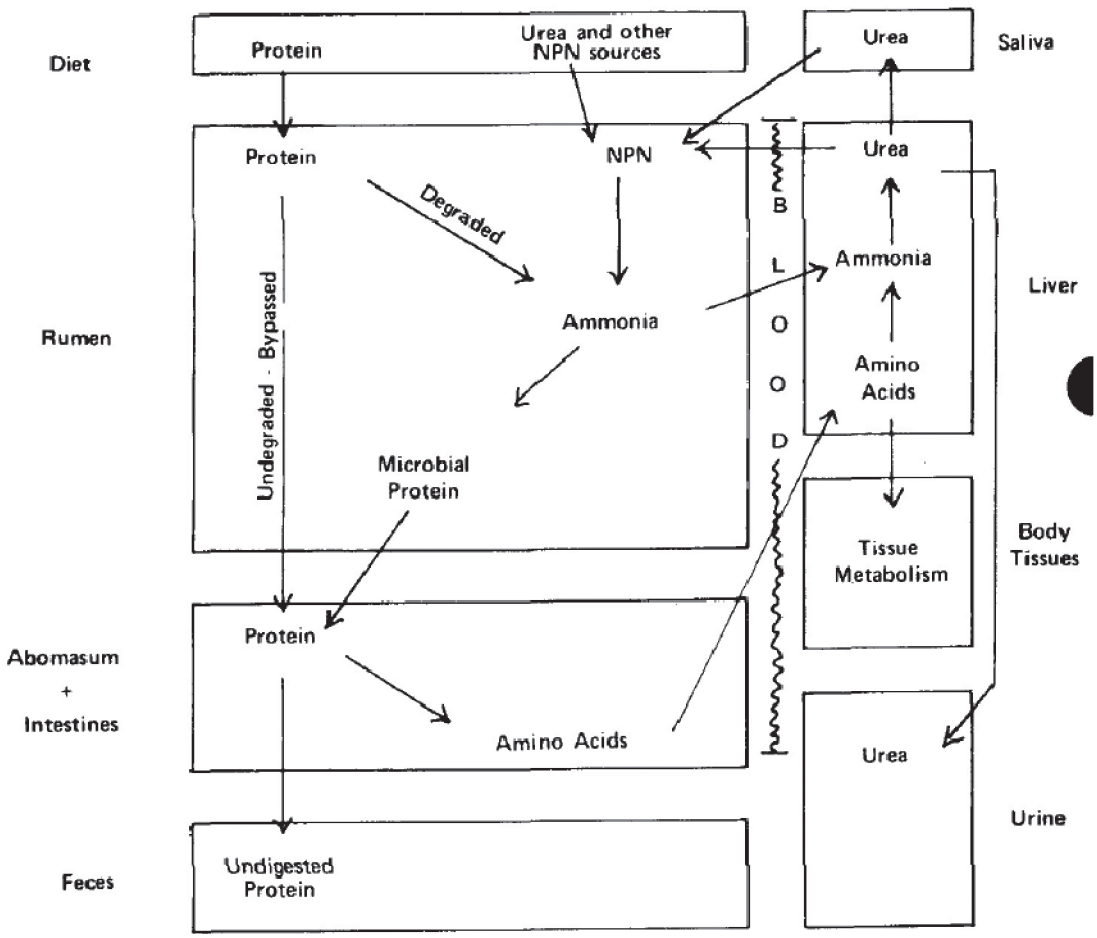


Fig.: Digestion and utilization of protein in cow.

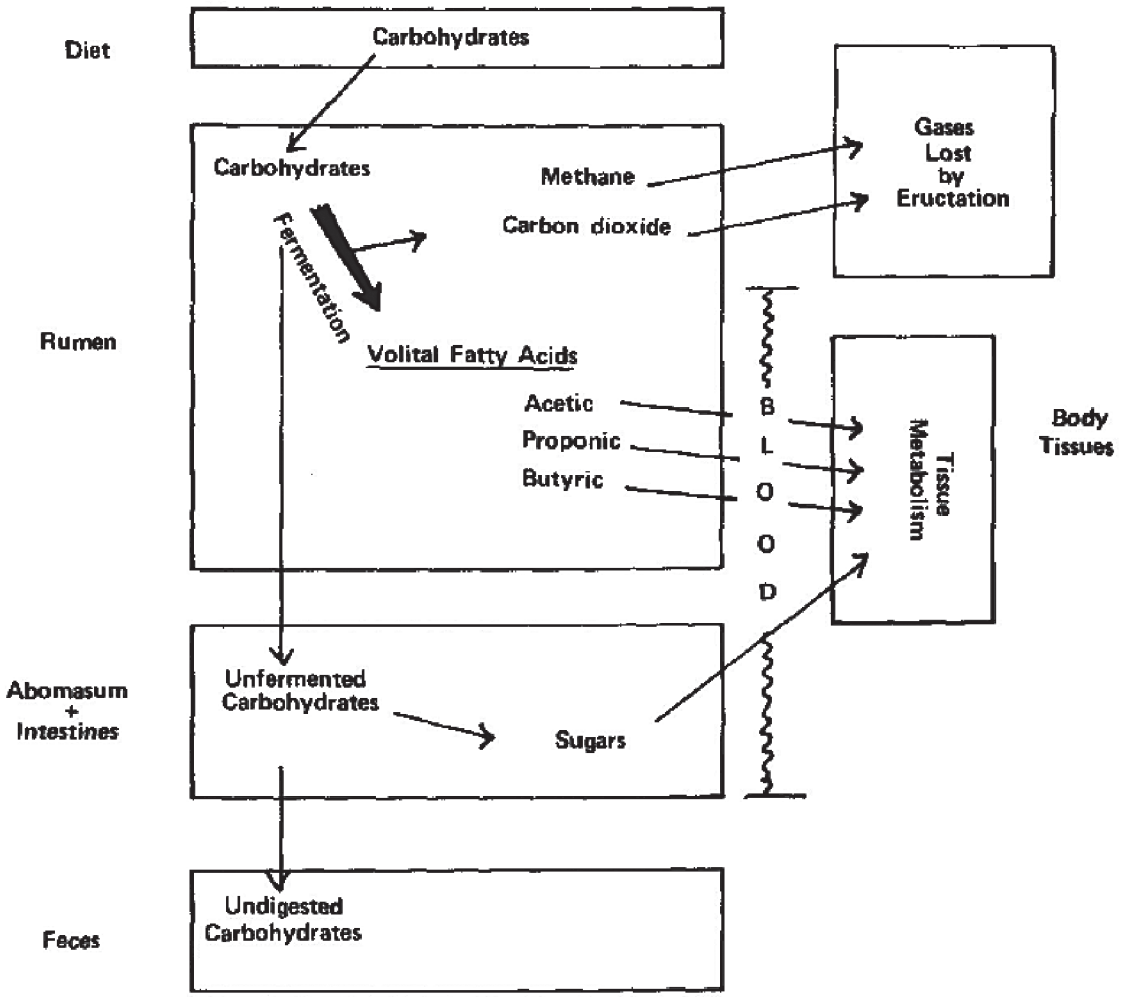


Fig.: Digestion and utilization of carbohydrates in cow.

Review Questions

1. Write the role of rumen in fibre digestion?
2. How protein is digested in ruminants?
3. Draw flow diagram of carbohydrate digestion in ruminants.

CHAPTER 3

Common Feeds and Fodders Used in Dairy Animals

Objectives

1. To classify the feedstuffs in to different categories.
2. To know the energy and protein contents in commonly available feedstuffs.

Introduction

Feeds are generally classified according to the amount of a specific nutrient they furnish in the ration. The first broad grouping of feedstuffs is based on the bulkiness which is dependent on the content of crude fibre (CF) content. They are divided into 2 general groups: roughages and concentrates. Roughages could be green or dry. Concentrates could be further divided into energy and protein sources which may be of plant or animal origin. Mineral and vitamin supplements, feed additives are the part of feed formulation.

Classification of feeds

Feeds are generally classified according to the amount of a specific nutrient they furnish in the ration. The first broad grouping of feedstuffs is based on the bulkiness which is dependent on the content of CF. They are divided into 2 general groups: roughages and concentrates. Roughages are bulky feeds containing relatively large amount of bulky material i.e., CF more than 18%.low in TDN on dry matter (DM) basis. Concentrates are the feeds which contain less fibre (<18%) and more than 60% TDN.

The roughages may be dry or green/succulent. Dry roughages contain10-15% moisture while green roughages may contain 60-90% moisture. Dry roughages include straws (rice straw, wheat straw, hay etc.). Green roughages include cultivated fodders: 1.Leguminous- (berseem, lucerne, cowpea etc.) 2. Non-leguminous- (maize, jowar, bajra, oat, perennial grasses : napier hybrid, anjan grass, para grass, guinea grass etc.). Other examples of green roughages are- tuber crops (e.g. turnip, sugarbeet), vegetable/fruit wastes, tree leaves (subaool, ber, kachnar, babool etc.), silage etc.

The roughages could also be grouped on the basis of their capacity to supply nutrients as given in the Table 3.1.

Table 3.1

Digestible crude protein (DCP) level	Category
<3%	Non-maintenance type. e.g. rice straw, wheat straw
3-5%	Maintenance type. e.g. green maize, oat
>5%	Productive type. e.g. berseem, Lucerne, cowpea

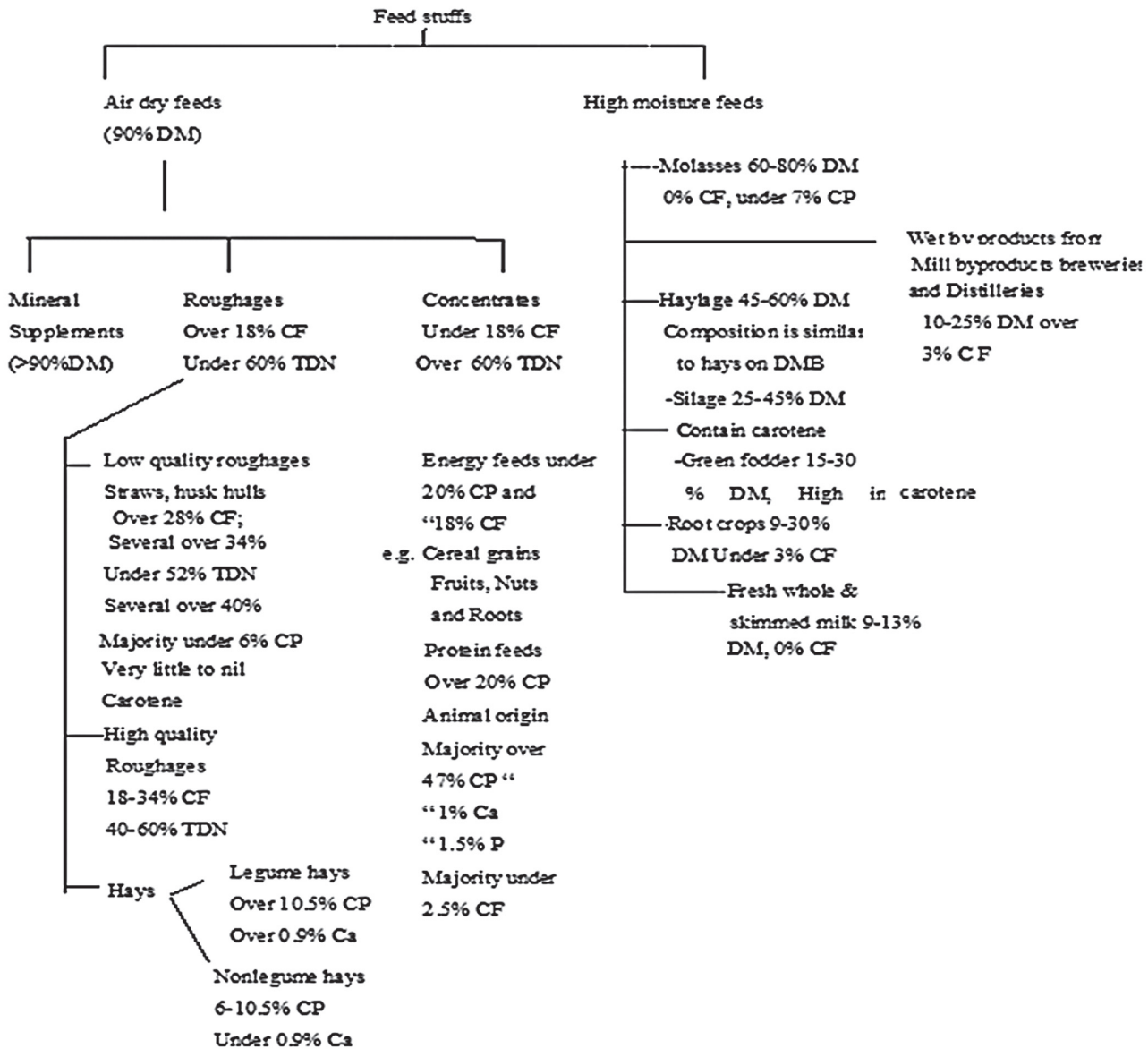


Fig. 3.1: Flow diagram of classification of feedstuffs

Table 3.2. Botanical names of various feedstuffs

Common name	Botanical name
A. Cultivated green fodders	
1. Leguminous	
Berseem	*Trifolium alexandrinum*
Lucerne	*Madicago sativa*
Cowpea	*Vigna sinensis*
2. Non-leguminous	
a) Annual	
Maize	*Zea mays*
Sorghum	*Sorghum bicolor*
Bajra/pearl millet	*Hordeum vulgare*
Oats	*Avena sativa*
b) Perennial	
Hybrid napier	Pennisetum purpureum x P. americanum/typhoides
Guinea grass	*Panicum maximum*
Rye grass	*Lolium perenne*
Para grass	*Brachiaria mutica*
Anjan grass	*Cenchrus ciliaris*
3. Non-leguminous non graminaceous	
Chinese cabbage	*Brassica pekinensis*
B. Tree.shrub	
Subabool	*Leucaena leucocephala*
Ber	*Zizyphus jujuba or Zizyphus mauritiana*
C. Dry fodder	
Rice/paddy straw	*Oryza sativa*
Wheat straw	*Triticum aestivum*

The concentrate feeds are broadly divided into 2 categories. A. Energy rich- these are high in energy and low in fibre (<18% CF) and usually contain <20% CP. Examples are- grains (maize, wheat, oat, barley, bajra), grain byproducts (wheat bran, rice bran, rice polish), dried tubers (tapioca, sweet potato, potato), molasses etc.

B. Protein rich- products either of plant origin (ground nut cake, cotton seed cake, mustard cake, soybean cake, til cake) or animal origin (fish meal, meat meal) containing >20% CP.

Feed supplements and additives

The BIS has given the composition of mineral mixture for cattle and poultry. Mineral supplementation is necessary for better milk production, reproduction and health. Likewise vitamin supplements are necessary under certain situations. Feed additives are also used for improvement in health and production of dairy animals. These are antibiotics, probiotics, prebiotics, enzyme preparations, anabolics etc. These are to be given in the diet in very minute amounts.

Non-conventional feed resources (NCFR): The use of NCFR is very important in augmentation of feed resource base as India is facing feed deficit. Some of the unconventional feeds used in India include vegetable protein sources (guar cake, niger cake, karanja cake, neem cake rubber seed cake, cassia tora seeds etc.), animal protein sources (hatchery waste, liver residue waste, dried poultry manure, crab meal, hydrolysed poultry feather etc.), energy sources (sal seed meal, cassava roots, tapioca starch waste, tamarind seed powder, oak kernel, mango seed kernel etc) and other miscellaneous feeds (babul poda, sea weed meal, jack fruit waste, sugar cane bagasse, sugar beet pulp).

Table 3.3. Protein and energy contents of commonly used feeds and fodders

FEED	CP (%)	TDN (%)
A. Roughages		
1. Green		
Berseem	18	62
Lucerne	18	60
Cowpea	20	62
Maize	9	60
Sorghum	7	55
Bajra	8	58
Oat	10	62
2. Dry		
Wheat straw	3	40
Paddy straw	4	45
B. Concentrate		
1.Energy sources		
Maize grain	11	84

Wheat grain	10	75
Broken rice	9	75
Sorghum grain	9	80
Bajra	11	75
Barley	10	70
Wheat bran	15	65
Rice bran (deoiled)	12	65
2. Protein sources		
Ground nut cake	45	78
Mustard cake	35	80
Soybean cake	50	65
Cotton seed cake	38	76

Review Questions

1. Differentiate between roughages and concentrates. Give examples.
2. Enumerate green and dry roughages.
3. What ore non conventional feed resources?
4. Write down CP and TDN values of green fodders (maize, sorghum, berseem and cowpea) and dry fodders (wheat straw and paddy straw).

CHAPTER-4

Packages of Practices for Production of Different Fodders

Objectives

1. To study the package of practices (sowing time, land preparation, fertilization, irrigation etc.) of common fodder crops.
2. To acquaint with agroforestry system to augment feed resource base.

Introduction

Growing forage crops has several advantages. Forage crops build up fertility of the soil, reclaim alkali soils and increase animal production greatly. Forage production enhances efficiency of crop production, soil and water conservation and proper utilization of land. Growth, reproduction and production are adversely affected when cattle or other ruminants are reared either without green or with poor quality forage even though they may be provided with quality concentrates. Green forages have cooling effect on the body as they are easily digestible, palatable, slightly laxative in action and provide nutrients in most natural form resulting in efficient utilization of the feed. A vast majority of our ruminant livestock thrive mainly on crop residues and naturally growing vegetation. For better growth and production, however, they should be supplemented with cultivated fodders and/or concentrate feeds. However, availability of concentrate feeds is quite low because of low production and high demand for the burgeoning human population. Therefore, the animals compete with the human beings for food items. For more efficient animal production, availability of green fodders round the year is very important. Feeding of good quality green forages can support an animal yielding 10 litres of milk per day.

Commonly grown annual fodder crops: package of practices

A. Graminaceous crops

1. Maize

Botanical name : Zea mays, Linn.; Family: Poaceae

Maize is also called corn in English and makka/makki in Hindi. Maize is almost an ideal

cereal forage crop because of its quick growing, high yielding, palatability and nutritious qualities. It is one of the most important cereal crops of the world both as food and feed. It can be safely fed at any stage of growth. The crop can be grown round the year with almost uniform yield and herbage quality. Maize is a tall annual, 1.5 to 6 cm high. Leaf blades are 30-150 x 5-15 cm. Maize is a cross pollinated plant. The male inflorescence (tassel) is a terminal panicle with the female inflorescence (cob) borne on the leaf axil is an ear. The central axis of the ear (30-40 cm long) called cob is thickened modified stem which bears paired spikelets in longitudinal rows. Grains/kernels are borne in an even number of rows along the length of the cob.

Varieties: Vijay composite, African tall, J-1006, Ganga-5.

Sowing and seed rate: Maize prefers fertile well drained alluvial soil. The normal spacing for forage maize is 25-30 cm between rows and 10-15 cm between plants with in the row. The seed rate varies from 40-60 kg/ha. Fodder maize can be grown in mixture with rice bean and cowpea. To check weeds, 2-3 intercultural operations are required up to 30-40 days of growth. The most suitable temperature for germination is 21°C and for growth 32°C.

Fertilization: At sowing time FYM/compost is required @ 10 t/ha. NPK should be given at 90:30:30 kg/ha. Two third of N and full P and K are given at basal dose. Remaining 1/3 N should be given 30 days after sowing. Provision of drainage is must during rainy season.

Irrigation: 4-5 irrigations are required during winter at 10-15 days interval, otherwise it can be raised as rainfed crop.

Harvesting and forage yield: Maize can be harvested at 50-80 days after sowing. As a green fodder, harvesting can be started at tasselling and continues up to wax-ripe stage. After tasselling, CP content goes down. For silage making harvesting should be done at soft dough stage. Green fodder yield could be 300-500 q/ha depending on season and variety. The yield is higher during rainy season. Intercropping with cowpea increases the nutrient yield and also provides fodder of balanced nutrients. After removal of cobs, stovers can be fed to the animals. After harvesting of cobs, partly green stovers can also be used for making silage.

2. Sorghum/jowar

Botanical name: Sorghum bicolor (Linn.) Moench.; Family: Poaceae

The forage sorghum is characterized by quick growth, high yield and dry matter content, leafiness, wider adaptability and as material for excellent silage. It can withstand heat and drought better than maize. Sorghum has adapted to wide range of soils except very

sandy ones. It tolerates poor soils and can withstand moderate salinity. A temperature of 25-30°C is required for its best development.

The plant is 5-6 m tall. The leaves are 30-100 cm long and up to 12 cm wide and normally waxy. It is a cross pollinated crop. The inflorescence is a terminal panicle, 8-50 cm long spikelets are borne in pairs. The grain is rounded, pointed and 4-8 mm in diameter.

Varieties: PC-9, PC-6 (single cut), MP Chari (multicut)

Sowing and seed rate: As a rainfed crop sorghum is usually sown from May-August. It is sown by 'Kera' method i.e., by dropping seeds by hand in a furrow. A spacing of 25-30 cm between rows and 10-15 cm between plants with in row is desirable. Seed rate varies from 40-50 kg/ha. Usually seeds are road broadcasted. As fodder, it can be conveniently grown in staggered sowings in different months for cutting and feeding as green fodder. Sorghum is usually sown as a single crop but intercropping with cowpea can also be followed. Sorghum (25 kg/ha) and cowpea (20 kg/ha) may be sown either in crosswise lines or two lines of sorghum alternated with 2 lines of cowpea. The mixture will reduce the DM yield, however, CP content and yield per ha will be higher.

Fertilization: For rainfed crop, FYM is applied at the time of @ 10t/ha. For single cut types, total requirement of nitrogen and phosphorus is 90 and 30 kg/ha. Two third of N and full P is applied as basal dose while 1/3 N is applied 30 days after saving.

Irrigation: Fodder sorghum is often grown as a rainfed crop. However, with irrigation the crop can be grown at any time of the year except winter. During hot dry months, irrigation is given fortnightly. Water stagnation should be prevented in rainy season.

Harvesting and forage yield: The crop should preferably be harvested after flowering but never before 40-50 days from the date of sowing. This is because in the early stages, the fodder contains cyanogenic glycoside called '*dhurrin*' which is toxic to the animals. In water deficit conditions there are more chances of accumulation of *dhurrin* in the plants. On enzymatic hydrolysis, *dhurrin* yields aglycon (methylglucosinolates) which dissociates to hydrogen cyanide and aldehyde in the rumen. Such compounds are toxic and affect the palatability of the fodder. The optimum time for harvesting is, therefore, at or up to 50% flowering with a yield of 300-500 q/ha. Beyond this stage, CP content and digestibility of nutrients declines rapidly but CF content increases. The Ca and P content also decreases. Here, 2 cuts could be obtained with a forage yield of 500-600 q/ha. For silage making, sorghum is harvested at milk or soft dough stage. It can be ensiled along with leguminous crops like cowpea in order to increase CP content. In multicut type (MP chari), first harvest is taken after 2 months and subsequent cuts at 30-40 days intervals. The yield ranged from 550-800 q/ha.

3. Bajra/pearl millet

Botanical name: Pennisetum americanum (Linn.) K. Schum. Family: Gramineae

It is a quick growing short duration crop. Plants are erect and 1.8-2.4 m tall. Leaves are long (90-120 cm) and broad (2.5-5 cm) with thick midribs and the margins are serrated. The stem is solid about 2.5 cm thick. The inflorescence is a cylindrical spike densely packed with spikelets. Panicle is spike like and very dense (10-90 cm long). It grows well on light loam and sandy soils.

Cultivars: Avika Bajra Chari, Rajasthan Bajra Chari-2 (RBC-2)

Sowing and seed rate: The seeds are dribbled using a spacing of 30-40 cm between the lines. The seed rate is 8-12 kg/ha. It can be combined with legumes like cowpea, guar etc.

Fertilization: In addition to FYM @ 10-15 t/ha at the time of land preparation, 30 kg N and 20 kg P_2O_5 may be applied as basal dose.

Irrigation: Two or three irrigations are usually sufficient. In the hot season, however, more irrigations may be required. Standing water is harmful, hence avoid waterlogging. It is advisable to give frequent but light irrigation.

Harvesting and fodder yield: The crop is harvested at boot stage or 50% flowering stage (60-70 days). A fresh yield of 250-325 q/ha could be obtained. Two cuts can also be obtained with better yield. Silage can be prepared from bajra fodder. As it contains oxalates, therefore, supplementation with Ca (leguminous fodders, GN cake, dicalcium phosphate) is advocated.

4. Oats/Jai

Botanical name: Avena sativa Linn Family: Poaceae

The green forage is well relished by all ruminants and rabbits as well. It can be fed as green forage, silage or hay. It is a *rabi* crop. It requires cold climate and assured irrigation for its good growth. Along with maize, oat can prove to be good fodder resource during winter because the cultivated perennial grasses normally undergo dormancy mainly due to low temperature and moisture scarcity. It can be cultivated as sole or mixed crop with Chinese cabbage.

It is a sub-erect annual growing to height of 1.0-1.5 m producing 5-8 tillers with drooping leaves. Inflorescence is loose and much branched panicle. The spikelets occur at the end of branches. Each spikelet consists of 2 or more flowers.

Varieties: OL-9, Kent, OS-6, OS-108

Sowing and seed rate: It can be sown during Oct.-Nov. For small seeded varieties, a seed rate of 75-80 kg/ha is to be followed while for bold seeded variety like Kent 80-100 kg seed/ha is needed. The spacing between lines may be 25-30 cm. Line sowing is better in order to facilitate weeding. The land must be prepared thoroughly for a fine and firm seed bed.

Fertilization: N-90 kg/ha; P_2O_5-30 kg/ha for single cut (60 kg N as basal and 30 kg N for top dressing). If two cuts are desired, then apply 80 kg N and 40 kg /ha as basal dose and the rest of 40 kg N after the first cut.

Irrigation: 4-6 irrigations at 10-12 days intervals.

Harvesting and forage yield: For single cut, the crop should be harvested at 50% bloom stage. For two cuts, the first should be taken 50 days after sowing followed by second at 50 per cent flowering. In case of single cut, the yield of fresh forage has been recorded to be 300-375q/ha and for two cuts, 250-425 q/ha. It can meet the maintenance requirement of the ruminant when harvested at right time. Oat plants have the tendency to accumulate nitrate particularly under the conditions of heavy nitrogen fertilization, low temperature, cloudy weather and water scarcity. The nitrate is toxic to the ruminants after its conversion to nitrite in the rumen and thus causing asphyxiation. The fodder is highly nutritious and palatable.

B. Leguminous crops

1. Berseem/Egyptian clover

Botanical name: Trifolium alexandrinum Linn. Family : Leguminaceae

It is succulent, nutritious, palatable and multicut crop. This fodder is more popular in north India. Longer duration of cool temperature promotes the growth and yield. It has been described as king of the fodders. Apart from being nutritious, the crop has a remarkable capacity to build up soil fertility.

It is an annual low shrubby plant growing 60-90 cm high. The main succulent stem gives off branches terminating in 2-3 leaves. Stems are succulent and hollow. Leaflets are small, oblong, bright, slightly hairy at the upper surface and rounded at extremities. Flower heads are rounded and white. Seeds are yellow to brown.

Varieties: Mescavi, Pusa Giant, BL -1, BL -2, IGFRI-S-54, IGFRI-S-99-1, Jawahar-1.

Sowing and seed rate: A good crop is raised on land which has been properly prepared, leveled and free from weeds. It can grow on all types of soils except very sandy but thrives best on well drained medium loam/clay loam. It requires well drained conditions. Sowing is done from mid October to mid November. The seed is soaked overnight in water and

broadcasted @ 25-30 kg/ha. Rhizobial (*Rhizobium trifoli*) inoculation of seeds is required where berseem was not grown previously. It is often convenient to mix an equal quantity of fine soil with seed to increase the bulk and ensure uniform sowing. Berseem responds well to P application. The seeds are broadcasted in irrigated field.

Manuring: Apply 15-20 tonnes FYM/compost at the time of land preparation preferably 2-3 weeks before sowing. Also apply 25 kg N and 75 kg P_2O_5/ha.

Irrigation: The crop should be irrigated frequently. It requires irrigation after 10-15 days intervals after sowing. 12-15 irrigations are needed.

Harvesting and forage yield: The crop is ready 50-60 days after sowing for first cut. Subsequent cuts are taken after 30-35 days intervals. Watering should be given 10 days before a cutting so that growth can restart immediately after cut without any irrigation. The plant should be cut when about 25-30 cm high. Cutting is done 5-6 cm above the ground. Four to six cuttings could be obtained. The fresh herbage yield is 500-1000 q/ha. It should be fed along with dry roughages like straws. Usual precautions against bloat should be taken.

2. Lobia/cowpea

Botanical name: Vigna unguiculata, (Linn.) Walp. Family: Leguminaceae

Cowpea is the most important or cultivated leguminous fodder crop in Tripura and has the ability to grow under not-so-severe winter condition of this State. However, the growth is quick during summer and rainy seasons. It can be grown on a wide range of soils from sandy to well drained clay. Proper drainage is required. The leguminous organic residues left after the harvest of the crop enrich the soil fertility. It is adapted to a wide range of soils and performs better at 5-6.5.

Cowpea is an annual bushy, trailing in climbing herb. Stems are 1-3 m long, glabrous but slightly hairy. Inflorescences are axillary on stalks (15-30 cm long). Pods are linear and cylindrical, 10-20 cm long. Leaves are trifoliate. Flowers are usually greenish or yellow.

Varieties: Bundela Lobia-1, Bundela Lobia-2, C-152

Sowing and seed rate: When raised as sole crop, the row to row distance of 30-40 cm and plant to plant distance of 10-15 cm is desirable. A seed rate of 35-40 kg/ha may be followed. Cowpea can be raised along with cereal fodder crops like maize on sorghum or other grasses like napier hybrid. The seed rate is halved (20 kg/ha) when raised with other cereal fodder crops. For better establishment of the crop, 2-3 intercultural operations should be carried out in the initial stages of growth.

Manuring: FYM/ compost is applied @10 t/ha at the time of land preparation. A basal dose of N-20 kg and P_2O_5-40 kg/ha is applied.

Irrigation: Fodder cowpea can be grown at any time of the year provided that irrigation facilities are available. 3-4 irrigations are required during winter otherwise raised as rainfed crop.

Harvesting and fodder yield: It can be harvested at 60-75 days after sowing. Green fodder yield was recorded to be 250-350 q/ha. Fodder cowpea is mainly used for green feeding, however, it can be used for making hay or silage in combination with other cereal fodder crops.

C. Non graminaceous-non leguminous

1. Chinese cabbage

Botanical name: Brassica pekinensis (Laur.) Rupr. Family: Crucifereae

It thrives best under cool and moist climate and is a *rabi* crop. It serves as a fast growing catch crop.

Sowing and seed rate: It is sown from mid October to mid December for better results. The seeds are sown at 1.5-2.0 cm depth in lines spaced at 25-30 cm. The seed rate is 6-8 kg/ha.

Manuring: N-40; P_20_5-40; K_2O-40 kg/ha which could be met using 7.5-10 t FYM/ha.

Irrigation: 4-5 irrigations are required at 10-12 days intervals.

Harvesting and forage yield: The crop can be harvested at 50% flowering stage (50-60 days after sowing). A fresh yield of 200-350 q/ha could be obtained. Herbage yield is increased when grown with oat.

The fodder should not be fed in large quantities for prolonged period. Hungry animals should not be fed this as sole feed particularly on dewy mornings. Otherwise, it may produce symptoms of respiratory, nervous, digestive and urinary disorders or photosensitization to the animals. It should be fed with other grasses or leguminous fodders. As it taints and produces a pungent smell in milk, it should be fed only after milking. Glucosinolates present in the fodder gives a pungent smell and may also hyperthyroidism interfering with iodine utilization.

Agro-forestry including silvipastoral system for augmentation of feed resource base

India has achieved self sufficiency in food production. Now attention is being focused more on the problems of acute shortage of fodder, fuel and other products. Therefore, agro-forestry has vast scope in meeting these requirements. The role of fodder trees and shrubs in providing highly nutritious green fodder is of great significance to livestock

production especially during lean period when grasses are not available or are of very low nutritional value. Therefore, silivipastoral type of agroforestry system is superior in terms of forage production, forage quality and period of forage availability and minimizes the seasonal variation in nutrient availability. Agro-forestry is a blend of forestry and agriculture ecosystems. It is basically a land use system serving two major functions i.e., production and service roles. For production roles, agroforestry is famous for '5F' viz., production of food, fuel, fruits, fodder and fertilizer from the system while for service roles natural resource management is the major one. Out of the total geographical area of the country, 97 million ha is under rainfed agriculture and 200 million ha under degraded lands. Agro-forestry has the ability to conserve soil and moisture and thus prevents land from further degradation.

There are 3 basic components of agroforestry

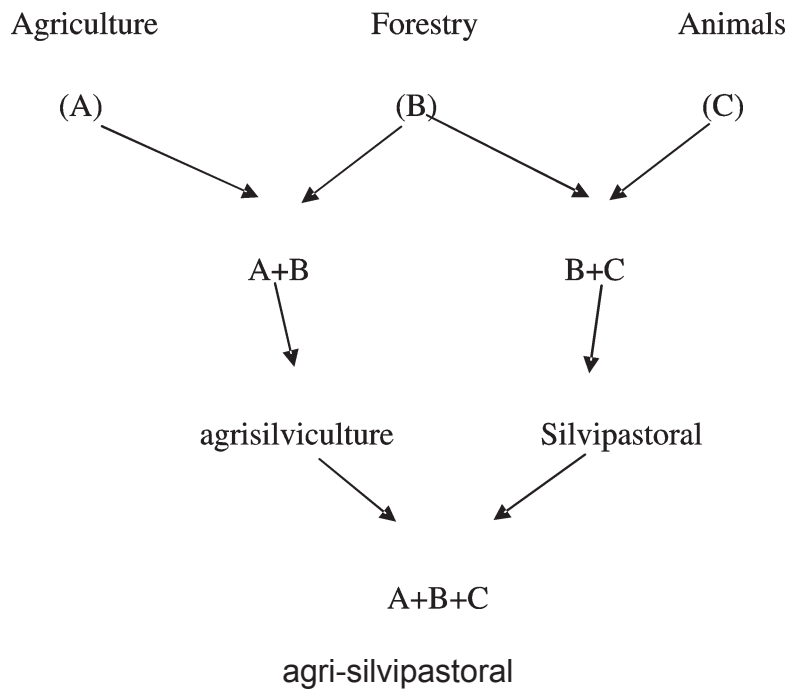


Fig. 4.1. Basic components of a agroforestry

The other systems are: horti siliviculture system, agri horticulture system, agri horti siliviculture system and multipurpose tree production. The most ideal agro-forestry systems should comprise productivity, sustainability and adaptability.

Agro-forestry can be adopted on agricultural lands (field boundaries, bunds, alongwith farm roads, old fallow lands, site of pump houses, cattle shed), marginal and submarginal wastelands, lands not presently available for cultivation of arable crops etc. The key features of agro-forestry system are:

- Utilization of cultivable wasteland, farmland, use of crop rotation etc. and planting of nitrogen fixing trees to reduce the need for purchasing fertilizer.
- Production of resources to fulfil local as well as national needs by suitable adoption of silivi pastoral, agri silvi pastoral and multi cropping systems.
- Provision of animal feeds / fodders on sustainable basis.
- Suppression of weed growth.
- Recycling of available resources.

Economic rehabilitation of poor farmers by creating perpetual income opportunities through quick and sustained returns from agricultural crops, fruits and vegetables.

Review Questions

1. What are the commonly cultivated forage crops?
2. What is the proper stage of harvesting of forages?
3. Write the forage yield of the crops.
4. What is agroforestry?
5. Explain silvipastoral system of agroforestry.

CHAPTER-5

Feed Processing and Fodder Conservation -

Importance of processing of feed, compounding of feed - milling, grinding, mixing, pelleting etc.; conservation of fodder - hay, silage, straw, methods of making hay and silage.

Objectives

1. To acquaint with the advantages of feed processing.
2. To prepare compound feeds involving the processes of grinding, mixing, pelleting etc.
3. To conserve green fodders in form of hay and silage.
4. To improve the nutritive values of straws with urea treatment.

Introduction

Processing of feeds has several advantages from animal production point of view. For making compound feed, grinding of different feed ingredients is the first step. Then, the ingredients are mixed in fixed proportions for different categories of animals. The mixed ingredients can be converted into pellets. Green fodders should be conserved in form of hay and silage for use during the scarcity periods. The nutritive value of poor quality roughages like straws can be improved by urea/ammonia treatment.

Importance of processing of feeds

1. To alter particle size: Some feeds need to be reduced in size to increase their intake or digestibility e.g. grinding. In some instances, particle size is increased by pelleting or curbing to overcome dust problem, to prevent selectivity and to improve handling efficiency.
2. To change moisture content: The moisture content of a feedstuff may need to be changed to make it safer to store (reduced to 10% level), more palatable, more digestible, or to prepare it for other processes (moisture level is increased).
3. To change density of feed: Bulky feeds (low density feeds) reduce feed intake. These are sometimes prepared for the purpose of limiting energy intake. These are prefered in feeding of horses because they causes digestive disturbances. Grains are flaked

rather than ground or pelleted. Very bulky feeds are pelleted or cubed to increase energy density and feed consumption. Transportation cost is reduced and storage space required is less.

4. To change palatability: Feeds are processed to increased acceptability and feed intake. Molasses, flavours and fats are added. Processing may be used to decreased palatability and limit feed consumption e.g. Salt-feed mixtures.

5. To increase nutrient content: When used alone and in their natural state, few feedstuffs meets the requirement of the animals.

6. To increase nutrient availability: Starch (70-80% of DM) and protein appear to be less available in jowar than in other grains but new processing techniques produced dramatic improvements in the feeding values of jowar. This is attributed to a gelatinization of the starch granules, rendering them more digestible. Pelleting of feeds increases the utilization of phosphorous for chicken and pigs.

7. To detoxify or remove undesirable ingredients. Considerable control of gossypol (the yellow pigment of cotton seed that is toxic to simple-stomached animals) is possible by heating. Addition of iron salts rupture pigments glands and thus protect against egg discoloration. Heating soybeans destroys, trypsin and chymotrypsin. Toxicity of linseed meal can be removed by adding two or three parts of water to the meal and allowing it to stand for 12 to 18 hours at a temperature between 22 to 37°C.

8. To improve keeping qualities: High moisture grains may be preserved by either drying or chemical treatment (adding an organic acid), or they may be stored in oxygen limiting silos. Similarly, green fodders are also conserved as silage.

9. To lesson moulds, salmonella and other harmful substances: Sometimes feeds are subjected to a certain process to ensure safety and avoid contamination, especially from moulds and salmonella. Proper harvesting, drying and storage are important factors in lessening aflatoxin contamination and toxin production. Propionic and acetic acids will inhibit moulds growth. Hence, they are used increasingly in the preservation of high- moisture grains. Treatment with ammonia or ammonium hydroxide will detoxify feeds.

10. To make more profit: Feed efficiency can be routinely improved as much as 10% and occasionally by as much as 15 to 20% by changing the method of grain processing.

Compounding of feeds

The compounding of animal feed includes processing of raw materials of wide ranging physical, chemical and nutritional characteristics into a homogenous mixture suitable to

obtain a desired nutritional response from the animals. Certain feed ingredients such as cereals, oil seed cakes, soybean meal, meat meal, blood meal, fish meal undergo processing prior to their inclusion into a compounded feed.

Once the raw material is purchased, it is stored in the godowns on wooden planks placed away from the walls. The ingredients could also be stored in concrete or steel silos or in bins. The proper storage of raw materials is not only essential to prevent physical losses but it is also an important aspect of quality control. The feed compounding process consists of a) grinding of ingredients; b) mixing of ground materials, c) further processing, if needed, d) packaging.

Grinding

It is a particle size reduction process which is the simplest and least expensive method for preparing feeds for livestock feeding. It is a prerequisite for mixing, pelleting etc. and it varies from fine to coarse. It is usually accompanied by hammer mill which reduces the particle size by means of impact grinding. Medium fine grinding is the best. Very fine grinding makes feeds dusty with lowered palatability resulting in poor animal performance.

Advantages of grinding

- Increases the particle numbers and thereby increases the surface area for better action of digestive enzymes in the rumen with enhanced digestibility and animal performance.
- Grinding results in better mixing of feed ingredients facilitating in better extrusion and pelleting.
- Segregation of particles is avoided.
- Selective feeding by livestock will be minimized and hence wastage in feeding.
- Increase is palatability of feed & diagobility of fobre. Energy loss due to mastication will be decreased. Feed passage time will be decreased. Feed consumption will be increased. But decreased feed passage time reduces the digestibility of fibre in ruminants since residence time in the rumen is less.

Mixing

Small quantities of animal feed can be adequately mixed manually using shovels. The ground raw materials should be layered one above one another, and then mixed and turned to form one heap. Mixing of the heap at least 3 to 4 times may produce an acceptable product. Micro-ingredients such as vitamins, minerals, antibiotics, etc. are first mixed with diluents e.g. wheat bran and then it is added to ensure uniform mixing.

For mixing of large quantities of feeds, mechanical mixers such as vertical mixers, horizontal mixers are used for uniform mixing. The most important operation in a feed mill is mixing and this is the single operation that would be required in a plant to define it as a feed mill. The aim of mixing is to disperse the ingredients of a certain formula so that each small unit of the whole has the same proportion of each ingredient as in the original formula.

The addition of various liquids to feeds include molasses, vegetable and animal fats, fish solubles, phosphoric acid, choline chloride, etc. These are added to enhance palatability (e.g. molasses), energy (fats) and other nutrient content of the rations. However, addition of any liquid can complicate feed mixing operations. Special equipment for preheating and spraying of liquid are needed to avoid the agglomerate formation. Agglomerate formation can result in suboptimum microingredient distribution.

Liquids are preheated to reduce their viscosity. Molasses is preheated to 95 to l00°F while fat to 140 to 210°F. When liquids are added to the mixer, they should be sprayed over the entire length of the mixer. Before doing so, allow the dry feed ingredients to mix for short time. This allows the microingredients to be dispersed throughout the moisture. The maximum amount of the molasses that can be successfully employed to the feeds is governed by the viscosity of molasses and by the absorptive quality of ingredients.

Microingredient premixing

Premixes are formulations of one or more microingredients, such as vitamins, minerals, or drugs mixed with diluent and/ or carrier ingredient. Diluent and carrier should be inert and inactive. Premixes are used to facilitate uniform mixing of the microingredients in the complete feed or concentrate mixture.

Diluent is an edible substance used to mix with and reduce the concentration of nutrients and/or additives to make them more acceptable to animals, safer to use and more capable of being mixed uniformly in feed. The mixing properties of the original ingredients are not drasticaily altered. Carrier is an edible material to which ingredients are added to facilitate uniform incorporation of the latter into feeds. The active principles are absorbed, impregnated or coated into the edible material in such a way as to physically carry the active ingredient. When a carrier is used with a microingredient, the mixing properties are drastically altered.

Microingredients are nutritional adducts or drugs that are added to the feed at very low levels. Dispersion of such low concentrations of active ingredients presents a challenge to the manufacturers of the compound feed. This challenge can be met by the premix-the dilution of an active component with a suitable carrier.

Physical characteristics of microingredients such as particle size, particle shape, specific weight, hygroscopicity, susceptibility to electrostatic charges, adhesiveness of the particles

due to physical properties, such as rough surfaces or additions of adhesives such as oils influence mixing them with the other feed ingredients. Microingredients have a very small particle size and high density compared to other feed ingredients. A significant uptake of moisture by a microingredient can seriously hamper its ability to distribute and mix well. A hygroscopic ingredient can affect the chemical stability of any moisture sensitive component. This problem may be dealt with during formulations by complexation or through a coating that acts as a moisture barrier.

Types of mixers

1. **Vertical batch mixer:** They may be single screw or double screw for elevating the material. However, single screw mixer is popular. These are relatively less expensive and little slower than horizontal mixers. These are not normally used in larger feed mills. It consists of a vertical bin tapering to a point at the bottom. A tube containing a vertical screw conveyor elevates and mixes the material as the mixer is filled. The screw conveyor continuously elevates the product and distributes it over the top of the mixer. Repeated elevation of· the product produces blending. Some mixers use two screw conveyors and few use other elevating devices. Normally screw is driven from the top but it can be driven from the bottom. These units range in capacity from 0.5 to 5 tonnes.

2. **Horizontal mixer:** This mixer is the most commonly used in larger feed mills. This mixer has right and left hand augers which conveys the material from one end of the mixer to the other while it is tumbled within the mixer. These mixers are equipped with openings at several places along the bottom to aid in more rapid discharge. The mixer shaft is accurately machined and mounted on bearings and is fitted with ribbons/paddles which thoroughly agitate and blend the ingredients to produce homogenous mix. The ribbon assembly /paddle is housed in a tub, the lower half of which is circular. Suitable speed reduction drive is provided to drive the mixer shaft at the designed speed to achieve proper mixing with or without liquid additives.

3. **Double paddle horizontal mixers:** These have curved paddle blades which scoop, lift and tumble materials as they are conveyed to the centre of the mixer, where they are continuously over lapped and cross blended. In addition to the cross blending action, a turbulent upward and downward movement is secured which provides the intense type of action required to blend solids and liquid additives including mOfasses blended with dry materials. These mixers have a side loading-cuminspection platform.

4. **Ribbon blenders:** The principle of these blenders is the same as paddle mixers except that they have double worm type ribbons. The large one continuously conveys the material forward and the small one conveys it backwards. Material to be mixed is conveyed from end to end, top to bottom or side to side in the mixer. This continuous

cross blending action tends to thoroughly mix the composition. The mixer is more suitable for blending powdery material of uniform fineness. In order to empty the mixer more rapidly than the product can be conveyed away with most elevators, a surge bin is usually provided. The mixed feed is dumped into the surge bin and another load can be mixed while the surge bin is emptying.

Factors affecting mixing of ingredients

These include physical properties of solids (particle size, shape, density, coefficient of friction, resilience and electrostatic charge) and liquids (density and viscosity). Particle segregation, during or after mixing has been attributed to differences in physical properties of materials and the design of the mixer. A decrease in particle size is necessary to attain a sufficient number of particles for dispersion into each portion of feed. Where very small amount of microingredients are added, the required particle size is very small. The electrostatic properties, roughness of the mixer and cohesiveness are important factors that cause segregation when very small particles are mixed. Mixing time to achieve good distribution increase with very small particles. The rate of mixing is dependent on the properties of the materials being mixed as well as type of equipment used. Differences in the performance of mixing equipment are reduced when the materials have nearly the same particle size and density.

Pelleting

Pelleted feeds are agglomerated feeds formed by extruding individual ingredients or mixtures by compacting and forcing through die openings by any mechanical process. The purpose of pelleting is to change the raw materials in to higher palatable and easy to handle product by applying optimum amount of heat, moisture and pressure. The normal size of pellets is 3.9-19 mm, though the maximum used pellet diameter is 6.25-9.4 mm. The shape is normally cylindrical. If smaller pellets are required, it is economical to produce 3.9 mm pellets and reduce them to desired particle size by crumbling.

Advantages

- Improves the feeding value of different feeds especially with roughages as compared to concentrates
- Increases the density of feeds and reduce the storage space required.
- Segregation of feed ingredients and selective feeding is avoided and wastage of feed is minimized.
- Pelled feed is in a free flowing form and can be handled mechanically saving the labour cost.

- Gelatinization of starch occurs and heat labile antinutritional factors are destroyed.
- Increases the palatability, feed intake, Growth rate and milk production

Conservation of fodders

A. Hay making

It is the process of preservation of green fodder by drying process. Hay refers to grasses or legumes that are harvested, dried and stored at 85-90% DM. Fodder crop is harvested before maturity (50% flowering stage) when it is still green. The crop is spread over a place in rows and then put on hay racks for further drying under sun. The fodder has to turned around from time to time and should not be exposed to severe sunshine to avoid decarotinisation. Non-leguminous fodders like oats, jowar and Anjan grass and leguminous fodders like berseem and lucerne can be converted into hay. Maize and barley are not suitable for hay making. The non-leguminous crops should be harvested after flowering stage and when 50% florescence is there. For leguminous crops, the harvesting should be done just when the flowering starts.

Characteristics of a good hay

- Hay must keep the characteristic green colour of the crop.
- It should be soft and pliable.
- It should be prepared in such a way that there is less loss of leaves due to shattering and maximum amount of green colour is retained by the hay.
- The hay should be free from dust, mould and bad odour.
- The aroma of the finished product should be such that it is relished by the animals.
- It should not have more than 15% of moisture so that it can be safely stored without risk of fermentation and combustion.

Crops suitable for hay making

The fodder crops having soft and pliable stems are more suitable for hay making. Green oats is the best crop for hay making. However, green berseem, lucerne, cowpea, guar, natural grasses, etc. can also be used for hay making if proper care is taken in curing whereby shattering of leaves is avoided. Annual and perennial grasses like dub, anjan, etc. can also form good hay. Maize, sorghum, bajra, etc. are more suitable for silage making than for hay making. To prepare hay of thick stemmed crop, it is advantageous to crush the stem or chop the fodder itself, Early cut graminacious crops are most suitable

for making good quality hay which are very nutritious and sometimes may be compared with the crop for second cutting.

Fig. 5.1. Oat hay prepared at NDRI, Karnal

Method

The aim of hay making is to reduce the water content of the green crop to a level low enough so that the plant and bacterial enzymes do not act on the plant nutrients. The moisture content in the green crop is reduced to 20% and for bailing and storage, it should range between 15-20%. In no case more than 20% of moisture should be allowed in Indian conditions, otherwise, due to fermentation the hay gets very hot and nutrients are lost. Sometimes, there is spontaneous combustion. A practical method of determining the safe limit for hay storage is to twist a wisp of hay in the hands. If the stems are twisted and there is no indication of moisture, it can be stored.

In situations like India, there is, however, greater prospect of making good quality hay both in the sun as well as on the farm. During the kharif season (wet and hot), the crops may be harvested in the early September when the monsoons are at decline and during rabi (dry and cold) season the crop may be harvested during February-March for hay making.

For the efficient production of good quality hay, the crop should be harvested early in the morning when the dew has dried. However, some experiments have shown that there is no advantage in delaying the cutting grasses. After cutting, the grasses are left as such for few hours for the curing. After about 4 to 5 hours, if there is a good sunshine, the fodder may be turned upside down with the hay rack. If it is September and October by afternoon, the moisture may come down from 75 to 40%. In the evening, small loose heaps (windows) can be formed with the hay rack and fodder is left. On the next day one or two turnings are given and by afternoon the moisture level will come down to 25%. At this stage it can be baled and kept in baled form or if it is heavy rainfall area it can be stored on tripod stand. The tripod system of hay making has an advantage that if there is rain the water will pass down and there is proper aeration from below which inhibits the fermentation.

Various methods of drying the forages have been tried in India like drying the crops on fencing, wires, roofs tops, tree tops, galvanized tin sheets, tripod stand, etc. Care should be taken to avoid shattering of leaves in leguminous crops like berseem, lucerne, cowpea, etc. For heavy rainfall areas, hay curing sheds have been developed where monsoon grasses are dried.

Factors affecting the nutritive value of hay

1. Stage of harvesting

The nutritive value of the fodder goes down as the plant matures. At a very early stage the protein and energy contents of the fodder are very high but the dry matter yield of the fodder per unit area is very low. At the later stages when the crop is full bloom, the protein value goes down and the digestibility of nutrients is also reduced. The total yield of dry matter is increased. In order to get more nutrients per hectare, the crop should be harvested just at preflowering stage or when about 10% of the crop is in bloom. This is the time when plenty of sunshine is also available for hay making. Under high moisture and temperature fungi and moulds may grow on the hays. Such infested hays are unpalatable and harmful to the farm animals and men. In later case, allergy to the farmer handling the infested hay has been reported. Common salt and fungicides like phosphoric acid have used to check the growth of moulds. Curing of hay under normal sunshine condition does not affect the nutritive value of the hay. However, if the crop is not quickly dried and left in the field unattended, then there are heavy losses.

2. Shattering of leaves

This loss is more common in leguminous crops like berseem, lucerne, cowpea, etc., where the leaves dry earlier than the stems. If drying is prolonged without proper turning, the leaves become brittle and shatter. Sometimes this loss becomes very serious since leaves

are richer in proteins, vitamins, minerals, etc. than the stems. This loss can be reduced if the forages are-chaffed before curing them for hay. Leguminous hays should be transported from the field early in the morning so that with dew there is less shattering of leaves.

3. Fermentation

After the crop is harvested, the plant enzymes act on the soluble carbohydrates forming thereby carbon dioxide and water. In a normal hay making process, some of the nutrients are lost which results in the higher crude fibre content of dry matter of hay as compared to the green fodder analysed before hay making. Although major changes during hay making occur in the carbohydrate fraction but other nutrient like protein is also affected. Proteins are also hydrolysed to amino acids which may be lost. In a normal curing there is a loss of about 5~9% of dry matter.

4. Oxidation

If the green fodder is exposed to the sun for a longer period without proper turnings, nearly all the carotene may be lost. In green fodder, it is between 150-200 ppm of dry matter and due to bleaching it can be reduced to 5-10 ppm. Rapid drying of the crop on tripod system conserves the maximum amount of carotene. Sunlight has a beneficial effect on vitamin D_2 formation.

5. Leaching

During hay making, if heavy rains prolong, severe losses due to leaching occur which causes loss of protein, NFE, soluble minerals and vitamins. The crude fibre content is increased.

B. Silage making

Silage: It is the green material produced by controlled fermentation of green fodder containing high moisture level. Fresh fodder when packed in a container and allowed to ferment under anaerobic conditions producing volatile fatty acids which preserve the material for a long time with minimum loss of nutrients is called as silage. The process of silage making is called ensiling.

Characteristics of a good silage

Among the physical characteristics, it should have acceptable aroma without mould growth. A good silge is greenish yellow and is highly palatable to the animals. A fermentation loss of 10-15% cent is acceptable. Chemically, its pH value should be between 4-5, in proportion to lactic acid, other volatile substances should be less, ammonia should not

comprise more than 10-12% of total nitrogen. Concentration of butyric acid should be less than 0.2 %.

Suitable crops

Soluble carbohydrate rich crops like maize, sorghum, bajra, napier, oat etc. are suitable for ensiling. Cultivated and natural grasses are very good substrate for ensilage. The crops used for the purpose should have about 65%. Legumes may contain 60-65% moisture. The crop should have solid stem so that small amount of air is trapped. For hollow stemmed crops, trampling should be adequate. Stage of harvesting is also an important aspect. For silage, maize should be harvested at dough stage, sorghum and bajra at milk to dough stage and natural grasses at flowering stage. Leguminous crops may also be ensiled with cereal crops in different ratios (2-4: 1).

Method

There could be several methods, however, the principle is same that green crops harvested at 65-75% moisture level can be ensiled or better chopped/chaffed. The mass is packed in silos, so that it contains no or vey less air after trampling down. After proper packing, the material is packed/sealed with mud/straw/polythene sheets. The soluble carbohydrates in the fodders are converted mainly to lactate and other organic acids by lactic acid bacteria. The resulting product is acidic in nature (pH=4.0). At this pH undesirable butyric acid production is inhibited and so also the degradation of proteins to ammonia and amines. This can be achieved by proper compaction of the chaffed fodder. The exclusion of air from silo minimizes the loss of nutrients due to respiration and encourages the growth of lactate producing bacteria, prevents the growth of aerobic organisms producing heat at the expense of nutrients. The silo should be airtight which can be done by providing polythene sheets all around (top, side and bottom). Inoculation with lactic acid bacteria (e.g. Lactobacillus plantarum) results in lactic acid production provided that forage contains sufficient amount of soluble carbohydrates. Silage is ready after 4-6 weeks. Higher moisture (>70%) should be avoided as it promotes undesirable clostridia. As far as possible, soil contamination should be avoided.

Tower and trench silos can be used for silage making. Silos should have air tight walls having no cracks whether they are above or below ground. If above ground, air may enter through cracks and moulds may grow while below the ground invites rain water and spoilage.

Fig. 5.2. Silage making

Advantages of silage making

- Silage can be prepared from green fodders when weather does not permit hay making.
- Silage can be prepared from plants which have thick stems and normally not suitable for hay making (e.g. sorghum, maize etc.)
- Weeds can be used alongwith major crops for ensiling. The process also destroys weed seeds.
- It is highly palatable to cattle and buffaloes.

Improvement in straw quality with urea treatment

Straws and stovers are less palatable, less digestible and have lower nutrient content (protein, energy, minerals). Urea/ammonia treatment is a simple technology which can be adopted by the farmers for improving the quality of straws ike paddy straw, wheat straw etc.. Urea treatment is a chemical method of improving the digestibility nd the nutritive value of the straws. Both protein and energy content of the straw goes up (Table 5.1).

Table 5.1. Protein and energy contents of treated and untreated wheat straw

Type of straw	Crude protein (%)	TDN (%)
Untreated straw	3.0	40.0
Treated straw	8-9	50-55

One quintal of straw is spread as a layer over a space of 2 meter radius. Four kg of urea is dissolved in 50 liters of water in a big drum and urea solution is sprayed with gardener's sprinkler or with bucket full of the solution, over the straw layer. This is followed by another layer of one quintal of straw over the previous layer. Similarly, the urea solution (4 kg in 50 liter of water) is again sprayed over the second layer, The straw is thoroughly pressed before the next layer of straw is put over it. Likewise, a stack of 12.5 quintals of straw can be made from 1 bag full of urea (50 kgs).

The top of the stack should take the shape of a dome. The whole of the stack has to be covered from all sides and from top to the base, preferably with polythene or with untreated unchopped paddy straw. It can also be covered traditionally by "Koop". A period of three weeks is required for proper action.

Precautions

- Use clean water for dissolving urea.
- Layer after layer, the stack should be thoroughly pressed to remove the air pockets

The stack should be properly covered from all sides to minimize the spoilage with rain.

- The stack should be opened from one side after 3 weeks for feeding the treated straw to the a1nimals. The stack should preferably be closed with untreated long paddv straw.
- Before offering the treated straw to the animal, it should be left in open for half an hour to remove the smell of ammonia.

Advantages

1. Crude protein increases 3 times.
2. Total digestible nutrient increases by 10-15% units.
3. Straw becomes more palatable and digestible.

Constraints in the adoption:

1. The technology is effective in areas where green fodder is not available
2. For treatment, it requires labour, farmer need neighbors' help to prepare treated straw.
3. Requires sufficient clean water.
4. Can be mostly used at large farms.

Review Questions

1. What are the advantages of processing of feeds?
2. Explain grinding, mixing and compounding of feeds.
3. What is the importance of hay and silage making? What are crops suitable for hay or silage making?
4. What are the characteristics of good hay and silage?
4. How would you prepare hay and silage?

CHAPTER-6

Feed formulation -

nutrients requirement for different category of dairy animals, balanced/complete ration, methods of feed formulation

Objectives

1. To study the nutrient requirements of different categories of dairy animals
2. To prepare balanced rations for different categories of dairy animals
3. To acquaint with important points to be kept in mind for feeding dairy animals

Introduction

There are different categories of animals in a dairy herd including growing calves, heifers, breeding bulls, pregnant and lactating animals. Each category has its own nutrient requirements which are by providing them balanced ration. Ration is defined as the amount of feed offered/given during a period of 24 hours while the balanced ration is one which provides nutrients in such amounts and proportions which meets the nutrient needs of animals for various physiological functions viz. maintenance, growth, production, reproduction etc. The term requirement signifies the amount of a specific nutrient needed by the animal for normal functions like maintenance, growth or production.

Nutrient requirement of different categories of dairy animals

Table 6.1: Nutrient requirements pre-ruminant cattle and buffalo calves (ICAR, 1998)

Age (day)	Body wt	Daily gain	DCP (g)	TDN (g)	ME (Mcal)	Ca (g)	P (g)
Birth to 15	25	200	80	0.40	1.5	2.5	1.5
16 to 30	30	300	90	0.50	1.7	3.0	2.0
31 to 60	40	300	125	0.80	2.4	3.5	2.5
61 to 90	50	350	150	1.00	3.6	4.0	3.8

Table 6.2: Nutrient requirements of lactating cattle and buffaloes (ICAR, 1918)

Body weight (Kg)	Dry feed (kg)	DCP (g)	TDN (kg)	Ca (g)	P (g)
Maintenance of mature cows/buffaloes					
200	3.5	150	1.7	8	7
250	4.0	170	2.0	10	9
300	4.5	200	2.4	12	10
350	5.0	230	2.7	14	11
400	5.5	250	3.0	17	13
450	6.0	280	3.4	18	14
500	6.5	300	3.7	20	15
550	7.0	330	4.0	21	16
600	7.5	350	4.2	22	17
650	8.0	370	4.5	23	18
700	8.5	390	4.8	25	19
750	9.0	410	5.0	26	20
800	9.5	430	5.3	27	21
Percent milk production (nutrient required/ kg of milk fat)					
3	-	40	0.270	0.97	1.8
4	-	45	0.315	1.13	2
5	-	51	0.370	1.28	2.2
6	-	57	0.410	1.36	2.4
7	-	63	0.460	1.54	2.6
8	-	69	0.510	1.80	2.8
9	-	75	0.500	2.06	3
10	-	81	0.600	2.16	3.2
11		85	0.700	2.34	3.4

Table 6.3: Water requirements for growth and milk production.

Atmospheric Temperature(^{0}C) (Litre)	Water Intake/ kg Dry Matter Intake(Litre)	Water Intake/ 100 kg Liveweight
Cattle (400 kg)		
10	3.0	5.5
27	3.5	6.0
35	4.5	8.0
Buffaloes (500 kg)		
10	5.0	6.5
27	5.5	7.0
35	6.5	10.0

During the first and second lactations to allow the growth of the lactating cows/ buffaloes, add about 20 and 10% of maintenance allowance

Feeding/ feed formulation for dairy animals:

Dry matter intake

The first thing that comes to our mind regarding the feeding of animals is how much dry matter they consume per day. Dry matter intake of animals is very much related to the body weight of the animals. Adult animal can consume 2.5 to 3.0 Kg dry matter per 100 Kg body weight. This should come partly from green plus dry roughages (2/3) and partly from concentrate (1/3 parts).

Feeding of young calves : Calf is the future dairy animal. Utmost care is required to be taken to raise a calf and keep it healthy and free from infections. New born calf is prone to all types of infections since the immune system is not well developed at birth. However, nature has provided a mechanism to give protection to new calf against infections in the form of colostrums, the first secretion from udder immediately after parturition.

Colostrum should be fed to calf within one hour to get maximum antibodies especially in buffalo calves, for developing immunity against diseases. The calf is capable of absorbing antibodies (immunoglobins) only for a short period of time. Maximum absorption occurs immediately after birth, which decrease with time. Colostrum also creates acidic medium in the intestinal tract which prevent diarrhea, white scour and other intestinal disorders.

After feeding colostrums for 5 days, calf is then put on whole milk feeding for 2 weeks to be gradually replaced by skim milk up to the age of 100 days.

Table 6.4: Milk feeding schedule for calves.

Body Wt. (Kg)	Calf Age (days)	Colostrum (Litres)	Whole milk (Litres)	Skim milk (Litres)
Upto 25	Upto 5	1/10th of body wt	-	-
20-30	6-20	-	1/10th of body wt	-
25-50	21-30	-	1/15th of body wt	1/20th of body wt
30-60	31-60	-	1/20th of body wt	1/25th of body wt
40-75	61-100	-	1/25th of body wt	1/25th of body wt

Green and leafy legume hay can be offered to young calves after two weeks of age, which helps in rumen development. After 3 month of age the concentrate can be offered @ 1.0 to 1.5 kg as per the body wt. changes.

Feeding of dairy heifers/ pregnant animals

Heifers are still in the growing stage. Growing animals need sufficient protein in the diet than energy. The concentrate fed to growing heifers should have 20% CP and 65-70% TDN. Better nutrition of heifers helps in attaining early maturity of the animals which may reduce the age at first calving.

Table 6.5. Feeding schedule for Heifers

Age (months)	Body wt. (Kg)	Roughages Green (kg)	Dry (kg)	Concentrates (kg)
6-9	70- 100	5-8	-	1.25-1.5
9-15	100-150	8-15	-	1.5-2.0
15-20	150-200	15-20	-	2.0-2.25
Above 20	200-300	20-25	2	2.25-2.5

Cows and buffaloes in late pregnancy (during pre partum period) need to be given nutritious feeds, about 2 kgs of good concentrate and a good quality green fodder. This is just to improve the body condition score. This helps in building the reserves, which can then be used during early part of pregnancy of lactation as mobilized nutrients.

Vitamin-E supplementation, 1000 IU may be given 60 days pre partum and 30 days post partum. This is a good preventive measure against sub clinical mastitis, as it provides immunity to the animal against infections, especially udder infections.

Feeding of bulls: Breeding bulls should be fed optimally, consisting of good quality concentrate mixture and green fodder, along with some dry fodder. Concentrate mixture of 14-15% CP should be fed @ 2-3 Kg per animals.

Feeding of concentrates mixture containing bypass protein is all the more beneficial in improving the semen quality, seminal attributes, sexual behavior and libido score bulls.

Feeding of lactating animals : Dairy animals with a potential for milk production need to be fed judiciously a balanced ration consisting of dry roughages, green fodder and concentrate. The concentrate mixture should be of good quality with a CP content 20% and TDN 70 %.

Dairy animals have to be fed nutrient to meet the requirement for maintenance (normal physiological processes) and for production. Additional concentrate has to be fed as per the quality of milk produced, providing allowance for the higher fat content in buffalo milk.

Accordingly, for cows for every 2.5 kg of milk produced 1.0 kg of concentrate has to be fed. For buffaloes, because of higher fat content in milk, for every 2.0 kg of milk produced, 1.0 Kg of concentrate has to fed.

If a sufficient amount of good leguminous fodder is fed, then upto 5 kg of milk, just kg of milk concentrate is enough and when a sufficient quantity of non-leguminous fodder is fed, then upto 5 Kg of milk, just 1.5 kg of concentrate is enough and when a sufficient quantity of non-leguminous fodder is fed 2.0 kg of concentrate may be given.

Table 6.6. Concentrate feeding of lactating animals:

Milk Production (Kg)	Cows (Kg)	Buffaloes (Kg)
5	2	2.5
10	4	5
15	6	7.5
20	8	10

Table 6.7: Composition of a concentrate mixture

Ingredients	Parts
Maize	16 %
Barley/ Wheat/ Oats	15 %
GNC (0iled)	18 %
Mustard cake Cotton Seed Cake	8 %
Cotton Seed Cake	7 %
Wheat Bran	15 %
Deoiled Rice Bran	8 %
Mineral Mixture	2 %
Common Salt	1 %

The above concentrate shall have 20 % CP and 70 % TDN.

Table 6.8: BIS Specification for Type-I & Type-II concentrate mixtures

Parameters	Limit	Type-I Feed %	Type- II Feeds %
Moisture	Max	11	11
Crude Protein	Min	22	20
Crude Fat	Min	3	2.5
Crude Fibre	Max	7	12
Silica	Max	7	4
Urea	Max	1	1
Calcium	Min	0.5	0.5
Phosphorous	Min	0.5	0.5
Salt	Max	2	2
Vitamin A(IU)/ Kg	Min	5000	5000

Table 6.9: Component of mineral mixture.

Ingredients	Percent
Di-calcium phosphate	55.0
Sodium chloride	30.0
Chalk	11.0
Magnesium carbonate	3.0
Ferrous sulphate	3.0
Copper sulphate	0.5
Manganese di-oxide	0.08
Cobalt chloride	0.06
Potassium iodide	0.01
Zinc sulphate	0.26
Total percent	100

Some examples of feeding balanced ration to dairy cow

A Cow weighing 400 kg and yielding 10 kg milk / Day (4% fat)

Sr. No	Feed Stuff	Quantity
Ration 1	Green maize (25% DM) Wheat Bhusa Concentrate mixture or (CP, 20% TDN, 70, %)	10 Kg 4 Kg 5 Kg
Ration 2	Green berseem (12% DM) Wheat Bhusa Concentrate mixture (Same as above)	12 Kg 5 Kg 5 Kg

A Cow weighing 450 kg and yielding 20 kg milk / Day (4% fat)

Ration 1	Quantity (Kg)	DM through feed (Kg)	Total TDN (Kg)	Total CP (Kg)
Maize/Jowar fodder	40.0	8.0	-	-
Concentrate	8.0	7.20	-	-
Total		15.20	10.48	2.16

Ration 2	Quantity (Kg)	DM through feed (Kg)	Total TDN (Kg)	Total CP (Kg)
Berseem fodder	80.0	9.60	-	-
Concentrate	6.5	5.85	-	-
Total		15.45	10.24	2.16

Ration 3	Quantity (Kg)	DM through feed (Kg)	Total TDN (Kg)	Total CP (Kg)
Berseem fodder	55.0	6.6	-	-
Oats fodder	25.00	25.00		
Concentrate	4.30	4.30	-	-
Total		15.47	10.13	2.10

A cow weighing 450 Kg and yielding 38 litres milk /day (4% fat), (Nutritional Requirements: DM 22.75, TDN 15.65 Kg and CP 3.76 Kg)

Ration 1. 40 Kg maize fodder and 17 Kg concentrate.

Ration 2. 80 Kg berseem fodder and 15 Kg concentrate.

Ration 3. 55 Kg berseem fodder, 25 kg oat fodder and 3.3 kg of concentrate .

The requirements of the buffaloes differ from that of cattle, as they are heavier in body weight, need additional 0.5 Kg feed for maintenance and additional concentrate as allowance for higher fat % in milk, as mentioned earlier.

Buffaloes have the ability to utilize more crop residues (straws) then cattle and that is also helpful in maintaining high fat content in buffalo milk.

Important tips in the feeding of dairy Animals

- Dairy animals should be fed balanced rations to meet all their nutrient requirements for the maintenance and production.
- Over feeding is not only uneconomical but it can also cause digestive disturbances.
- Ration should be fed at regular intervals, at least 3 times a day for better fermentation in rumen.
- Feeding of concentrate at each milking time helps in the let down of milk.
- Inclusion of at least 5 Kg of green fodder in the ration, Provides necessary vitamins and minerals to the animal.
- Compound feed must contain 2% mineral mixture. If farmers prepares his own concentrate from cakes, bran and grains, then the mineral mixture should be fed separately. Mineral supplementation improves both productive and reproductive efficiency of the animals.
- Leguminous fodders if given in larger quantities, should be accompanied with some chopped straw to avoid the digestive disturbances like bloat.
- The existing practice of "Sani" as followed by the farmers of the northern India, which is actually the modern concept of "Total Mixed Ration", should be extended to the other regions of the country. This results in less wastage of feed and its better utilization by the animal.

Review Questions

1. What is balanced ration?
2. What are the nutrient requirements of growing calves?
3. Give the feeding schedule of calves up to one month.
4. Compare Type1 and type-2 feeds of BIS.
5. Important points to be considered for feeding dairy animals.

CHAPTER-7

Feeding of Dairy Animals-

Principles of feeding dairy animals, feeding of different categories of dairy animals viz., new born calf, heifers, pregnant, lactating, dry calf an bulls; feeding during extreme weather condition, requirements of water for different categories of animals

Objectives

Feeding of animals is to provide all nutrients in optimum ratio and adequate quantity to maintain the health, production and well being of animals. Scientific feeding is to optimize the production through balance feeding where carbohydrate, protein, fat, vitamins, minerals from feeds along with water to the animals for sustainable production. This will reduce calf mortality, cost of feeding and disease management at the same time will improve the production performance and economy of the farmers.

Principles of feeding dairy animals

For feeding of dairy animals, one should know the requirement of the animals which are again depends on breed and level of production, parity and body weight etc. Requirement of an animal weighing 350 kg, producing 10 litres of milk with 4.5 percent fat is different from the animals with same milk production, fat percent having different body eight and vice versa. It is also important to consider the relationship between feed nutrients intake and milk output ratio of an animal or efficiency of nutrient utilization as high producing animals utilized feed nutrients more efficiently than low producing animals. Similarly, feed ingredients available to the farmers or to that area and their nutritional value is also important for feeding animals. One feed may be available to one particular area, may not be available to other and nutritional value of same feed may differ from region to region depending on stage of harvesting, variety and processing methods. However, dairy cows are the excellent converter of feed and fodder nutrients into milk. Ration of cows composed of forages and agro-industrial by products which can not be directly be consumed by humans. Agro-industrial by products, mill by products includes maize gluten meal, brewers' grain, distillers' grain, wheat bran, rice polish etc. India with around 10, 25, 30 percent deficiet of dry, green and concentrate feeds, ranks 1st in world milk production (128 million tonnes). This is possible because of selective breeding, scientific feeding and better disease management of dairy animals. In addition to scientific and better feeding management farmers must follow dairy replacement progamme for future productivity and success of dairy enterprise. Genetic improvement in the dairy hers depend on replacing

cows leaving the herd with superior heifers. The following steps to be taken for successful dairy replacement programme.

1. Calf mortality to be reduced below 2 percent of live births.
2. Heifers should be bred at 60 percent of its mature body weight below 18 months of age, though the age is much longer in buffaloes.
3. First calf should come from the heifers at 28 months or less at 80-85 percent of its mature body weight.
4. Energy, protein, amino acid and minerals should be correctly balanced and to promote optimum growth and milk production.

Thumb rule of feeding animals

Feeding of dairy cows prime considerations must be to ascertain and to meet up the requirements in terms of dry matter, protein/ digestible or metabolizable protein and energy in terms of total digestible nutrients or metabolizable energy for 24 hours. The requirement of quantity of dry matter (DM) depends on the body weight of the animals and level of production. Dairy cows needs around 2-2.5 kg DM for every 100 kg live weight, while, crossbred cows and buffaloes needs 2.5- 3.0 kg daily. Naturally, all the requirement of energy, protein, vitamins and minerals come from total DM allotted to a particular animal. However, DM allowances may be divided in to concentrate (grains, oilcakes, mill by products an mineral and vitamin mixtures) and roughages (green fodders like maize, gorghum, oats, berseem, cowpea etc. and dry fodders like lucerne hay, sorghum hay, wheat and rice straw etc.). Under normal conditions, concentrates with around 18-20 percent protein may be given 1/3rd of total ration while 2/3rd may be given as roughage to have the protein around 8-14 percent depending on requirement of the animals. Again, among the roughages, 2/3rd may be dry or 3/4th, if sufficient succulent greens available, while 1/3rd green may be given, if succulent legume available 1/4th may be given.

Feeding of newborn: Dairy calf is born is virtually without immunity from diseases. Immunity must be acquired from immunoglobulins absorbed through the intestinal wall during first 24 hours of life. After this period absorption ability of intestine to immnoglobulins diminished greatly. Primary source of these immunoglobulins is colostrum or 'yellow milk', the first secretion from the udder after parturition. Colostrum contains antibodies to protect the newborn against disease, as well as being lower in fat and higher in protein than ordinary milk. Bovine colostrum from pasture-fed cows contains immunoglobulins specific to many human pathogens, including *Escherichia coli, Cryptosporidium parvum, Shigella flexneri, Salmonella, Staphylococcus* and rotavirus (which causes diarrhea in infants). Before the development of antibiotics, colostrum was the main source of immunoglobulins used to fight infections. Mean percentages of fat, protein, and lactose in colostrum are 6.7, 14.9,

and 2.5, respectively. Concentrations of IgG_1, IgG_2, IgA, IgM, and lactoferrin are 35.0, 6.0, 1.7, 4.3, and 0.8 mg/mL, respectively. Mean concentrations of fat-soluble vitamins, including retinol, tocopherol, and beta-carotene, are 4.9, 2.9, and 0.7 µg/g, respectively. Mean concentrations of water-soluble vitamins were 0.34, 0.90, 4.55, 0.60, 0.15, 0.21, and 0.04 µg/mL for niacin, thiamine, riboflavin, vitamin B12, pyridoxal, pyridoxamine, and pyridoxine, respectively. Mean concentrations (mg/kg) of selected minerals in colostrum are Ca -4.716; P- 4.452; Mg- 733; Na -1.058; K- 2.845; Zn -38; Fe- 5.3; Cu -0.3; S -2.595; and Mn -0.1). Colostrum is secreted upto 72 hours of parturition and may be fed to the calf as much as it can take voluntarily. Upto 3 months, the energy and protein requirement are met by whole and skim milk. The average daily intake of milk is around $1/10^{th}$ body weight. At the same time after 2.5 months, may be exposed to soft grasses to acquainted and adjusted with the fodders and proper development of rumen. Milk replace, may be given to the calves having protein level 20-22%, calf starter may also be fed to the calves which have 18-20% protein and 80% total digestible nutrients with minimum 3% fat. Calf starter must be palatable with highly digestible nutrients.

Feeding of growing calves: Indian Council of Agricultural Research (ICAR) has given detailed specification on the nutrients requirements and we can take two examples. For 100 kg growing cattle calves growing @550 g/day requires 2.8 kg dry matter, 270 g digestible crude protein, 2.1 kg total digestible nutrients, 10 g Ca, 8 g P, 10 mg carotene and 300 IU vitamin A per day. Similarly, for 180 kg cattle calves growing 550 g/ day requires 4.7 kg DM, 310 g DCP, 2.9 kg TDN, 15 g Ca, 12 g P, 18 mg carotene and 8 IU vitamin A. For 120 kg buffalo calves growing @450 g/day, requires 3.1 kg DM, 179 g DCP, 1.9 kg TDN, 14 g Ca, 11 g P, 16 mg carotene and 4 IU vitamin A. For buffalo calves weighing 260 kg growing @550 g/day, requires 6.2 kg DM, 410 g DCP, 3.5 kg TDN, 20 g Ca, 16 g P, 30 mg carotene and 13 IU vitamin A. These all nutrients to be supplemented through roughage and concentrate discussed in other chapters.

Feeding of heifers: Female calves grown mainly for milk purposes and their feeding starts from the beginning i.e., birth. Colostrum to be fed in adequate quantity to make the animal resistant against many diseases. Then proper vaccination and dosing should be done regularly. Fed the animals properly as per requirements as stated in thumb rule method and calculations based on chemical composition of every feed ingredients. DM intake may vary from 2.5 to 3.0% per 100 kg body weight, for 400 kg body weight animal DM requirement may be 10-12 kg. This DM should be supplied through roughages (fodders like maize, sorghum, oats, berseem, lucerne, cowpwea, tree leaves and straws, stovers and agro- industrial byproducts and others available in a particular region singly or in combinations) and concentrates which contains around 20% protein and 75% TDN. Protein or crude protein in the ration may be around 12-14 % and TDN may be around 60-70%. Neutral detergent fibre (comprising of cellulose, hemicelluloses and lignin) may

be 30-40%, Ca- 0.4 to 0.5%, P- 0.34-0.4%, trace mineral salts -0.3% or mineral mixture 2% in the concentrate mixture is sufficient to meet the requirement of animals.

Feeding of pregnant animals

Pregnancy means mother plus foetus, so in fulfilling the requirement of pregnancy includes the maintenance requirement of mother and demand of growing foetus which is high in last trimester of pregnancy. In last 60 days of pregnancy, lives weight of the animal increases almost by 25-30 kg depending on the breed and management condition besides their foetal growth. For example, an animal (cattle and buffalo) weighing 350 kg body weight requires about 5.0 kg DM, 230 g of digestible crude protein and 2.7 kg TDN for maintenance. If the weight of the animal is around 500 kg, needs 6.5 kg DM, 300g DCP and 3.4 kg TDN. If the respective animals are in last two months of pregnancy then, the requirement will be 6.4 kg DM, 290 g DCP and3.4 kg TDN; and 8.6 kg DM, 430 g DCP and 4.8 kg TDN, respectively. In addition to Ca, P and other macro and minor or trace minerals are essential to supply for proper management of the foetus. Fat soluble vitamins like vitamin A, D and E also to be incorporated in the ration of the animals for optimum health and production. Further, animals need regular exercise, optimum fresh and clean drinking water even under intensive system of management.

Feeding of lactating animals: Formulating ration for dairy animals is very difficult because there are a number of nutrients drained through milk. So nutritionists should look into three main things: maintenance requirement of the animal, quality and quantity of milk excreted and finally change of body weight. A cow producing 10 lit of milk, excreting about 8.8 lit of water through milk only. So, foremost important nutrient to be supplied to the animal is water. Just after parturition animal cannot take much DM due to stress, so dairy animals must be supplied with palatable feeds and other feeds that fulfils the energy and protein requirement. Rumen bypass protein or undegradable protein and bypass fat or calcium salt of long chain fatty acid may be given during this stage (fate of dietary protein discussed below). Requirements, for example, an animal (cattle and buffalo) weighing 350 kg body weight requires about 5.0 kg DM, 230 g of digestible crude protein and 2.7 kg TDN for maintenance. If the weight of the animal is around 500 kg, needs 6.5 kg DM, 300g DCP and 3.4 kg TDN for maintenance. In addition to that, for 4 % fat extra 45 g DCP and 315 g TDN to be given per kg of milk yield. For 7% fat, 63 g DCP and 410 g TDN extra to be given in the ration.

Fate of dietary protein in ruminants

Feed protein is composed of non protein nitrogen (NPN), true protein and fibre bound protein among which NPN and part of true protein degraded in the rumen, part of true protein digested in small intestine and fibre bound protein neither degraded in rumen nor

digested in intestine and excreted though faeces. Ruminal degradation of NPN and true protein leads to production of ammonia, amino acid and small peptides which are utilized by ruminal microbes to produce microbial protein in presence of readily available energy / fermentable energy source. Efficiency of microbial protein synthesis depends on type and source of diet of the animal and it may vary from 13-20 g microbial protein synthesis/ kg of organic matter digested in rumen. Ammonia usually utilized by fibre degrading bacteria while amino acid and small peptides utilized by sugar utilizing bacteria. Bacterial protein is well balanced and have all essential amino acids required by the organisms, though this may be inadequate depending on micronutrient supply for limiting amino acid synthesis and requirement of the animal for a particular stage of growth or lactation. If the growth rate is too high or milk production of the animal is high, then bacterial protein may not be sufficient to meet the requirement or amino acid from microbial source is not sufficient to meet the requirement at intestinal level. To increase the intestinal availability of dietary protein, ruminal degradation of feed protein to be reduced either by using naturally occurring bypass protein like cotton seed cake, maize gluten, fishmeal etc. or by protecting the highly degradable protein by formaldehyde, heat, tannic acid, lignosulphonate or encapsulation of protein or amino acids.

Feeding during feed and fodder scarcity: Scarcity of feed resources is a common problem limiting the animal production in the developing countries like India. Various natural calamities like floods, droughts and cyclone produces scarcity of foods and feeds. Among all, flood is the major devastating natural calamity leading to a heavy loss of vegetation. On an average about 50-60 percent of the cropped area in flood affected area remain submerged and it takes at least a minimum of 30 days to bring the field for cultivation purposes. Different kinds of damages caused by floods can be categorized as follows:

- ✓ Loss of standing crops due to submerging in flood water which is very difficult to harvest the grain and biomass.
- ✓ Damage of stored dry roughage due to water soaking followed by fungal growth causing loss of nutrients. This may decrease the palatability and thereby intakeof that particular fodder and feedstuffs.
- ✓ Washing away of dry roughage stored in open space by aggressive currents of flood water, mostly seen in hilly areas due to cloudburst.
- ✓ Damage of stored food grains by water soaking followed by fungal growth resulting in loss of nutrients and production of harmful/toxic metabolites. Most predominant fungi are *Aspergillus flavus* and *Aspergillus parasiticus* which produces toxins called aflatoxin B and G based on colour produces under uv rays (B- blue and G is green). Aflatoxin M also found in milk and very toxic to human beings.
- ✓ Pollution of water with dung, urine, debris and other wastes.

On the other hand, drought causes a different type of loss where there is no or limited growth of plants. In such condition, there is an acute shortage of feeds and fodder in flood affected areas. Therefore, there is a need to formulate feeding strategy for maintenance of animals to ensure its survival during and after flood. Feeding strategies during scarcity depend on the specific conditions prevailing in any particular area. In general the farmer has to make decisions based on economics, knowledge of nutrition, the availability of feed resources and the length of the drought may affect. There are many economical technological interventions may be adopted to encounter such problem of scarcity due to extreme weather condition and environmental calamities.

- ✓ Complete feed block (CFB): Complete feed block is composed of forage, concentrate and other supplementary nutrients in desired proportions capable to fulfil nutrient requirement of an animal. The CFBs can be used during flood situations due to easy transport. Complete feed system is advantageous against conventional system of feeding by reduced labour cost, maintenance of uniform roughage concentrate ratio, uniform feed intake favouring uniform supply of nutrients and maintenance of rumen environment. This system of feeding is well suited to our country as it helps utilizing locally available crop residues, agro-industrial by products and non-conventional feeds.

- ✓ Urea molasses mineral block licks (UMMB): The urea molasses mineral block is a strategic feed supplement for ruminant animals. Molasses, urea and other ingredients are used in the manufacture of molasses/urea feeds that are prepared as blocks. Crop residues are deficient in fermentable nitrogen, energy and minerals. In absence of adequate quantity of green fodder in the diet, rumen microbes don't get nutrients for their own growth. As a result, digestibility of fibrous feed in the rumen is affected. As ruminants can synthesize protein from non-protein nitrogen, UMMB supplementation delivers urea and energy in small doses on continuous basis. These preparations are an excellent way of providing readily degradable protein and readily fermentable energy to ruminant animals, and they help to increase the protein supply to the animal. The blocks can be made from a variety of components depending on their local availability, nutritive value, price, existing facilities for their use and their influence on the quality of blocks.

- ✓ Urea treatment of straws: Potential sources of feeds for livestock are by-products from both arable crops and agro-industrial processes. These can be valuable sources of nutrients for livestock, rich in both protein and energy. However, they are often low in nutritive value but rich in anti-nutritive factors. Many of the crop by-products (such as straws and stovers) are also extremely fibrous and more suitable for feeding to large ruminants (such as cattle and buffalo) rather than sheep and goats. There has been a considerable amount of work done on the urea treatment of straw. The

recommended treatment rate is 40 g urea/kg straw with the urea usually being added as a solution in water (40 g urea/L water) which is then sprinkled on the straw. The straw may then either be fed straight away, or ensiled to enable the urea to degrade the fibre to some extent. If the urea treated straw is fed straight away, then straw digestibility is increased by about 5 units, whereas if it is ensiled for ten days, the increase in digestibility is twice. If straw is treated with urea, the urea solution should be dispersed uniformally.

- ✓ Use of unconventional feedstuffs: Tree leaves, sugarcane tops and bagasse (bagasse is available in sugar factories and crushers after extraction of juice), mill by-products etc. may used for the purpose. Even aquatic plant like water hyacinth, azolla may also be fed to the animals during scarcity of feeds.
- ✓ Planting drought resistant trees for leaves may also be beneficial.
- ✓ Establishment of fodder bank to with the objective to store surplus fodder/crop residues, to make available nutritious fodder for scarcity period, to stabilization of fodder prices and maintenance of fodder round the year, to enhance the nutritive value of crop residues, to minimize the wastage of conventional and non- conventional fodder, to encourage dairy farmers for proper feeding to animals.

Water requirement of growth and milk production: Water requirements are equivalent to water consumed voluntary plus water intake through feeds. Requirements are influenced by many factors like growth rate, pregnancy, lactation, type of work, type of diet, feed intake and environmental temperature. Its therefore very difficult to calculate exact water requirements in animals.

However, the following table may be referred for water requirements in animals.

Environmental temperature	**Water intake / 100 kg liveweight**	
10^0C	Cattle	5.5 lit
	Buffalo	6.5 lit
27^0C	Cattle	6.0 lit
	Buffalo	7.0 lit
35^0C	Cattle	8.0 lit
	Buffalo	10.0 lit

Water intake per kg of DM intake in cattle may vary from 3.0 to 4.5 lit depending on environmental temperature while in buffaloes it may be 5.0 to 6.5 lit. Though in extreme high temperatures production of the animals decreased due to discomfort and that can

be minimized by supplying fresh drinking water along with leafy green fodders to the animals.

Review Questions

1. What is colostrum and why it is fed to new born calf?
2. An animal weighing 350 kg, producing 10 lit milk with 4% fat, what will be the DCP, TDN and DM requirement?
3. In last trimester of pregnancy, why nutrient requirement is more than dry period?
4. What is UMMB and urea treatment of straws?
5. What may be the possible impact on animals if environmental temperature rises above 35^0C?

CHAPTER-8

Metabolic Disorders and Deficiency Diseases in Dairy Animals-

Bloat, mineral and vitamin deficiency diseases

Objective

To study the causes and possible line of control and treatment of various metabolic and deficiency diseases in dairy animals.

Introduction

Diseases of metabolic origin are commonly known as metabolic disease viz., bloat, acidosis, milk fever, hypomagnesimia. However, few common metabolic diseases encountered in herd/ flock management are discussed in the chapter. In addition to these disorders, deficiency of one or more nutrients are also causes huge economic loss to the farmers. In the rumen, microbial fermentation occurs due to unique structures and environment. Microbes converts fibrous feeds which are of no use for human beings to important product viz., milk meat, hair and fibre etc. Some bacteria and protozoa have isolated from rumen with their fermented products and pathways. Name of the fermented products with the products is presented in the following table.

Common species of rumen bacteria, protozoa and their fermented products

Organism	Nature	Fermented end products
Bacteroides succinogenes	Cellulose (fibre of forages) fermenting bacteria	Acetate, butyrate, succinate, formate, lactate
Butyrovibrio fibrisolvens		
Ruminnococcus flavifaciens		
Bacteroides amylophilus	Starch and sugar fermenting bacteria	Acetate, formate, propionate, lactate
Succinomonus dextrinosolvens		
Selenomonus ruminantium		
Streptococcus bovis		

Pepostrepcoccus elococci	Protein degrading bacteria	Acetate, propionate, butyrate, valerate etc.
Bacteroides ruminicola		
Methanobacterium ruminantium	Methanogenic bacteria	Methane
Isotricha prostoma	Wide variety of sugars and bacteria	Store starch, H^+ Volatile fatty acids
Isotricha intestinalis		
Dasytricha ruminantium	Many sugars, cellobiose	
Entodinium caudatum	Starch and bacteria	
Entodinium bursa		
Diplodinium dsitaceum	Starch, bacteria, cellulose and hemicellulose	-
Diplodinium dentatum		
Diplodinium cristagalli		

Any irregularity like sudden change of feed ingredients, roughage to concentrate ratio, specific physiological change or disease may lead to ruminal dysfunction or system, resulting in metabolic disorder in ruminants.

Bloat

The condition is also known as tympany or hoven and results in either due to excessive production of gas or physical obstruction in the process of eructation gas from rumen. It is a clinical condition where rumen and reticulum are filled with gasses of fermentation due to excessive highly fermentable feeds, fodders like lucerne, berseem, clover etc, some time gas bubbles remains intimately adhered with the ingesta, the condition called frothy bloat. Symptoms of generalized enlargement of rumen (left side of the animal), extension head, protrusion of tongue, restlessness, anorexia, ruminal motolity goes high initially followed by hypo- motility and later atony may be observed. If the animals not treated in time, animal may die.

Treatment: Trocarization to remove the gas, carminative mixtures and mineral or vegetable oil for immediate treatment. Dimethicone suspension (bloatosil, bloatonil) may also be the drug of choice for bloat to rumen directly through syringe or orally.

Acidosis

Accidental ingestion of excessive carbohydrate containing grains like maize, rice, wheat, barley, potato etc there is formation of lactic acid in huge quantities in rumen, resulting in lowering pH from 6.8 to about 5.0 or so. This results in accumulation of more fluid form rumen wall and circulatory system due to high osmolarity of lactate. This may lead to dehydration, oligourea and anurea causing ruminal stasis and laminitis.

Treatment: Sodium bicarbonate 2.5-5.0 percent solution 500 ml to 1 lit through i/v route, 7 percent solution 200-500 ml. pH correction by $MgCO_3$, MgO, $Mg(OH)_2$ or $NaHCO_3$. Corticosteroid may be injected to prevent shock.

Ketosis

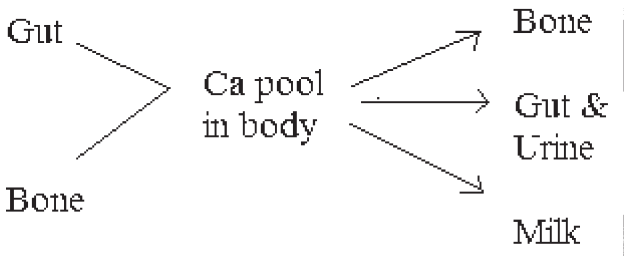
It is a condition of relative or absolute lack of carbohydrate in the hepatic cells leading to oxidation of fats, resulting in production of ketone bodies i.e., acetoacetic acid, β- hydroxyl butyrate and acetone. All carbohydrate feeds in the rumen on fermentation produces VFAs i.e, acetate, propionate and butyrate along with some branched chain fatty acids. Among which, acetate and butyrate are ketogenic whereas propionate (glycogenic) are the major one and produced in the ratio of 65:25:10. The ratio if changed due to feeding or any other reason caused ketosis. It may be primary where starvation/ underfed for longer period and secondary where any disease or syndrome causes starvation to the animal. But clinically ketosis may be of four type i.e., alimentary, spontaneous, nervous and milk fever type.

Treatment:

1. 500- 800 ml of 40-50 percent dextrose solution through i/v route.
2. Glycerine of glycerol @100 gm twice daily for 2-3 days.
3. Sodium propionate@ 100-200 g once daily for 3 days.

Milk fever

It is also known as parturient peresis, is a metabolic disease occurring mostly within 72 hrs of parturition in adult female and is characterized by hypocalcaemia, changes in neuromuscular tone ranging from fine tremor in early stages to peresis, recumbancy, circulatory collapse and ultimately diminution of conciseness. Temperature is generally subnormal in advance stages. There is muscle weakness and flaccidity of muscles. Hypocalcaemia may be termed as deficiency disease but since the deficiency of Ca in feed is not the main factor of disease and there are other causal factors, the disease termed as metabolic disease rather than a deficiency disease. In case of low intake of Ca and excretion through milk in high producing animals leads to the disease.



Treatment: Effort should be to supplement Ca to the infected animals. If it is not done in proper stage, lateral incumbency for longer time may cause death of the animal.

1. Ca borogluconate through i/v route @ 250-500 ml
2. Ca Mg borogluconate-same dose.
3. Vitamin D_3 or cholecalcipherol single dose i/m route @ 8mg prior to 3 – 4 days calving in high producing animals.

Grass tetany

Metabolic disease of cattle, sheep, goat and even horse characterized by hyper- aesthesia, in coordination and convulsion as a result of altered Mg homeostasis. Young green pasture is generally poor in Mg than mature grass. Low soil Mg or heavy application of K rich fertilizers in pasture may lead to Mg deficiency in grass and subsequently to the animal lead to grass tetany. Other factors like excessive production of ammonia in rumen prevents absorption of Mg, reduction of dry feed intake etc may lead to grass tetany among the livestock.

Treatment:

1. Administration of Mg salt like MgSO4 (10-20%) @ 200-300 ml (s/c route).
2. Mifex @ 1 bottle (500 ml through i/v route and 500 ml through s/c route).
3. Mg gluconate 15% solution @ 200-300 ml s/c route.

Fatty cow syndrome

Recently the milk production has increased few folds with the demand and improved feeding system, but the dairy cows or small ruminants found to be associated with an increase in the incidence of some emerging diseases like fatty cow syndrome or pregnancy toxaemia. The diseases occurs sporadically depending on feeding and management practices. Mobilization of excessive fat from body depots to liver due to in appetence either because of deprivation of feed or sudden demand for energy in the immediate post partum period leads to this disease. Symptoms like inappetance, dull and depression etc. may be seen but its always associated with other metabolic diseases.

Treatment: Glucose, Ca and Mg to be supplemented through i/v route. Propylene glycol orally @ 100 mg daily for 10 days. Choline chloride may be tried @ 50 g (50 percent solution) in a single dose. Mild exercise and fresh green fodder feeding may also be beneficial.

Rickets and osteomalcia

A deficiency of vitamin D in the young animals results, a disease of growing bone in which the deposition of calcium and phosphorus is disturbed. Normal calcification can not occur in the absence of adequate Ca and P. therefore either a deficiency of vitamin D which impaired utilization of Ca or a deficiency of Ca and or P will produce the abnormalities in the skeleton. As a result of this, bones are weak and easily broken. In most of the cases legs may become bowed. In young animals symptoms like swollen knees, hock joints and arching of back. In growing animals bone ash reduced and weight gain may be depressed. Vitamin D deficiency can be prevented by only a few moments exposure to sunlight, although skin pigmentation affects the amount of sunlight required to prevent rickets. Injection of vitamin D also needed to prevent to this deficiency symptoms. In adults the symptoms called as osteomalacia. In elderly humans, this also causes osteoporosis which characterized by reduction of bone mass, resulting in tendency to fracture. Adequate supply of vitamin D or Ca and P in 2:1 ratio may give beneficial effect.

Pica

Deficiency of Ca and P causes rickets in youg animals and as the deficiency progresses appetite reduced and growth is retarded. Deficient animals often have depraved appetite and may chew on wood and rods and other inappropriate objects. This abnormal behaviour of eating called pica. Adults fed low P diets may exhibit pica and bone density decreased as in rickets. Impaired fertility may also be observed.

Anaemia

Iron, copper and cobalt deficiency may lead of anaemia which is characterized by change in size of red cells and quantity of hemoglobin.

Review Questions

1. Differentiate metabolic diseases and deficiency diseases.
2. What is acidosis and how it differs from bloat?
3. Why milk fever occurs in high producing dairy animals?
4. What is pica and how it is to be prevented?
5. What are the ketone bodies and how it is formed in dairy cows and buffaloes?

CHAPTER-9

Anatomy of Male and Female Reproductive System

Objective

To learn the anatomy of male and female reproductive system

Introduction

Production of dairy animals largely depends upon reproduction. For successful reproduction, the animal should attain puberty and sexual maturity at right time, insemination or naturally mating at proper time, conceive, carry the fetus for full gestation, calve normally, start cycling and conceive again at right time: Approximately 6 – 8 such cycles can happen in life time of a cow. If there is any break in this cycle, then the reproduction efficiency of the animal and the farm goes down. For efficient reproduction management, proper knowledge about the reproductive organs is necessary. This chapter explains different parts of male and female reproductive system using bull and cow as model.

Male reproductive system

The basic components of male reproductive system are testis, excurrent duct system, accessory sex glands and supporting structures. Male reproductive system is supported by the pelvis, and is housed internally in the abdomen and outside the abdominal cavity in the region of the groin.

Testis

Testis (plural, testes) is like a factory that produces spermatozoa. Male hormone (testosterone) is also produced by the testis. The testes are oval shaped and in most of the mammals they descend outside the body into the scrotum. The testis consists of testicular capsule, parenchyma, mediastinum and rete tubules. The testicular capsule covers the testicular parenchyma. The testicular parenchyma can be divided into the tubular compartment comprising of the semeniferous tubules and the interstitial compartment consisting of blood vessels, connective tissue, nerves, lympatics, leydig cells, etc. Several seminiferous tubules are present in parenchyma. Interstitial cells are found in the connective tissue septa surrounding the seminiferous tubules. Sperm production occurs along the entire length of these highly convoluted and densely packed seminiferous tubules within the testes. All of the separate sperm producing tubes however, eventually converge into a single collection tube in the center of the testicle. The interstitial tissue of the testis consists of loose

areolar connective tissue containing numerous reticular fibers, which serves to support the seminiferous tubules. The interstitial cells (Leydig cells), located in this connective tissue, are responsible for the synthesis and secretion of the steroid hormone testosterone.

Excurrent duct system

The excurrent duct system helps in storage, maturation and conveying the sperm cells out of the testis and eventually out of the body. They include vas efferentia (ductuli efferentes), epididymis, vas deferens and urethra. The epididymis is a large tortuous duct outside the testis through which sperm migrate slowly across the head (Caput), body (Corpus) and tail (Cauda) of the epididymis; the tail portion is the chief site of sperm storage. The epididymis is tightly adhered to the outside of the testicle. The function of the epididymis is to provide environment for final maturation of spermatozoa so that the sperm acquires capacity to fertilize the ovum. The epididymis also serves as a storage reservoir and exit control for spermatozoa. The ductus epididymis continues as the ductus deferens. The vas deferens or ductus deferens is a slender tube connecting the epididymis with the urethra and which enlarges into an ampulla just before joining the urethra. The vas deferens leaves the testicle to become part of the spermatic cord and pass thorough the inguinal canal and enter into the abdomen. Urethra is the tube in the penis through which semen is discharged at the time of copulation and through which urine is excreted. Urine enters the urethra by relaxation of a muscle under voluntary control. Fluids are added to sperm in the pelvic urethra during the process of ejaculation. The male urethra consists of two portions; the pelvic urethra and the penile urethra.

Penis

Penis is the organ of copulation. The penis provides an outlet for both urine and the copulatory ejaculate (spermatozoa and semen). In general, the penis is composed of three parts viz base (root), body (shaft) and glans. The body of the penis consists of the urethra, erectile tissue, smooth and skeletal muscle, touch and pressure receptors and a dense connective tissue capsule. When a bull is not sexually stimulated, a major length of the penis is flexed inside the body cavity by a paired “retractor penis muscle” called as “Symoid flexure.” Once the male is excited, the neurohormonal mechanism favours relaxation of retractor penis muscle and thus erection, elongation and protrusion the penis outside the prepuce occur.

Accessory sex glands

Accessory glands include the ampullary glands, vesicular glands (seminal vesicles), prostate gland, bulbourethral gland (cowper’s gland) and urethral gland. The accessory glands are important for adding seminal plasma to the sperm cells. The products of these glands

serve to increase the volume, to nourish and activate the spermatozoa, to clear the urethral tract prior to ejaculation and serve as the vehicle of transport of the spermatozoa in the female tract. Vesicular glands produce most of the volume, energy sources, buffers and ions. The prostate glands lie in close proximity to the pelvic urethera. The bulbourethral glands are paired glands located on either side of the pelvic urethra.

Supporting structures

The supporting structures of male reproductive system comprised mainly spermatic cord, scrotum, tunica dartos and cremaster muscles. The testes are connected to the internal components of the male reproductive system by a cord-like attachment. This connection is called the spermatic cord and passes through a small opening of the abdominal wall called the inguinal canal. The spermatic cord serves as a passageway for blood vessels and nerves, which allows entry and exit for substances necessary to sustain cell life and supply hormones for reproductive regulation. The scrotum encloses the testis and is located between thighs in most of the farm animals with an exception of boar, where it is located caudal to the thighs. The outer layer of the scrotum is skin that is relatively free of hair.

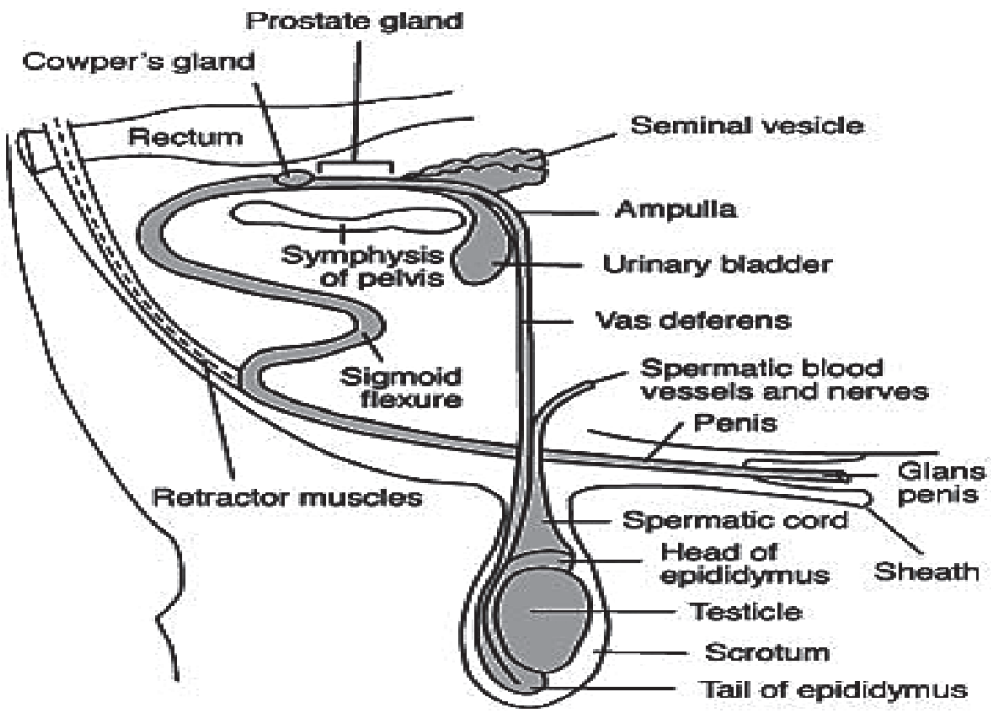


Figure 1: Parts of male reproduction system

Female reproductive system

A thorough understanding of functional anatomy of female genital organs is essential to obtain high conception rates in artificial insemination.

Internal genitalia: The internal genitalia comprise of ovaries, oviduct, uterus and cervix.

Ovaries: The normal, mature cow/ buffalo possess two almond shaped ovaries which are suspended in the abdominal cavity by a ligament (the mesovarium) and are partially surrounded by the infundibulum. Size of the ovaries varies with stage of the reproductive cycle and age of the animal, but generally are 1 to 1-1/2 inches long. The cow is born with the maximum number of immature ova (termed oocytes) that she will ever have (between 60,000 and 80,000).

The primary functions of the ovaries are

- Production of the female gamete (egg or ovum)
- Production of two primary reproductive hormones, estrogen and progesterone.

Oviducts or Fallopian tubes are a pair of narrow convoluted tubes extending from the ovary to the uterine horn. Each oviduct is supported by the mesosalphinx, that is derived from broad ligament. The oviduct may be divided into four functional segments; the fringe like 'fimbria'; the funnel shaped abdominal opening near the ovary 'the infundibulum'; the more distal dilated 'ampulla'; and the narrow proximal portion connecting the oviduct with the uterine lumen, 'the isthmus'. The major functions of the oviducts are capturing of ova at the time of ovulation, transport of the egg and spermatozoa in opposite directions almost simultaneously, fertilization, transport of zygote and nourishment of the gametes and embryo.

Uterus: The body of the uterus of the cow/ buffalo is short and poorly developed, while the uterine horns are relatively long and well developed. The fertilized embryo moves from the oviduct into the uterine horn, where fetal and maternal membrane development begins. This newly developing fetus grows within a layer of membranes called the placenta, through which nourishment from the dam (mother) diffuses. There is no direct blood connection between the fetus and the dam, but rather a complex system that selectively allows certain molecules to pass from the maternal side of the placenta to the fetal side and vice versa. It also provides nutrients from dam to fetus and carries waste products from the fetus to the dam side. The inner surface of the uterus in the cow also contains 70 to 120 caruncles (Caruncles are oval or round thickenings in the uterine mucosa resulting from proliferation of sub-epithelial connective tissue) through which the fetal placenta (cotyledons) attaches and the fetus receives nourishment during pregnancy. Muscular and secretory activity of the uterus is controlled by ovary hormones and oxytocin from the posterior pituitary. The major functions of the uterus are sperm transport, capacitation of spermatozoa, production of prostaglandins for regulation of corpus luteum, nourishment of sperm, embryo and fetus and maintenance and expulsion of fetus.

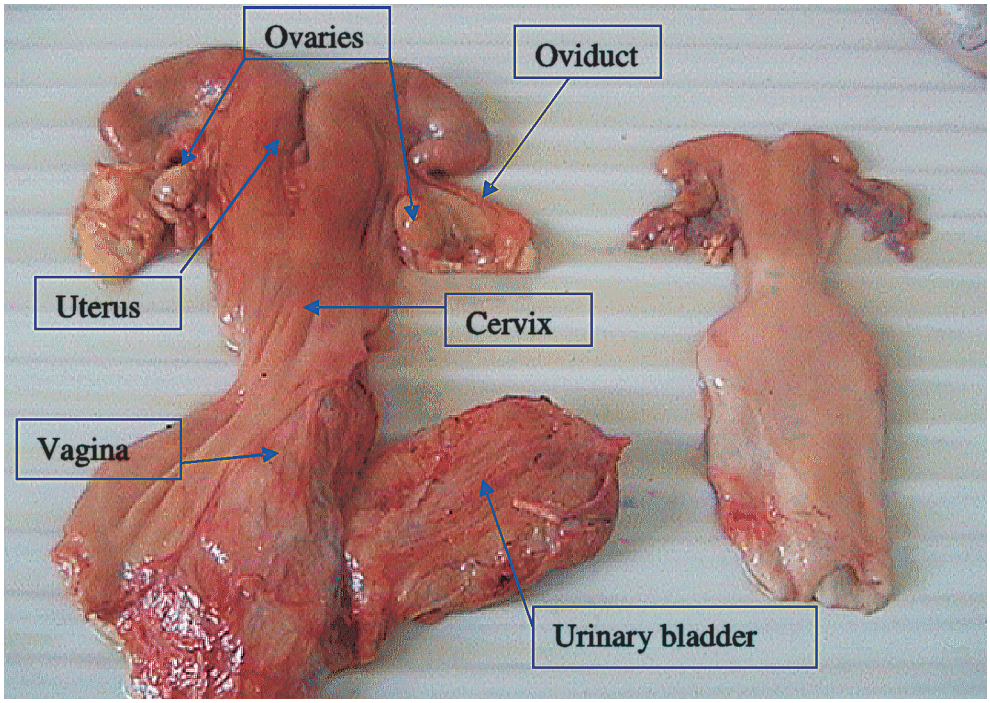
Cervix: Neck of the uterus is known as cervix. The primary function of the cervix is to

prevent intruders from entering the uterus. The cervix remains tightly closed throughout the gestation except during parturition and estrus/ heat at which the semen passes to uterus after copulation. It has thick walls and a small opening which softens and relaxes to allow a passageway for sperm at mating and expulsion of the fetus at the time of birth. During pregnancy, the cervix is filled with a thick mucus secretion known as the cervical plug, which protects the uterus from infections entering from the vagina. The cervical plug is expelled and the cervical opening begins to dilate in the days prior to calving. Like the rest of the uterus, the activity of the cervix is controlled by ovarian hormones.

Vagina: The vagina serves as a receptacle for the male's penis during mating/service. Vagina is a copulatory organ in which semen is deposited and acts as an excretory duct for the secretions of the cervix, endometrium and oviduct. It also serves as a birth canal during parturition. In case of cows and buffaloes, the semen is deposited in the vagina near the cervix during natural mating by the bull. Whereas during artificial insemination catheter (inseminated gun) is inserted through the vagina and cervix and semen is deposited at the uterine side of the cervix. Urine is discharged from the urinary bladder through the urethra, which opens into the base of the vagina. The region behind the urethral opening is called the vestibule and is a common passageway for both the urinary and reproductive systems. The external opening of the vagina is called the vulva.

External genitalia

The vestibule, the labia majora, the labia minora, the clitoris and the vetibular glands comprise the external genitalia. The vestibule is located between the vulva and vagina forming the caudal termination of the genital tract. The urethra opens into the cranial ventral portion of the vestibule. Just posterior to this opening lies a blind sac called sub uretheral diverticulum. The vestibule has several circular or sphincter like muscles that close the genital canal to the outside. Vulva is located below the anus and constitutes the terminal part of the genital tract opening to the exterior through a vertical slit or cleft. The vulva lips meet above and below the opening at an acute angle forming the dorsal and ventral commissure. The vulva and vestibule are the only reproductive organs of female well innervated by sensorly nerve fibers. The labia minora is poorly developed in domestic animals. Clitoris, a homologous organ of penis in male, is embedded in the lower commissure of vestibule and vulva. The clitoris is stimulated naturally by the bull during mating and if stimulated manually during artificial insemination, it can result in increased conception rates (the success rate of artificial insemination or natural mating in domestic animals, usually expressed as a percentage) in mature cows.



Note:

The words describing anatomical position in animals such as anterior and cranial are synonyms for towards head, posterior and caudal for towards tail. Proximal means towards body and distal means away from body.

Activity

Obtain male and female genitalia from slaughter houses and study different parts of the reproductive system. Compare the reproductive tract of cow with buffaloes and identify the differences.

Review Questions

1. Write the importance of reproductive system
2. What are the different parts of internal genitalia in cows?
3. What are the organs involved in sperm production?

CHAPTER-10

Basic Concepts of Animal Reproduction –

puberty, oestrus cycle, estrus length, gametogenesis (production of male and female gametes), ovulation, fertilization, embryogenesis, gestation and parturition

Objectives

- To understand the basic physiology of reproduction process in dairy animals
- To be acquainted with the reproductive cyclicity
- To recognize the process of sperm and oocyte formation, maturation, fertilization, pregnancy establishment and parturition

Introduction

Reproduction is one of the most important considerations determining the profitability of cattle production. Reproductive performance of a farm is reflected by the interval between two calving of a cow (Calving interval) and how many animals are culled for reproductive reason. These parameters are directly or indirectly influenced by certain parameters such as heat detection rate, conception rate and breeding period. Reproduction management, in broad sense, is manipulating all these contributory parameters to achieve a calving interval of 12-13 months with reproductive reasons contributing less than 8% in total culling of animals. Understanding the basics of animal reproduction would help in efficient reproduction management. In this chapter the basic physiology of animal reproduction is discussed.

Puberty

The term Puberty is defined as the achievement of the ability to reproduce. For the female, although the onset of sexual activity (in domestic animals) or first menstrual bleeding (in primates) is often used as the onset of puberty, When a male or female animal able to release gametes that have capacity to fertilize and characterized by showing the sign of estrus in females and by the presence of sperm **(**at least 50 millions of which >10% are motile**)** in the ejaculates in males has said to reached puberty.

At the onset of puberty, the circulating concentration of gonadotropins (GnRH) increases. Gonadotropin releasing hormone (GnRH) secreted from the hypothalamus. GnRH stimulates the anterior pituitary gland for the secretion of follicular stimulating hormone (FSH) and

Lutinizing hormone (LH). FSH and LH stimulate the gonad, which is ovary in female and testes in male for the growth and development of gamete (egg or sperm). After influence of FSH and LH on ovary and testes they start secreting hormone, estrogen in female and testosterone in male. Estrogen is responsible for the development of female sex organs and the sexual behaviour (e.g heat or estrus behaviour). Testosterone is responsible for the development of male secondary sex organs and secondary sexual characteristics. For the achievement of puberty and sexual maturity the secretion of these hormones in balance ratio, amplitude and the frequency of periodic impulses are necessary.

Age of puberty

The age of puberty is different in different animals. The following table is showing the age of puberty in different animals in normal conditions.

Animal species	Age of puberty (months)
Exotic Cattle	12 - 18
Zebu Cattle	18 - 24
Buffalo	24 - 30
Sheep	04 - 08
Goat	04 - 08
Mare (female horse)	12 - 24
Sow	06 - 10

The age of puberty is affected by many factors. Some important factors are as follows:

1. ***Hormonal****:* Estrogen and testosterone are also known as sex hormones. Disruption of the release of GnRH from the hypothalamus leads to affects in the release of FSH and LH and ultimately secretion of estrogen and testosterone from ovary and testis respectively. All these hormones are playing a very important role in female and male reproduction. Disruption or improper release of these hormones effects puberty.

2. ***Genetic Background*** –Breed of mother (dam), breed of bull (sire) that used in mating, within the breed, among different crossbred and pure breed have effect on age at puberty. Some of the good breed may reach at the age of puberty earlier than other breeds.

3. ***Nutrition*** – Ration offered to the growing animal plays an important role at the age of puberty. If growing animals are offered a balance ration as per the requirement regularly, the animal may reach puberty at proper time or may achieve puberty at a younger age. But the low quality feed or underfeeding causes slow in growth rate

that leads to delay in puberty. The onset of puberty is more closely related to body weight than age. So the attainment of a certain size is necessary for initiation of puberty in all species. For example, dairy cattle reach puberty when the body weight is 30-40% of the adult weight.

4. ***Environmental Factors*** – Temperature, humidity, rainfall, sunlight, etc. affects the fodder quality. So, animal may not get good quality fodder in all the season that hamper at the age of puberty. For example, in hot summer season the fibre content of forages increase. High fibre in the forage may not fulfills the nutrient requirement of growing animals and thus delayed in puberty. In hot summer season, animal have to maintain their body temperature by eliminating heat from their body. Animals release heat by radiation, convection, conduction, evaporation (sweating) and panting (Bird, Dog: increase respiration with protruded tongue).

Estrous cycle

After puberty the female enters a period of reproductive cyclicity called as estrous cycle, which continues throughout most of her productive life except during pregnancy. Estrous cycle is the rhythmic sexual behaviour pattern and is the period between one estrus to subsequent estrus. Estrus is the period of sexual receptivity and commonly referred as heat. Based on the frequency of occurrence of estrous cycles, animals are divided into poly estrus (exhibit frequent, periodic estrous cycles over the year e.g. cow, sow), seasonally poly estrus (exhibit periodic estrus cycles only during a particular season e.g. sheep, mare) and monoestrus (exhibit only one estrus cycle per year (e.g. wild animals). Based on the ovarian activity, the estrus cycle is divided into follicular or estrogenic phase and luteal or progestational phase. The estrus cycle can be divided into four stages viz. pro estrus, estrus, metestrus and diestrus.

Proestrus is an ill-defined period, which is characterized by growth of graffian follicle and increased production of estrogen. This is the period during which the animal prepares herself for mating. The entire system is in a stage of development and excitement. Estrogen is rising at this time and is primarily responsible for the changes observed in animals.

Estrus is a well-defined period and assumes greater significance as proper detection of estrus is very much essential for successful AI. This period is characterized by sexual desire and begins with first acceptance and ends with last acceptance of the male. Generally it lasts for 12 - 24 hours. The willingness to mate is referred to as “standing estrus”. During this period the animal shows several behavioral changes due to changing hormonal profiles and this behaviour helps in deciding the stage of heat and time of insemination. Most commonly observed symptoms of estrus in cows are standing to be mounted, mounting on others, appearance of mucus from vulva, restlessness, increased phonation, drop in

milk yield, reduced feed intake, frequent urination, vulva edema etc. Not all these signs are exihibited by a singly cow and there is lot of individual variations in expression of heat. Similarly within the estrus period different behaviour are expressed at different times. For convenient, estrus period can be again divided into early heat (coming to heat), mid heat (standing heat) and late heat (going out of heat). During early heat, which lasts for around 8 hours, the animal stands, bellows, smell other cows and attempts to ride on other cows but will not stand to be mounted. Vulva is moist, red, slightly swollen and may have clear watery discharge. The mid heat, which lasts for approximately 18 hours, is characterized by standing to be mounted, frequent bellowing, highly excitedness and sometimes ride on other cows. There is clear, roapy mucus discharge from vulva. The second half of this period is the optimum time for breeding the animal. In the late heat, the animal will not stand to be ridden but attempts to mount, smells the other cows and may have mucus discharge from vulva.

Metestrus is the transitional period between ovulation and full development of corpus luteum and lasts for 3 - 5 days. In cows, capillary haemorhage occurs in the uterus and is excreted along with mucus. This phenomenon is called as post estrual or metestrual bleeding. There is no correlation between metestrual bleeding and conception.

Diestrus is the longest period of estrous cycle characterized by maturation of corpus luteum. During this period under the influence of progesterone, hypertrophy of endometrial gland and increased thickening of endometrium occurs for nourishing the embryo. The cervix is closed, vaginal mucus is scanty and vaginal mucus membrane is pale. Females is diestrus do not display sexual receptivity.

Oestrus cycle in dairy animals

Species	Length of estrous cycle	Proestrus	Estrus	Metestrus	Diestrus	Average length of estrus	Time of ovulation
Cow	21 days (Poly estrus)	3 - 4 days	12 - 24h	3 - 5 days	10- 14 days	18h	10 - 12h after the end of estrus
Buffalo	21 days (Poly estrus)	2 - 3 days	5-27h	3 - 5 days	10- 14 days	20h	33-40h after onset of estrus
Doe	21 days (Poly estrus)	2 - 3 days	24 - 48h	3 - 5 days	10- 14 days	30h	Near end of estrus

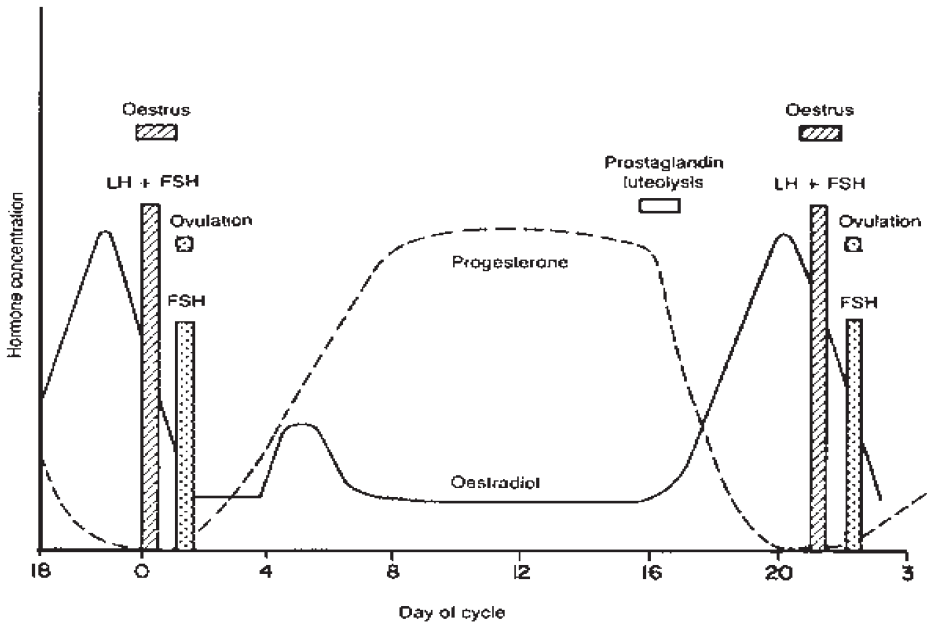


Fig: schematic diagram showing the level of oestrogen, progesterone and other related hormones in respect to the oestrous cycle.

Gametogenesis

The first phase in the sexual reproduction of an organism is gametogenesis. A process of formation of gametes from the germ cells in the testes and ovaries is known as gametogenesis. This process is termed as spermatogenesis in the male and oogenesis in the female. It is the fundamental biological process in both the sexes and the key event of gametogenesis is the reduction of the number of chromosomes (2n) to produce haploid (n) germ cells (sperm and oocytes). This haploid (n) chromosome number in the germ cell is achieved through meiosis. (For example, in goat, the chromosome number of somatic cells is 60 (2n), each sperm and each oocyte has only 30 (n) chromosomes). The formation of primary spermatocytes and primary oocytes, the spermatogenesis and oogenesis are similar. After this each primary spermatocyte divides meiotically and produces four spermatids, each destined to become a functional sperm. In female, on the other hand each primary oocytes divides meiotically and produces four cells. But the division of cytoplasm is unequal. Only one cell receive greater portion of cytoplasm and other three cells receive lesser cytoplasm which are known as polar body. The cell which received higher portion of cytoplasm and in bigger size give rise to functional oocytes also known as ovum. So, from each primary oocytes divides meiotically and produces only one functional oocytes (ovum) and the polar bodies were extruded from the cytoplasm (oolema).

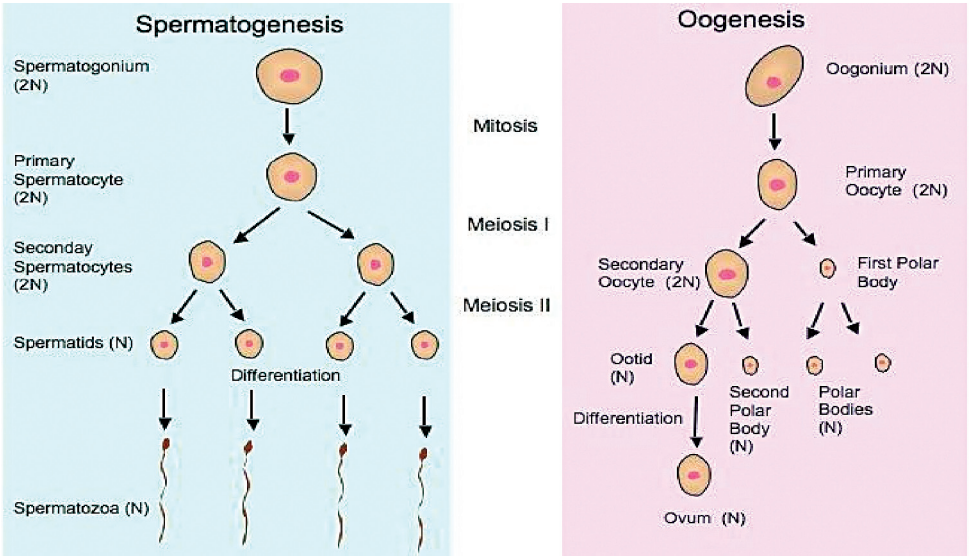


Fig: schematic diagram showing the process of spermatogenesis and oogenesis.

Sperm production or spermatogenesis

Spermatogenesis is a complex process of producing sperm with half number of chromosomes (haploid) as somatic cells. Spermatogenesis takes place within the seminiferous tubules and eventually involves cell division and differentiation. Within the seminiferous tubule, germ cells progress first from the diploid to haploid state and then change the shape (metamorphosis) to become spermatozoa. The sertoli cells, support the germ cells, provide environment for germ cells to develop and secretes substances required for spermatogenesis. The entire process of spermatogenesis can be divided into three portions, spermatocytogenesis (proliferate phase), meiotic phase (production of haploid gamete) and spermiogenesis (differentiation phase or metamorphosis phase).

Spermatocytogenesis is the proliferative phase in which primitive germ cell are multiplied by a series of mitotic divisions. This phase begins with the mitotic division of spermatogonia. The spermatogonia are activated to divide and one or two divisions occur to maintain their population in a stem cell pool of the cells resulting from these mitotic divisions. Some spermatogonia stays in the “resting pool” while the remaining spermatogonia proliferate several times. Most of the type A spermatogonia divide to form intermediate spermatogonia, which then divide to form type B spermatogonia. From the type B spermatogonia primary spermatocytes are formed by mitotic division and this ends the process of spermatocytogenesis.

Meiotic Phase is the second phase of spermatogenesis, which involves primary and secondary spermatocytes. The primary spermatocytes undergo the first of two divisions that constitute meiosis. Division of the secondary spermatocytes completes meiosis and produces the haploid spermatids.

Spermiogenesis is characterized by the nuclear and cytoplasmic changes in the spermatid so that a spherical undifferentiated spermatid undergoes a remarkable transformation that results in fully differentiated, highly specialized spermatozoa. Spermiogenesis consists of four phases namely Golgi phase, cap phase, acrosomal phase and maturation phase.

Spermiation is the process by which the sperm cells embedded in the sertoti cells are released into the lumen of the seminiferous tubule for transport out of the testis.

Oogenesis or ovogenesis

The process of formation and maturation of the female gamete (the oocyte) is known as oogenesis. Oogenesis in mammals includes seven steps:

(a) Generation of primordial germ cells (PGC).

(b) Migration of PGCs to the prospective gonads.

(c) Colonization of the gonads by PGCs.

(d) Differentiation of PGCs to oogonia

(e) Proliferation of oogonia

(f) Initiation of meiotic prophase or prophase1.

The migrated germ cells in the ovary multiply and form primary oocyte. These are surrounded by a layer of follicular cells. The oocytes together with these follicular cells are known as primary follicles. The new born female calf has approximately 1,50,000 primary follicles in the ovary which decline to 75,000 by spontaneous degeneration in a 3 month old heifer. The cells lining the follicle multiply during estrous cycle and eventually a fluid filled cavity is formed around the oocyte. A layer of cells immediately surrounded the ovum (oocyte) which is connected by a bridge-like cellular growth known as the cumulus oophorus to the follicular cell layers.

At birth, all the oocytes from growing and dominant follicles are arrested at the diplotene stage of prophase 1. This dictyate stage is characterized by the enclosure of the chromosomes within the large nucleus, also known as Germinal Vesicle (GV). The oocytes remain in the arrested state until a few hours before ovulation. Ovulation is the process of release of oocyte from the dominant follicle known as grafian follicle. The infundibulum portion of the fallopian tube will pick up the released oocytes from ovary. The oocytes along with the oophorus cumulus cells move in the fallopian tube by ciliary movement and the contraction of the fallopian tube. When the oocytes come in contact with sperm, the oocytes stimulated from the arrested state. Then undergo the completion of meiosis division from diplotene stage of prophase1 and give rise to ovum and polar body. The polar body is extruded away from the cytoplasm.

Ovulation

Ovulation is the process of releasing ova from the Graafian follicle. The process of ovulation is a gradual one. The oocytes were covered by the granulosa cells and formed primodial follicles. The granulosa cells grow and multiply around the oocytes which give rise to primary and growing follicles. The primodial and primary follicle does not contain any fluid inside the follicle. When the granulose cells in the follicles starts secreting fluid by the influence of FSH, give rise to antral follicle. As the follicular secretion increase the follicular size also increases. Continuous secretion of follicular fluid by granulose cells leads to acute bulging of the follicle with thinning of its wall at the point of bulging. The surge of LH causes contraction of smooth muscles of ovarian stroma leading to slow rupture of follicle and extrusion of ovum. In multiparous species more than one ova (oocytes) are released over a few hours during each cycle. However, in uniparous animals like cattle only one follicle matures and release during most of the cycles.

Ovulation occurs at the end or a little after the end of oestrus (desire) in all the animals. Based on the physiological mechanisms, ovulations are of two types. Spontaneously and induced ovulation. Species like Cat, rabbit, camel require mating stimulus for ovulation (ovulation fails in absence of mating stimulus) are known as induced ovulation. The cycle length in these animals differs depending on whether mating has taken place or not. In most of the farm animals' ovulation takes place during each cycle irrespective of whether coitus has taken place or not. Hence they are known as spontaneous ovulators. Even in these animals, stimulation of the genital tract has been found to hasten ovulation. The mating stimulus is important for timely ovulation. In all the species, oxytocin released from the posterior pituitary due to the stimulus of copulation.

Oocyte transport

When the oocytes (surrounded by cumulus oophorus cells) released from the graafian follicles (ovulation) pick up by the funnel like structure (infundibulum) of the oviduct (fallopian tube). The oocyte with the surrounding cumulus mass is swept into the oviduct by cilia present in the wall of oviduct. The oviductal contraction also helps in the movement of oocytes to the site of fertilization, i.e. the ampullary isthamus junction of oviduct.

Transport of spermatozoa

The spermatozoa are ejaculated as a mature cell. The bull, ram and man ejaculates on the face of the cervix and the cranial vagina. Millions of sperms or spermatozoa are ejaculated at the site of female reproductive tract. The ejaculated sperm have to move all the way of female reproductive tract to the site of fertilization. During mating or artificial insemination, oxytocin releases from the posterior pituitary by the reflex action in response to genital stimulation. This causes contraction of female genital tract. These musculature contractions

propel the sperms towards the oviduct. The fluid present in the uterus helps the sperms to swim. During the movement of spermatozoa in the tract, numbers of spermatozoa die due to phagocytosis and other barriers in female reproductive tract. Abnormal spermatozoa do not reach to the site of fertilization. During travelling of spermatozoa in reproductive tract, physiological and biochemical changes occurs in the spermatozoa, the process is known as capacitation. This change makes the spermatozoa able to fertilize the oocytes.

Capacitation: The spermatozoa must reside a minimum period in the female reproductive tract before gaining the ability to fertilize oocytes. It is speculated that during this time, glycoproteins from the sperm surface are removed, thus exposing receptor sites that can respond to oocyte signals and lead to acrosome reaction. This process allows the spermatozoa to bind to the ZP (zona pellucida), penetration the ZP and fertilize the oocyte. In another word, the spermatozoa gain the capacity to fertilize the oocyte and therefore, it is termed as capacitation.

Acrosome reaction: During fertilization, a sperm must first fuse with the plasma membrane and then penetrate the ovum to fertilize it. Fusing to the ovum usually causes little problem, whereas penetrating through the egg's hard shell can present more of a problem to the sperm. Therefore sperm cells go through a process known as the acrosome reaction which is the reaction that occurs in the acrosome of the sperm as it approaches the ovum. The *acrosome* is a cap-like structure over the anterior half of the sperm's head. As the sperm approaches the zona pellucida of the egg, which is necessary for initiating the acrosome reaction, the membrane surrounding the acrosome fuses with the plasma membrane of the oocyte, exposing the contents of the acrosome. The contents include surface antigens and numerous enzymes which are responsible for breaking through the egg's tough coating and allowing fertilization to occur.

Fertilization

The ovulated oocytes is surrounded by cumulus oophorus cells, zona pellucida and vitelline membrane. When the spermatozoa reach the oocytes, it has to cross all these barriers.

As the sperm approaches the ovum, it has been prepared by capacitation so the acrosome now is capable of releasing enzymes to digest the bonds between the protecting cells of the cumulus oophorus and corona radiate. The major enzyme is hyalurnidase, but numerous other hydrolytic enzymes are present. The sperm penetrates the matrix of the outer cell mass, and as the sperm approaches the zona pellucida, enzymes of the inner acrosome membrane permit penetration. The sperm forms a channel through the zona and passes into penetration thus far. Chemical reactions between the product of the sperm and the zona pellucida cause a sealing to prevent penetration by other sperm. This is called the zona reaction. This thin membrane is the last barrier to penetration of the ovum. The sperm head lies flat against the vitelline membrane and fuses with it as the membrane

and vitellus engulf the sperm. There is an immediate sealing of the vitelline membrane called the vitelline block to prevent other sperm from penetrating.

Pronuclei formation

Penetration of the vitelline membrane is the stimulus for completion of the second metaphase, anaphase and telophase stage to expel the second polar body in to the perivitelline space and form the female pronucleus with 1N complement of chromosomes. The first polar body may or may not divide; therefore, two or three polar bodies may be present in the perivitelline space.The sperm head begins to enlarge once it penetrates the vitellus and gradually separates from the membranes and tail to form a rounded male pronucleus. The tail and membranes disintegrate.

Syngamy

Fusion of male and female pronuclei to create diploid zygote is called as synzamy. There is a loss of the nucleoli and nuclear membrane. The new nucleus and its surrounding cytoplasm are now considered as zygote, which is ready for mitotic cell division to form a new life.

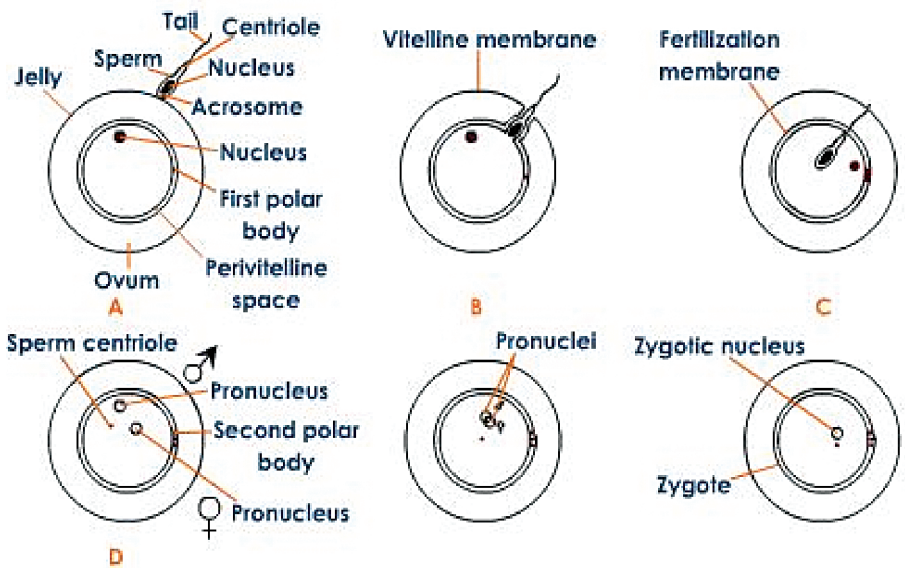
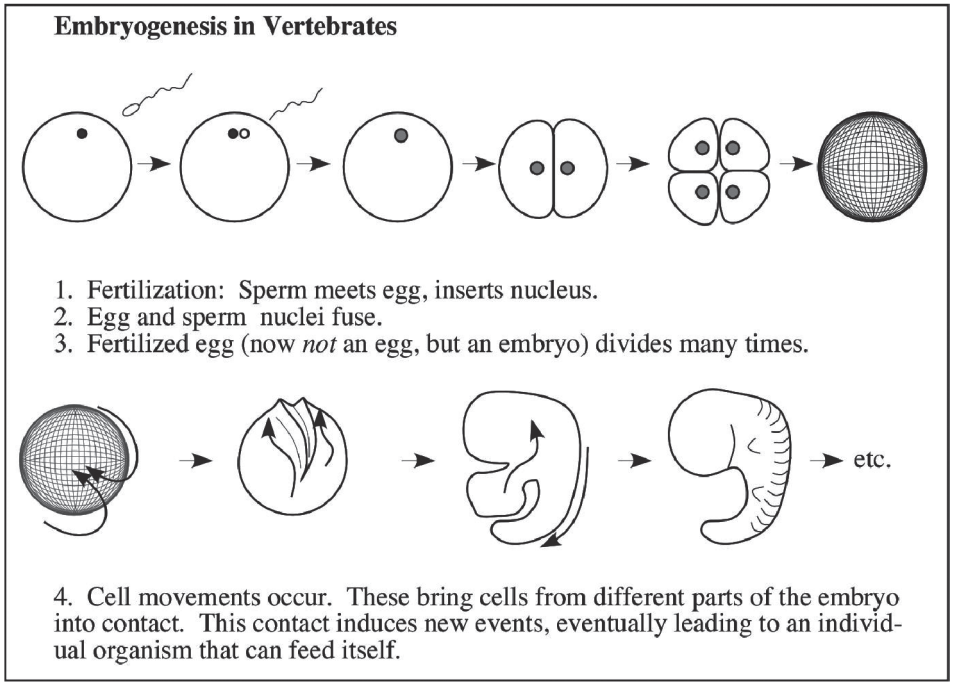


Figure showing the process of fertilization (penetration of sperm, pronuclear formation, fusion and zygote formation)

Embryogenesis

The new cell divides to form two blastomeres, which are smaller daughter cells. Cells divide from 2 to 4 cell and then 8, 16 so on without loss in mass. The zygote continues its cell division and forms a ball of cells called the morula, which transforms into a hollow

sphere of cells in the zona pellucida. The fluid is formed within these cells and the embryo is term as blastocyst. Further embryonic development results in hatching from the zona pellucida. The whole process is shown below in the form of a diagram.



Gestation

Gestation or pregnancy period begins with the fertilization of the ovum by the sperm and terminates with the birth of a young one. The period of gestation varies considerably among species of farm animals. The average gestation period of cattle is 282 days, buffaloes 310 days, and sheep and goat 151 days. Generally, male calves are carried few days longer than female calves.

Table: Gestation period of different domestic animals

Animal species	Gestation period (days)
Sahiwal cow	282
Holstein cow	282
Buffalo	310
Sheep	144-151
Goat	146-152
Horse	340

Parturition

Parturition is the physiological mechanism that enables the uterus to expel fetus after a certain period of development and nourishment. The process is called **"foaling"** in mares, **"calving"** in cows and buffaloes, **"lambing"** in ewes, and **"kidding"** in goats.

The mother (dam) shows a number of signs of approaching parturition, which are usually divided into following four stages.

(a) ***Preliminary stage:*** This stage may last for hours or even days. The ligaments in the pelvic region and around the tail head begin to relax and sink a few days before calving. The dam exhibits difficulty in movement. The external genitalia are swollen, enlarged, and flabby, and strings of mucous are seen. The mammary glands are enlarged and become tender. A clear, waxy fluid oozes out of the teats when pressure is applied.

(b) ***Dilation of the cervix:*** This stage merges with preliminary stage. Uneasiness increases and the animal may lie down and get up frequently. Frequency of micturition (urination) increases. At this time the cervix is fully dilated, and the next stage follows without any appreciable break in the sequence of events.

(c) ***Expulsion of the fetus:*** This stage begins with the fetus entering the dilated cervix and the birth canal. During this time, uterine contractions occur at about two-minute intervals and the amnion is not ruptured. There is a rush of fluid from the uterus when the water bag ruptures, and the animal appears relieved. Normally, the forefeet, with the muzzle lying behind and over them, appear at the vulva. The young one is expelled from the fetal membranes by a forceful and painful effort by the mother.

(d) ***Expulsion of membranes:*** The expulsion of the fetal membranes is commonly known as the delivery of the afterbirth. The placenta is expelled by action of uterine contraction within half an hour to eight hours after parturition.

Activities

Obtain ovaries from slaughter houses and study the structures

Observe estrus in animals

Review Questions

1. Write the process of sperm formation.
2. How oocyte is ovulated from the ovaries?
3. During which period of the estrous cycle the animal shows signs of heat?
4. Name two species in which the ovulation does not take place spontaneously?

CHAPTER-11

Importance and Role of Hormones Involved in Animal Reproduction –

FSH, LH, estrogen, progesterone, testosterone, oxytocin, prostaglandin etc.

Objectives

1. To understand what are hormones.
2. To know what are the major hormones that control reproduction in dairy animals.

Introduction

Reproduction in animals is regulated by the endocrine system. Hypothalamic, pituitary and gonadal hormones regulate the entire process of reproduction in animals. The major reproductive hormones are Gonadotropin releasing hormone (GnRH), follicle stimulating hormone (FSH), leutinizing hormone (LH), estrogen, progesterone and prostaglandins. This chapter deals with the major hormones that control reproduction process in dairy animals.

What are hormones and how they act on the body?

Hormone is a substance produced in one tissue, excreted into the blood and transported by the vascular system to a distant target tissue, where it exerts its effect. The glands producing hormones are called as endocrine glands. Endocrine glands are ductless glands and their secretions are directly dropped into the circulatory system (Exocrine glands are connected by a duct to the target tissue). Based on the chemical structure, hormones are classified into three classes viz protein or polypeptides, steroids and fatty acids. Under normal conditions, the target organ regulates release of a hormone in a feedback manner. Once released, the hormone binds to its receptor and activates series of responses in the target cells like cell multiplication, synthesis of a specific enzyme or release of secretory product. The receptor proteins for hormones are located either on the surface (protein hormones) or in the nucleus (steroid hormones) of the target cells depending upon the type of hormone. Binding with specific blood target proteins transports steroid hormones in the blood from the site of secretion to the target cells.

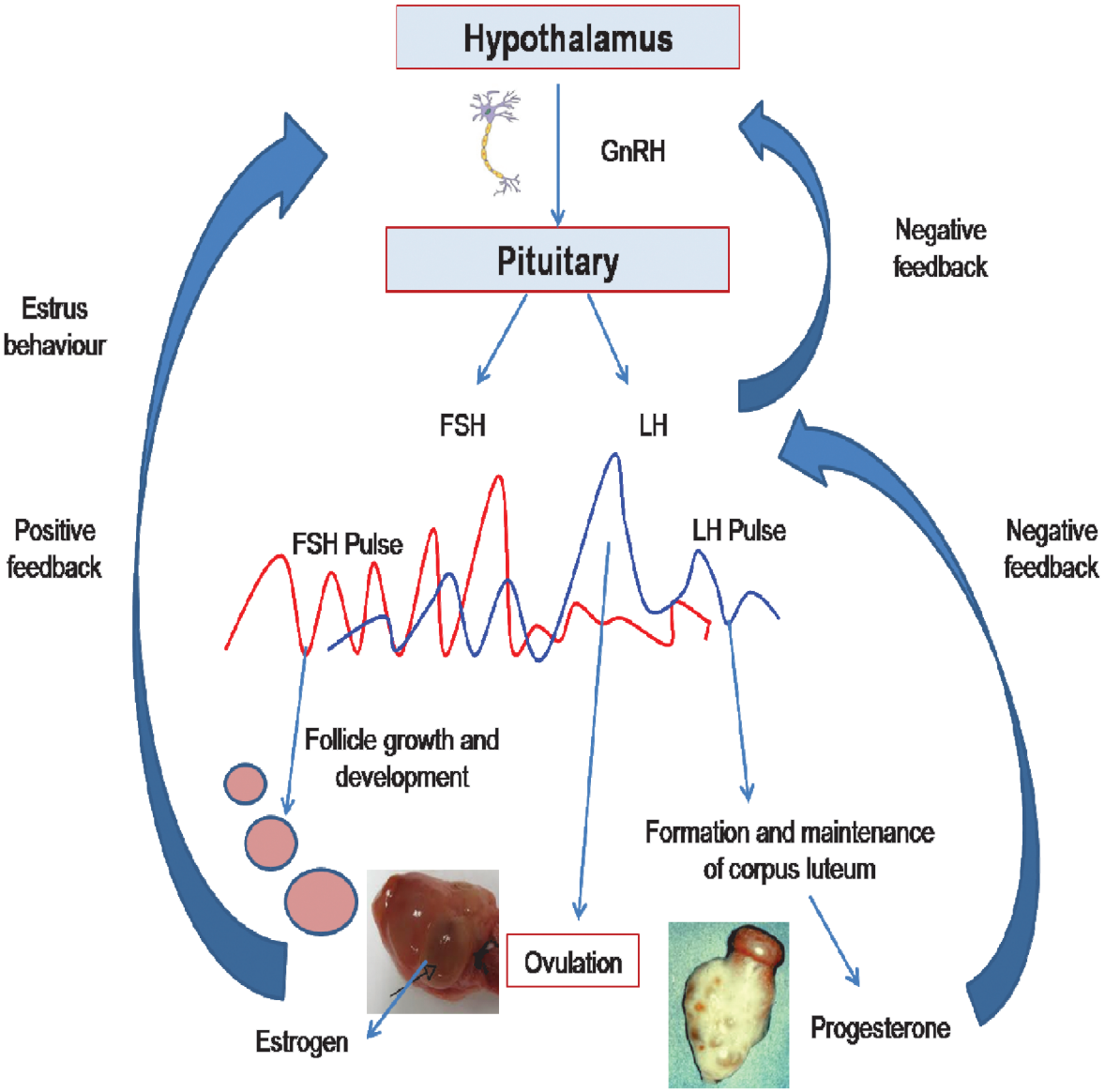


Figure: Hormones of reproduction and their inter play

Table: Major hormones and their usage in management of reproductive disorders in dairy cattle and buffaloes

Hormone	Origin	Major functions	Indications for use
Gonadotropin Releasing Hormone (GnRH)	Hypothalamus	Stimulates the release of both LH and FSH from the pituitary gland.	Anestrus Delayed ovulation Anovulation Suspected cases of luteal insufficiency Follicular cyst
Luteinizing Hormone (LH)	Anterior pituitary	Along with FSH and estrogen, causes final development of the follicle. Pre-ovulatory surge of LH during estrus induce ovulation of the follicle. Stimulates progesterone secretion by the corpus luteum.	Delayed ovulation Anovulation Suspected cases of luteal insufficiency Follicular cyst
Follicle stimulating hormone (FSH)	Anterior pituitary gland	Stimulates growth of antral follicles. Stimulates estrogen production by granulosa cells In conjunction with estrogen, induces LH receptors in granulosa cells in follicles destined to ovulate. Secondary FSH surge after estrus may recruit small follicles into the growing phase.	Anestrus
Estrogen	Follicle Placenta	Acts on the hypothalamus to cause estrous behavior. In conjunction with FSH, induces LH receptor formation on granulosa cells of follicles destined to ovulate. Increased levels induce pre-ovulatory LH surge for ovulation. Stimulates uterine secretions and activity and help in ovum and sperm transport during estrus. Promotes growth of the mammary duct system.	Banned in many countries for usage in animals, however it can be used in the following conditions. Mummification Estrus induction protocols (Heat synch)

Progesterone	Corpus luteum (CL)	Suppresses the frequency of gonadotropin (LH and FSH) releases to prevent ovulation. Stimulates uterine milk secretions to aid in nourishment of pre-implantation embryos. Depresses smooth muscle activity in the reproductive tract. Development of the clusters of milk-secreting alveoli on the mammary ducts.	Suspected cases of luteal insufficiency Threatened abortion Habitual abortion Pre-partum vaginal prolapse Anestrus
Prostaglandin F_2 alpha	Uterus	Regression of the corpus luteum. Contraction of uterine muscles Ovulation	Fixed time insemination in repeat breeders, silent heats Luteal cyst Induction of parturition Estrus induction and synchronization Mucometra Pyometra Endometritis Persistent corpus luteum Retention of fetal membranes (RFM)
Oxytocin	Hypothalamus (stored in the posterior pituitary) and specific cells of the corpus luteum	Stimulates milk let-down Causes smooth muscle contractions in the reproductive tract to aid in sperm, ovum transport and expulsion of the fetus and fetal membranes. May be involved in luteal function and/or regression.	RFM Repeat breeding (after insemination) Uterine inertia
Relaxin	Corpus luteum (ovary)	At the end of pregnancy, stimulates ripening and opening of the cervix and relaxation of the pelvic ligaments.	Not commercially available

Activity

1. Collect the literature for different hormones from the medical shops and paste their labels in work sheet
2. Go to nearest Veterinary hospital and see how hormones are being used

Review Questions

1. What are the hormones secreted by the ovary?
2. Name two releasing hormones from anterior pituitary

CHAPTER-12

Oestrus/Heat Detection –
signs of heat (visual and behavioural), standing heat, methods of heat detection, heat expectancy chart

Objectives

1. To understand the estrus/heat symptoms in dairy animals
2. To know about the commonly used tools/methods for detection of estrus

Introduction

Among the several components of the reproduction management, estrus detection is one of the crucial as it contributes towards the ultimate pregnancy rate and the survival of the embryo. Each missed heat is a missed opportunity. Inadequate estrus detection results in reduced conception rate and reduced life time productivity. The symptoms of estrus vary with animal species and even within same species individual animals may show variations in exhibition of estrus signs. Attaining higher estrus detection efficiency and accuracy is important key to improve individual animal along with overall herd fertility. From the inception of dairying several tools have been developed and employed for estrus detection but with varied success rate. The selection of proper estrus detection method for a particular dairy farm is dependent on several factors like scale of operation, availability of man power, type of animals etc. and a single aid cannot be used invariably. The present chapter summarizes the presently available tools to detect estrus and their detection efficiency and accuracy rates in modern dairying.

What is estrus and how it is manifested?

Estrus in cow is fairly well defined period when she exhibit sexual desire and receptivity to the male. It is the behavioural strategy of the female to ensure, mating close to the time of the ovulation to achieve a successful conception. The term estrus derived from a Greek word ‘Oistros’, meaning ‘gatfly’, whose buzzing during summer cause the cow to frenzied behaviour. The cow at estrus also shows certain changes under the influence of ovarian steroid hormones on the behavioural centre of the brain.

During the normal bovine estrus cycle there are visible changes in the ovary, for instance: close to estrus, the preovulatory follicle grows to a larger size producing noticeable amounts of estradiol. These increasing estrogen, in turn, promote behavioural estrus and

the release of LH to cause ovulation. Blood estradiol concentration reaches its highest level at the same time as the maximum behaviour score.

Symptoms of estrus

The best indicator of a cow or heifer in estrus is when she allows other herd mates to mount while she remains standing. Thus the primary and surest sign of estrus in a herd of animals is "standing to be mounted by other animals". However the cow or buffalo in estrus exhibit several other signs that can be considered as secondary signs, which include grouping together (animals coming into heat will usually congregate in small groups), smelling other females, trailing other females, bellowing, depressed appetite, nervous and excitable behavior, roughed up tail hair, vulva swelling and reddening, clear vaginal mucous discharge, mucous smeared on rump etc.

A major difference between buffalo and cattle in estrus expression is that in buffaloes behavioural signs of estrus are less overt and homosexual behaviour rarely observed in buffaloes. Acceptance of the male is considered as the most reliable estrus indicator in buffalo. Frequent urination, bellowing, vulval swelling, mucus discharge are salient estrus signs in buffalo, but their expression is weak and vary from season to season. In the absence of bull, the main behavioural signs are restlessness, bellowing and frequent voiding of small quantities of urine, but these are not consistently exhibited by all animals. When a bull is present, however, the bull will show increasing interest in a cow that is approaching estrus, and the cow will stand to be mounted by the bull during estrus.

Methods of heat detection

1. ***Visual observation*:** It is the simplest method to detect an animal in heat and with proper guideline and training it can be the most effective. This method involves the visual appraisal of the cardinal symptoms of heat and for this animals have to be regularly observed. Depending upon breed, the oestrus period lasts for 12-16 hrs with the range of 2-30 hrs. It is best to fix the time of detection in the early morning (before morning milking) and late evening (after the feeding). During heat detection, observing a single behaviour cannot be conclusive in predicting a true heat and thereby a proceeding ovulation. Different scoring system has been developed for estrus detection in which different score has been assigned for particular behaviours according to their frequency and reliability to predict estrus.

2. **Record:** Visual detection of heat will be more effective if the history of the animals can be made available as with this the observer can pay more attention on the animals anticipated for estrus. This can maximize the accuracy of estrus detection provided if the records are kept in daily basis.

3. **Heat expectancy chart:** It is a modified record keeping system which includes generation of a list of cattle that should cycle during a given time so that an animal proceeding for oestrus can be identified well in advance. 'Breeding Wheel', 'Herdex record system' or 'Computer generated action list' are different modified version of the 'Heat expectancy chart' with almost same principle of action.

4. **Marker animals:** Marker or Heat detector animals can improve heat detection if they are used with proper precision and supplemented with visual observation. Surgically altered bulls or androgenized cows can serve the purpose of marker animal effectively. This method is most effective in stall tied herd where a bull parading is the most effective way of detecting a heat. Using a surgically altered bull in heat detection also shorten the post partum interval in cows by some unknown male effect. Generally the marker animals are equipped with different marker device such as Chin-ball marker, which left mark on the back of the female animal preceding an oestrus with an attempt to mount them. This device can only be effective if aided by a regular visual appraisal of heat.

5. **Pressure sensing devices:** These devices are generated to record the mounting and stand to be mounted behaviour of the animals which gone unnoticed otherwise. It include Mount detectors which rub off, change colour, light up or send a signal to computer when pressure is applied on it by the mounting animals. Among them the most cheap and easy to use is tail head painting or chalking. There are different livestock marking crayon or heat detector paints available for this purpose. Paints or chalks are applied 18-21cm long and 5-6 cm wide on the rump 12-15 cm behind the level of tuber coxae and extended posteriorly on either side of the midline. The animals, standing to be mounted, show the symptom of rubbed off chalk or paint. Several commercially available devices are also evolved based on the above principle of heat detection such as capsule embedded on fabric patch, colour patch covered with scratch off surface, device containing audible signal emitter. Sometime lower branches of tree or farm house equipments rub off or activate the device giving false positive detection.

6. **Activity monitoring by Pedometry:** During oestrus the activity of the cow increased upto 2-3 folds than during diestrus and this can serve as an important indicator of oestrus. Based upon this principle, Pedometer is generated to record the increased activity. Pedometers are devices that contain motion switches to detect increased activity and a recorder to quantify activity. These devices are attached to the animals on neck or leg or sometime implanted subcutaneously. Sometime these devices are incorporated into the electronic identifying tags of the animals. Data stored in the recorder are either retrieved by observation of the visual signals emitted (flash light) or through computerised counter connected by rediotelemetry.

7. **Video cameras and recording:** This system has been extensively used in research for continuous monitoring of the animals and yet to accepted as economically viable system in commercialized dairy. The device can only be effective if the animals can be identified from a distance and if the records are reviewed daily by experts. With the advent of infra red cameras this system of heat detection is showing lot of opportunities to be explored.

8. **Recording and evaluation of vocalisation:** During periestrual period there is an evidence of increased vocalisation which is most predominant in tethered animals. This behaviour can also be used as a good predictor of animals in heat. A radio microphone system harnessed in neck of the animals can record and transmit the signals to a stationary receiver which can be further analysed by recording algorithm. Recently a work has been carried out in NDRI, Karnal showed clear difference between the vocalisation pattern of estrus and non estrus cows.

9. **Trained dogs and electric nose:** Sometime dogs are used to detect the animals in heat by the specific odour they emit around oestrus and they can detect estrus with 80% accuracy (Kiddy *et al*., 1978) but they are not preferred as they can inflict injuries through biting. Depending upon this principle attempts has been made to develop automatic electronic detector of pheromones associated with estrus (Lane and Wathes, 1998).

10. **Rectal palpation of the genitalia:** The stage of the oestrus cycle can easily be detected by rectal palpation if the detector has a sound knowledge of the tract and ovary characteristics at different stage of the cycle. With the introduction of ultrasonography in animal reproduction, understanding of follicular dynamics during the different phase of estrous cycle has been delineated.

11. **Rheological properties of cervical mucus:** The physical and rheological properties of the cervical mucus changes in relation to the stage of estrus and the altered hormonal milieu. The most important characteristics of the cervical mucus includes the colour, appearance, pH and other rheological properties like spinnbarkeit value, flow elasticity, viscosity, thixotrophy, arborisation pattern and the sperm receptivity.

12. **Milk and plasma progesterone detection:** Under experimental conditions, detection of milk or blood plasma progesterone can be used to monitor oestrus in animals. There is sharp decline found in milk progesterone from e”10 ng/ml to d” 3 ng/ml and plasma progesterone from e” 7 ng/ml to d” 0.05 ng/ml during estrus. Therefore it can be a good aid to oestrus detection but the main constraint is the cost involve with the kit

Activities

1. Go to nearby dairy farm and observe the estrus signs
2. Discuss with the farmers about the method they use for heat detection

Review Questions

1. What are the primary signs of estrus in dairy animals?
2. Do you know which method is commonly used in India to detect estrus in dairy animals?

CHAPTER-13

Artificial Insemination –

importance, advantages and disadvantages, semen composition, collection, processing, preservation, storage and transportation, A.I technique, time of insemination, factors affecting semen quality an quantity, conception

Objectives

1. To know the importance of artificial insemination in dairy animals.
2. To understand the process of artificial insemination.
3. To learn the semen evaluation, preservation and AI techniques.

Introduction

Artificial Insemination (AI) is the process by which semen is deposited inside the reproductive tract of the female by means of instruments. AI is the first great biotechnology applied to improve the reproduction and genetics of farm animals. AI is the major tool in the hands of animal breeders to propagate superior germplasm in quicker and efficient way. AI technology is the prime fact behind the success in dairy industry and India's top position in milk production.

Advantages of AI

1) AI with frozen semen allows transportation of semen to any corner of the world instead of purchasing superior bulls; its semen can be procured and taken to any country for improving the genetic of the local animal.

2) In AI, one bull can replace the use of at least 10 bulls. The number of spermatozoa in a single ejaculate is enough to cover 100 females in AI against a single female in natural service. Thus, an outstanding bull can be utilized maximum during his productive life span.

3) AI facilitates accelerated entry of new genetic material in a particular herd and thus an advantageous character is quickly propagated among the individuals in a herd.

4) In the routine examination of bulls under AI programme, it is possible to identify the bulls with poor sex drive or semen quality and helps in culling undesired bulls.

5) During processing of semen for AI, the procedures like filtration and incorporation of additives increases the fertility of semen and such processed semen gives good conception when inseminated. Thus, AI also helps in preventing unnecessary culls of high quality animals due to inferior semen quality.

6) As many contemporary females become available in shorter time, the progeny testing becomes easier and the indexes become more precised.

7) Recto-vaginal method of insemination provides an opportunity to evaluate the reproductive status of the female so that corrective measures can be employed timely.

8) AI may be used to overcome problems that may preclude a female from natural service. In animals with problems like skeletal abnormalities, weakness, laminitis, nervous temperament, natural service is difficult and AI provides an opportunity to breed these female, however, possibilities of inherited defects should be kept in mind while breeding such animals.

9) AI allows cows and bulls isolated due to health restrictions (for example FMD) still to be bred at the planned time, as no direct contact between stocks is required.

10) As the bull is routinely examined for major infectious diseases in AI program, it helps in reducing the transmission of diseases to the females. Further addition of antibiotics to semen extender also reduces the chances of venereal transmission of bacterial diseases.

11) AI also permits use of injured males and also permit more precise use of fixed time insemination

12) Mating of unequal sized animals and interspecies breeding is possible in AI.

13) AI provides employment opportunity to several unemployed youths

Disadvantages of AI

1. Artificial insemination of pregnant female results in abortion.

2. Trained person is required for the process of semen collection, preservation and insemination. Insemination may spread infection from animals to animals, if it not careful in all the steps in maintaining hygiene.

3. Artificial insemination requires special facilities like good laboratory and equipment etc.

4. Sometime there is failure of A.I. may be due to inappropriate time of AI. So, it requires more time than natural mating or services.

5. It requires a person who has sufficient knowledge of the structure and function of reproductive part of female animals.

6. Improper cleaning of instruments and in sanitary condition may lead to lower fertility.

Semen collection

Semen from a bull can be collected approximately 2 – 4 times a week. Various methods of collection of semen have been devised from time to time. The older unsatisfactory methods have gradually replaced by the new modern techniques. From bulls, semen is collected by three methods viz Artificial vagina (AV) method, Electro-stimulation method and by massaging the ampulae of the ductus difference. AV method most commonly used to collect the semen from bulls.

Assembling AV

Artificial vagina consists of a hard spongy rubber cylinder or hose, latex liner, neoprine liner or other suitable material which is non toxic, non irritant sterilizable can be used, director cone, collection tube and tube cover. The rubber cylinder is open both the ways and has a ventil at its distal third part on the surface. The ventil is used to pour hot water in the compartment between the latex liner and rubber hose. The ventil is also provided with a valve to pump air. Latex liner or sleeve is used as inner lining of the cylinder, so that a vacant space is created between two components. The sleeve is inverted over both the ends of the cylinder. Latex cone is attached at the distal end of the cylinder over the turned up part of the latex liner. A graduated semen collection tube is attached to the narrow opening of the cone. The size of AV for cattle and buffaloes is 40 x 6.5 cm and 30 x 6.5 cm. respectively. The cone is 10 - 13 cm in diameter at proximal end and at distal end it is 1.5 to 2 cm. The size of AV for zebu bulls is almost similar to buffalo bulls.

All the components of the AV should be thoroughly washed and sterilized before assembling for semen collection. Hot water (45 – 50^0C) is filled through the ventil on the rubber cylinder in the space between the cylinder and latex liner. The temperature of the AV at the time of collection should be between 43 and 48^0C. Sterilized Vaseline is applied over the inner surface of the latex liner up to proximal two third distance. Air is pumped through the valve in the ventil of the rubber hose to construct the inner passage of AV and also to create folds resembling the vagina of cow. All the rubber parts should be thoroughly scrubbed with soap and hot water, rinse with alcohol and distilled water and then dried and stored in dust free cabinet.

Proper sexual stimulation of bulls just prior to semen collection is a pre-requisite for harvesting optimum quality and quantity of semen. A bull or castrated male is convenient

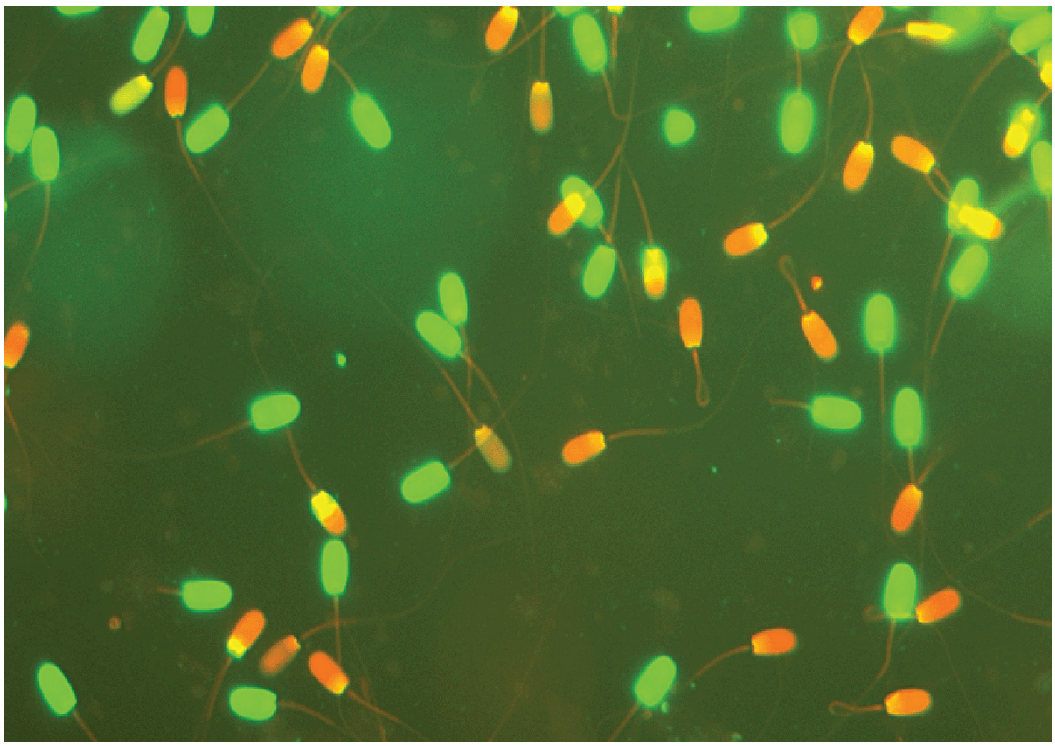
as a teaser and is as good as cow. The main criteria for selection of a teaser are physical strength, appropriate height and immobility. The bull is brought near the dummy and few false mounts are allowed before collecting semen. This practice increases the volume of semen and concentration of sperms. After mounting the sheath of the erected penis is hold in hand and directed towards the AV. Most of the ruminants are thrust ejaculators and their penis is made up of elastic tissues and hence AV temperature is very much essential rather than the pressure inside the AV. Once the semen is ejaculated and the donor dismounts the collection tube is pulled down and the valve is opened to release the air and water. The collection tube should be covered to protect the semen from intense sunlight and fluctuating ambient temperature.

Artificial vagina for semen collection

Semen collection from bulls

Semen evaluation

It is economically and biologically important that only semen with a high fertilizing potential should be used in AI programme. Generally, in most of the semen stations in the country, the ejaculate quality is assessed to find out its suitability for preservation. These tests include the following. Immediately after collection, the ejaculate is examined for colour, volume, mass activity and for contamination if any. Then the sperm motility is estimated using microscope. It is advised to estimate the proportion of live spermatozoa, intact acrosome spermatozoa, membrane intact spermatozoa and sperm abnormality. Nowadays computer assisted semen analyzers (CASA) are commonly used to quantify different motility parameters.



Quality assessment of bull spermatozoa (live spermatozoa – green colour; dead spermatozoa – red)

Semen preservation and storage

Semen is then diluted in an extender which provides an appropriate concentration of spermatozoa, allowing more inseminations from each sample. The extender also nourishes and protects the spermatozoa during storage and distribution. Bull semen can be preserved either at refrigerated temperature (short term; 3-4 days) or at ultra low temperature (-196^{o}C). The extension rate depends upon the purpose, sperm concentration and semen volume. Generally, the extension ratio is 1 part of semen with 10 parts of extender for preservation at refrigeration temperature. For refrigerated storage, semen is extended at minimal part

(semen 1 part: extender 3 parts) and cooled to 5°C over a period of 2 hours. Initially extended semen is further extended with precooled extender (5°C) to the final amount and stored in a refrigerator. In case of bovine, the dilution rate is kept in such a way that each ml of the extended semen contains at least 25 million sperm/ml. The motility and fertility of the semen is good up to 72 hrs in refrigerated temperature.

Ultra low preservation or freezing of semen is of great importance in livestock breeding and farm management. It has made it possible to make available the use of outstanding proven sizes for larger number of cows, covering larger area, frozen semen shipment has become possible to different continents in the globe to any place connected with any service. At present frozen semen is used in most of the states in India. For ultra low temperature, the semen is extended with extender (generally Tris Egg Yolk Citrate extender is used) containing a cryoprotectant (generally glycerol) and extended semen is filled in straws (French straws) and equilibrated at 5°C for 4 hours. Then the straws are exposed to liquid nitrogen vapour for 8 – 10 minutes and plunged into the liquid nitrogen. The semen can be stored for an indefinite period in liquid nitrogen, however care should be taken to maintain proper liquid nitrogen level in the container. Identification of the bull is done on each individual semen container. Each straw contains around 20 million spermatozoa.

Transportation

The frozen semen is transported dipped in liquid nitrogen, the main precautions in the transportation of frozen semen are:

1. It should be ensured that the level of liquid nitrogen does not go down and the semen straws/ampoules remain dipped in liquid nitrogen.
2. Liquid nitrogen containers should be protected from damage during transportation.
3. Undesirable material should not be put in the liquid nitrogen containers.
4. Transportation with public vehicle should be avoided. It may lead to serious consequences.
5. The consignee should be well informed about details of semen, date of dispatch and mode of transportation etc.
6. The container should be labelled as; living biological product, handle with care, rush it etc.

Insemination methods

Insemination can be carried out surgically or non-surgically, the later being most commonly used in farm animals. Non-surgical method of insemination can be carried out using a speculum or recto vaginal method. Recto vaginal method is the most popular technique

of insemination for large animals. An advantage in this method is that it is possible to find out the estrus stage and other pathophysiological conditions of the female genital tract. In this method, gloved, well-lubricated hand is introduced into the rectum and the faeces is removed. Inside the rectum the lower wall is pressed down with the hand to locate the uterus and the cervix is grasped. Before inserting the insemination rod into the vagina, the vulval area is cleaned with towel and while inserting the rod care should be taken to prevent the tip of the rod touching the vulva lips. The rod initially is introduced at 45^0 angle and then made straight line with the animal's body. When the rod reaches the anterior vagina it is guided through the external os of the cervix with the help of gently pressure and manipulation of cervix with the hand in rectum until desired penetration is achieved. Then the semen is deposited by pushing the stillet of the insemination rod.

Site of semen deposition

In natural service the site of semen deposition varies with species. In cattle, buffaloes and ram, the semen is ejaculated in the anterior part of the vagina i.e the semen is sprayed on and around the os uteri. In horse, the semen is partly ejaculated in the cervix and partly into the uterus. In the sow, most of the semen usually is ejaculated into the uterus since the penis of the boar enters in the cervix. In AI with liquid semen, the preferred site of deposition in mid cervix however, uterine insemination is also possible. When frozen semen is used it may be deposited in the mid cervix or in the uterine body. In case of sperm deposition at mid cervix the cervical mucus provides optimum environment for longer survival of sperm, and cervix is less susceptible for trauma by the catheter compared to the uterus. Also, chances of induced abortions especially in early pregnancy and gestational heat are eliminated. However, when sperm are deposited in the mid cervix, a significantly higher degree of retrograde loss of spermatozoa occurs. Hence it is now recommended that frozen semen is to be deposited at the beginning of the uterine body but due care need to be given so that no damage occurs to the uterus.

Time of insemination

Spermatozoa require some period of stay in female reproductive tract to acquire final changes for fertilization to occur. This process is called as "capacitation". On an average a cow is in heat for 12 - 24 hours and ovulation occurs approximately 10 - 12 hours after the end of the estrus. Thus, insemination between mid estrus to end of the estrus gives maximum conception rate. In routine practice cows and buffaloes that are in detected in heat in morning are inseminated in evening and those, which are diagnosed in heat in the evening, are inseminated in the morning. Animals whose cervical mucus shows typical fern pattern are more suitable for successful insemination. Several studies suggest insemination of cattle and buffaloes at 12 - 18 and 18 - 24 h after onset of estrus, respectively results in better conception rate.

Accomplishing high conception rate in bovines using AI

Several steps are to be followed in day-to-day insemination practices to achieve high conception Rate in cattle and buffaloes under field conditions.

Frozen semen quality: In order to achieve high post thaw semen quality, it is essential to obtain high quality fresh semen. From collection of ejaculate to deposition of semen in female reproductive tract, spermatozoa are extremely sensitive to deviations in temperature. Usually, semen stations supply frozen semen straws of ejaculate obtained from highly fertile bulls after they full fills the post thaw requirements. The steps to be followed after receiving the frozen semen straws are discussed in detail.

Semen storage, transfer and retrieval: Once frozen, exposure of straws to temperatures above –130°C and re-cooling results in irreparable sperm cell damage. This results in reduced sperm motility, viability and acrosomal integrity. Progressive motility of sperm is required for transport of spermatozoa from the site of deposition to the site of fertilization, while acrosomal integrity is essential for membrane specific recognition and binding of sperm with ovum. Hence, it should be ensured that the canister containing semen is well below the top of the tank neck.

Handling of straws and thawing: The straws should be removed from LN_2 container using a tweezers/forceps as quickly as possible (with in 3-5 seconds) and shaked to remove excess nitrogen. It is generally advocated to thaw the frozen semen straws at 37°C for 30 seconds. The temperature and time must be followed strictly to achieve high post thaw sperm recovery rate. Hence, it is important to maintain necessary equipments for heating arrangements, thermos flask and thermometer. Frozen semen straws can be thawed vertically as well as horizontally, but, it is important that in both the methods straws should be fully dipped in water. After thawing, the straws should be wiped gently to remove water. It should always be remembered that water is lethal to spermatozoa. If the air bubble is located in the single plug (laboratory seal) side of the straw, then it can be cut with clean scissors. If it is located in the middle of the straw, it should be moved towards the single plug side by shaking gently before cutting. The straw should be gently placed in the gun and slided into the sheath and the sheath should be secured with the gun tightly using 'O' ring. Before loading, the AI gun should be warmed. There should be no gap between the cut end of the straw and the sheath otherwise part of semen may remain in the sheath thus reducing the number of spermatozoa per insemination.

Selection of female for insemination: It is essential that insemination should be done at proper estrus to obtain high CR. Though the owner/herds man of the animal to be inseminated claim that the animal is in estrus, it should be confirmed by clinical/gynecological examination. Efficiency of detection/confirmation of estrus using clinical methods vary with inseminators depending upon their expertise, knowledge level etc. In India, besides

veterinarians, village level workers and technicians are also performing AI. The arborization pattern (fern pattern) of cervical mucus can be used to predict the optimum time of insemination. It is not advocated to palpate ovaries during estrus or before insemination unless one has proper expertise in gentle handling of ovaries. Rough handling may lead to rupture of the Graffian follicle and anatomical disposition of fimbria of oviduct leading to alterations in egg pick up.

Properly timed insemination: The most important primary requisite to obtain high CR is inseminating cows and buffaloes at appropriate time. It is generally advocated that insemination should be done from the middle to end of estrus. Thumb rule under field conditions is if the animal exhibits beginning of estrus signs in late night or early in the morning it should be inseminated evening of the same day. If the estrus signs start at late morning/ afternoon/ evening then the animal should be inseminated next morning.

Proper method of insemination: All efforts to make AI successful using proper collection, handling and processing of semen are worthless if insemination is not properly carried out. The cow or buffalo to be inseminated should be restrained well; otherwise there is every chance to damage the uterus by AI gun and improper deposition of semen leading to poor CR. Before introducing the gun, perineum and vulval area of the animal has to be wiped properly to avoid infection carried through the gun. Insemination gun should be inserted at 30-45^{o} angle after opening vulval lips to avoid urethral opening. In case of frozen semen, the site of deposition is the body of uterus, just next to the internal os of the cervix. After withdrawing the gun, uterus can be massaged gently as it may hasten the sperm transport.

Clitoral stimulation: In normal cyclic buffaloes, ovulation has been reported to occur between 11 and 20 hrs after the end of estrus. But, the time period between end of estrus and ovulation has been found to be longer (25-48h) in higher percentage of sub-estrus buffaloes. It is well known that in buffaloes the incidence of sub-estrus is high. Hence, delayed ovulation has been reported to be a cause for low conception in buffaloes under field conditions. Mechanical stimulation of reproductive tract by massaging clitoris after AI has been shown to improve CR by hastening the surge of luteinizing hormone and ovulation. The clitoris should be massaged gently and immediately after insemination to get favorable results.

Figure: Proper method of artificial insemination and messaging of clitoris

Activity

1. Go to nearby veterinary hospital and observe how artificial insemination is performed

Review Questions

1. Artificial insemination is comparatively easier in ———————————— than in ————————————

2. Write about AV method of semen collection

3. What is the common extender used for cryopreservation of semen?

CHAPTER-14

Breeding Calendar, Gestation Length in Different Dairy Animals, Pregnancy Diagnosis, Record Keeping

Objective

1. To learn the use of breeding calendar.
2. To understand gestation and pregnancy diagnosis in dairy animals.

Why to use a breeding calendar?

Success of any dairy farm depends upon how often the cows calve. This requires efficient observation of heat, insemination at the right time, drying off prior to calving and attention at calving time. This information can be written down in note books, on loose sheets of paper but it may be irregular and forgotten. A simple breeding calendar, kept in the barn, makes it easy to write down every important event for each cow in the herd.

A breeding calendar helps to improve breeding in a herd. The important things about the cows can be written on the calendar. Checking breeding calendar every day helps to plan breeding. From the breeding calendar one can know when the cow is going to calve, when the cow show heat, when was she bred and when she should be dried off. Even in the small herd, efficient breeding is the main problem. A breeding calendar can often improve breeding efficiency on the farm considerably, because it helps the farmer to do the right thing at the right time.

Gestation length in different dairy animals

Breed	Gestation length (days)
Aberdeen Angus	273-282
Ayrshire	277-278
Jersey	277-280
Holstein	278-282
Shorthorn	281-282
Guernsey	282-285
Hereford	283-286
Brown Swiss	288-291

Brahman	271-310
Afrikaner	293-296
Sahiwal	278-289
Red Sindhi	276-285
Kankrej	279-288
Buffaloes	310

Pregnancy diagnosis

Early identification of nonpregnant dairy cows and heifers post breeding can improve reproductive efficiency and pregnancy rate by decreasing the interval between AI services and increasing AI service rate. Thus, new technologies to identify nonpregnant dairy cows and heifers early after artificial insemination may play a key role in management strategies to improve reproductive efficiency and profitability on commercial dairy farms. There are several methods for diagnosing pregnancy in dairy animals.

Attributes of the ideal pregnancy test

For successful integration into a reproductive management system, an ideal early pregnancy test for dairy cattle would be 1) sensitive (i.e., correctly identify pregnant animals) 2) specific (i.e., correctly identify nonpregnant animals), 3) inexpensive, 4) simple to conduct under field conditions, and 5) able to determine pregnancy status at the time the test is performed. Most currently available methods for pregnancy diagnosis exhibit one or more of these attributes, but none currently available or under development exhibit all of them.

Non-return to heat*:* Non-return to estrus from 18 to 24 days after AI is often considered by dairy farmers the easiest and least costly method for determining nonpregnancy in dairy cattle early post breeding. However non-pregnant animals also may not return to heat due to other reasons, which is the disadvantage of this method of pregnancy diagnosis.

Transrectal palpation*:* Rectal palpation has been routinely used for pregnancy diagnosis in cows for many years and has remained one is the most simple and valuable methods. The documented reports suggest an average efficiency of >95^{0}C for this method to detect pregnancy accurately after 50 days of pregnancy. The landmarks for pregnancy diagnosis by rectal examination are given below.

Landmark	Remarks
Corpus luteum of pregnancy	The accuracy of this method is around 80% for pregnant and higher for non-pregnant animals.
Disparity in horn size	Gentle handling is required, accuracy is high
Amniotic vesicle	Careful and gentle palpation is required to avoid direct pressure on the vesicle, which may lead to death of the embryo
Slipping of fetal membrane (double slipping)	This can be best performed 40-90 days of gestation with high accuracy
Palpations of placentome	Accuracy 100%
Palpation of "thrill" in the middle uterine artery	Pulse in internal iliac artery should be differentiated from middle uterine artery; the later is movable while the former is tightly secured.

Progesterone assay: Progesterone, a hormone associated with pregnancy can be used to detect the pregnancy of animal. It can be estimated in blood as well as milk at 21 - 24 days after mating. Elevated levels of progesterone indicate pregnancy. The efficacy of this test in detection of pregnant animal is around 80% while it is 100% in detection of non-pregnant cattle.

Detection of pregnancy specific proteins: This method involves specific detection of protein associated with pregnancy. These are secreted by placental membrane are detectable in maternal circulation. Several specific markers have been identified for detection of pregnancy. These include pregnancy specific protein B (PSPB), bovine pregnancy - associated glycoprotein (bPAG), pregnancy serum protein (PSR 60) etc. PSPB can be estimated after 30 days of breeding. A limitation with this protein is that, it is present in the blood of the cows even up to 80 days after calving. The bPAG assay can be carried out from 30 days of gestation onwards while the PSP60 assay can be used from day 28 of gestation onwards. Early pregnancy factor (EPF) is one of the protein seeneted during pregnancy shortly after fertilization. Its molecular weight is nearly 21KDa. Rosette inhibition test is used to detect EPF in sheep as early as 6 - 24h after fertilization.

Ultrasonography: Diagnostic ultrasound scanners with transducers suitable for transrectal and transabdominal use have become available recently for imaging the reproductive tract of large and small animals. With this instrument, a trained operator, can visualize organs previously accessible only with tactile sense and is used to monitor the pregnancy and embryo loss. The method of scanning in large animals is transrectal. In this method the animal is prepared in a similar way as for rectal examination. If there are some faeces or air between the surface of transducer and rectal mucosa, the image will be disturbed. After

removal of faeces, the ultrasound transducer is covered with coupling gel and introduced into the rectum. First structure to be located is cervix because of its hyperechoic nature. The transducer is then moved over the body and horn of the uterus.

Indications of pregnancy

i) Presence of non-echogenic area in transverse as well as in longitudinal image.

ii) Embryonic heart beat.

iii) Placental membranes containing embryo and fluid.

iv) Placentomes in later stages

Record keeping

Keeping track of what is happening on the dairy farm requires some records. Good farm management requires a good useful set of farm records. Farm records are like the report cards students receive at school. With a farm report card, farmers can tell how well they are managing their operation compared to other producers. They can also see the strengths and weaknesses in their operation.

The information on calving dates, daily milk yields, daily herd milk yield, regular milk composition data, mastitis treatment, routine monitoring of feed offered, live weight and body condition of young stock, dates when each cow is on heat, dates and results of pregnancy diagnoses, animal sickness, veterinary visits and drug treatment, routine vaccination and drenching, stock purchases and sales of culls, stock deaths and probable causes, milk and concentrate intakes of young calves, yields of forage crops and other dairy enterprise sales etc. should be recorded and available at any given time in the farm.

Following are some of the important records to be kept in dairy farms.

Cow byre sheets/Milk recording book: This record may contain body weight, body condition scores, daily milk yields, fat and SNF percentages, total lactation length and yield, concentrate use, drying-off dates, oestrus, breeding details and incidence of diseases like mastitis.

Individual animal cards: All the details of individual animals

The heifer record card

The breeding record card

Production records

Veterinary records

Cow and heifer calendars

Insemination / pregnancy diagnosis (PD) notebook

The daily diary

Review Questions

1. What is the importance of record keeping?
2. Name the methods for pregnancy diagnosis. Describe progesterone assay.

CHAPTER-15

Common Reproductive Disorders in Dairy Animals – anestrus, repeat breeder, abortion, dystocia, prolapsed etc.

Objectives

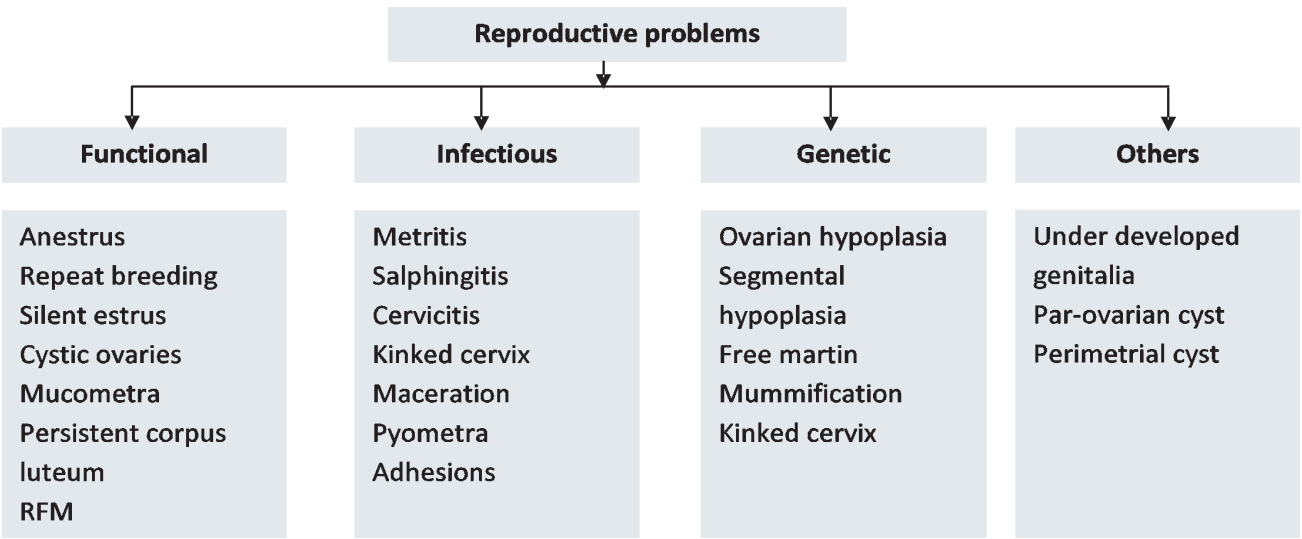
To learn about the most commonly occurring reproductive disorders in dairy animals

Introduction

Reproductive disorders and associated Infertility (transient loss of fertility) among cattle and buffaloes pose serious economic loss to farmers in terms of low returns and veterinary expenses. Due to impaired reproduction ability, the calving to conception (days open) period is prolonged leading to extended calving interval, which jeopardize the aim of obtaining a calf per cow per year. The causes of infertility in dairy animals are many and can be complex. They relate to follicle development and maturation, onset of estrus, successful coitus/insemination, ovulation, fertilization, implantation, the development and delivery of the normal fetus and its membranes, proper uterine involution and cleansing, resumption of ovarian cyclicity and estrus expression.

What are the common reproductive problems in dairy animals?

The reproductive problems can be divided into some major categories which include functional disorder, infectious disorders, genetic disorders and other miscellaneous disorders. The following figure depicts some major reproductive disorders.



Among the reproductive disorders, repeat breeding and anestrus are more common and results in huge loss to the farmers.

1. What is repeat breeding?

A repeat breeder cattle or buffalo is defined as one that has apparently normal genitalia without any abnormal discharge from genital tract and with normal estrous cycle and estrous period but fails to conceive after 3 consecutive inseminations/services with fertile semen/bull.

Repeat breeding (RB) in cattle or buffalo is one of the most frustrating reproductive problems at field conditions. Incidence RB in cattle and buffaloes ranges from 5.5 to 33 and 6 to 30 per cent respectively. Etiology of RB is mainly divided into: (1) Failure of fertilization, which may be due to defective gametes transport, abnormalities in ovulation and egg pickup or defective gametes and (2) Embryonic morality due to chromosomal abnormalities, dietary deficiencies, high environmental temperature, hormonal imbalance or adverse uterine environment (inflammation and infection). It has been reported that 20-30% of RB cases were due to embryonic morality and approximately 25% of bovine embryos were lost during the first three weeks of life. Failure of fertilization and embryonic mortality cannot apparently be differentiated if the embryo dies before 13 days of gestation because the inter-estrus interval usually remains unaltered. But if the embryo dies after this period, the inter-estrus interval is prolonged. Several reasons have been attributed to resulting in repeat breeding condition.

Managemental and therapeutic approach for repeat breeding

Once the animal is considered as repeat breeder, the cause should be identified. Since RB is a syndrome and may be due to multi-factorial etiology, no single technique or method can be used to diagnose the cause. Examination of the suspected animal at various intervals may be useful to rule out certain conditions and to identify the underlying cause.

1. **Ovulation abnormalities:** Ovulation should take place at proper time so that capacitated/ spermatozoa and ova could meet at ampulla of the oviduct, where fertilization takes place. Normally ovulation takes place at 10-12 hr after the end of oestrus in cattle and buffaloes. Abnormalities in ovulation include delayed ovulation and anovulation. If ovulation occurs beyond the specified time period, it is called as delayed ovulation. If ovulation does not occur (anovulation), the follicle may persist, luteinized and lysed by $PGF_2\alpha$ and the animal may come into oestrus normally or it may turn into cystic. The differential diagnosis between delayed and anovulation can be made by examination per rectum of ovaries of suspected animal on the day of oestrus, day 2 and day 10-12 of the oestrus cycle. If the follicle is present on all three exanimations, the case is diagnosed as anovulation, while if the follicle

is present on first and second examination and a corpus luteum (CL) at the same place on 3rd examination, the case is delayed ovulation. Once diagnosed, delayed/ anovulation can be treated by administration of LH or hCG on the day of estrus.

2. **Subclinical infection:** In subclinical infection of the reproductive tract, there may not be any visible abnormalities in discharge except from occasional whitish flakes and the animal experiences normal cycle length. Because of these subclinical infections, uterine environment is altered, which may interfere with embryo survival. Confirmatory diagnosis is made by uterine cytology or biopsy. However, due to technical constratints, it is not usually practiced at field level. White side test can be used to some extent to identify subclinical infection. In this test to 1 ml of genital discharge, 1 ml of 5% NaOH is added and heated up to boiling. Appearance of yellow colour indicates infection. Uterine infection can be treated with wide range of antibiotics, antiseptics, hormones and other alternative therapies. Post insemination antibiotic therapy may be useful in these cases.

3. **Defective gamete transport:** It may be due to abnormalities in tubular genital tract or hormonal imbalance. Transport of gamete in tubular genital tract is controlled by oestrogen: progesterone ratio. If this ratio is altered, gamete transport is impaired. Other abnormalities like oviductal occlusion (partial/complete) also interfere with gamete transport. This can be easily diagnosed at field level by infusing 1% phenol red or 0.1 % phenosulphonpthalene (PSP) into uterus. Phenolsulphonphthaleine (PSP) is a dye that is not readily absorbed at the uterine lumen. When this dye is placed in the uterine lumen and is the tubes are patent, it passes along them into peritoneal cavity. From this site it is readily absorbed into the circulation and excreted by the kidneys into urine. If an alkali is added to the urine containing this dye the color of the urine changes to red or pink. If the oviducts are occluded, the dye does not go to peritoneum and thus do not appear in the urine. Thus an unchanged urine colour after addition of alkali indicates tubal occlusion and a change of colour to red or pink indicates that the tubes are patent.

4. **Luteal insufficiency:** Progesterone, secreted by CL, is essential for embryo survival. If the CL is not compeletely formed, or if it is not functioning adequately, it leads to failure of pregnancy. Luteal insufficiency has been suspected to cause infertility for many years, and although proof is difficult, repeat breeders are frequently treated on this assumption. It is impossible to diagnose this condition by rectal palpation. Some assessment about luteal function can be done by measuring progesterone level in blood of milk. If other causes are ruled out, a RB animal can be suspected for this condition and can be treated with GnRH or hCG at 2-3 days after insemination to improve the CL formation, at mid cycle to stimulate accessory CL information or at around day 17 to prevent the CL regression.

Fixed time insemination

To avoid human errors in identifying estrus in sub-estrus buffaloes and cattle, $PGF_2\alpha$ can be used to bring the animal into estrus and insemination can be done at fixed time. $PGF_2\alpha$ can be administered at 5-16 days of estrous cycle or to those animals, which have mature CL as assessed by rectal examination. In this case, single injection is usually sufficient to bring the animal into oestrus. Double injection of $PGF_2\alpha$ at 11 days interval can also be employed and it avoids the rectal palpation of CL. It should be taken care that no pregnant animal is administered with $PGF_2\alpha$. It was observed by many workers that fixed time insemination at 72 and 96 hr after $PGF_2\alpha$ administration yielded higher conception rates. Hence, this method can be employed in repeat breeders.

2. What is anestrus?

If the animal fails to exhibit estrus for longer period, excepting during pregnancy, called as anestrus, affects the economy by prolonging the calving interval. This condition is generally observed after parturition (post partum anestrus) especially under field conditions. A variety of factors are known to be associated with anestrus, few important factors are discussed below.

Nutritional

Several cases of prepubertal anestrus reported are due to under nutrition and dietary deficiencies. However, infertility due to deficiency of single nutrient is seldom observed and is usually of multiple deficiencies. Only few nutrients have direct effect on reproduction.

Under feeding: In heifers, under feeding delays the onset of puberty and sexual maturity where as in adults, it is characterized by irregular estrous periods and anestrus. Underfeeding or starvation for prolonged period causes failure of proper follicular development, leading to follicular atresia along with loss of sexual desire. Under feeding may also lead to production of weak young ones.

Protein and vitamin deficiency: Deficiency of protein which delays onset of estrus is not much encountered except due to severe under feeding or inaniation where vitamin A and phosphorus deficiencies are other complicating factors. Except for vitamin A, other vitamins deficiency seldom affects reproduction. Vitamin A deficiency adversely affects reproduction in most species, as it is necessary for maintenance of epithelial tissues. Vitamin A deficiency is characterized by keratinization of epithelium, degeneration of placenta, fetal death, abortion and retention of foetal membranes. Deficiency of vitamin B complex is rare because of the ability of its ruminal synthesis by cattle and buffaloes and may occasionally produce some inhibitory effects on reproduction.

Mineral deficiency: The deficiencies causing anestrus in cattle and buffaloes are mostly

limited to phosphorus and trace elements. The phosphorus requirement for reproduction is about 10 – 12 g daily except during lactation when an additional amount is required. Phosphorus deficiency usually occurs when an animal is fed with a feed, which is low in protein and green grass. The usual symptoms of phosphorus deficiency are delayed onset of puberty in heifers and failure of exhibit estrus in cows. Calcium deficiency does not have much impact on animal's cyclicity. Copper, cobalt, manganese and iron deficiencies are not uncommon and their deficiencies may affect normal reproduction.

Hormonal

Most of the hormonal disturbances causing infertility are secondary to basic nutritional, hereditary and other stress factors. It should always be remembered that indiscriminate use of hormones itself may lead to infertility. Treatment of anestrus depends upon the etiology.

3. What is retention of fetal membranes?

Retention of fetal membranes (RFM) is defined as inability of a cow to shed the fetal membranes even after 12h of parturition. This is an economically important condition because it affects the general health of the cow and her subsequent reproduction and lactation performance. RFM predisposes cows to different peri-partum diseases that includes but not limited to, mastitis, metritis and ketosis, and directly decrease the milk yield and disease resistance. The reproductive consequences of RFM are due to postpartum metritis and include an increase in the service period, days open, calving to conception interval and calving interval. Proper management of cows and buffaloes during pre and peri-partum period is at most important to reduce the RFM and associated complications

Preventive management of RFM

A vast repository of preventive and therapeutic regimes has been reported for RFM with variable efficacy. Prevention of RFM is the key in maintaining post-partum reproductive efficiency. The nutritional management of mature cows for proper body condition and minimal cases of milk fever are the major two points to be taken care to keep the incidence of RFM minimal. Proper growth rates resulting in heifers calving at desirable body weight and selection of calving ease sires are the most important management considerations for prevention of retained placenta in heifers. The strategy should focus on maintaining a healthy, contented and active cow prior to, during and after parturition. A balanced, limited ration during the 6-8 week dry period; sufficient daily exercise; sufficiently large, clean and comfortable calving areas and proper sanitary procedures during the calving period minimize the chances of retention and infections of the reproductive tract.

- In selenium deficient or borderline areas, the administration of a dietary level of selenium (0.1 ppm) tended to minimize the incidence of retained placentas. Vitamin E

and Selenium supplementation during the dry period reduces the risk of RFM. Results indicated that treatment with either type of synthetic Vitamin E (a-tocopherol acetate and a-tocopheryl acetate) was associated with a lower risk of RFM compared with treatment with natural Vitamin E (α-tocopherol). A single intra muscular injection of 1100 IU of DL α-tocopherol acetate and 30 mg of sodium selenite during dry period (preferably on 21 days prior to calving) has been shown to reduce the incidence of RFM.

- Vitamin A and D deficient cows have high retention rates. Intramuscular injections of Vitamins A & D may be given 4 to 8 weeks prior to calving if a deficiency is suspected.
- The calcium:phosphorus ratio for the dry cow is extremely important in the prevention of milk fever, and in turn, retained placentas. Maintenance of calcium:phosphorus ratio between 1.5:1.0 and 2.5:1.0 is absolutely necessary. Above 2.5:1.0, the incidence of milk fever and retained placenta increase. Supplementary phosphorus may have to be fed to dry cows to maintain the proper ratio as recommended by the Veterinarian.
- Administration of either Oxytocin (20-30 IU) or Prostaglandin $F_2\alpha$ (natural 25 mg; synthetic 200 µg) immediately after calving has been shown to reduce the incidence of RFM.

Therapeutic management of RFM

The basic goal in any treatment of RFM is to return the cow's reproductive tract to a normal state as quickly as possible. There are generally two methods of managing retained placenta when no systemic involvements are present manual removal and natural separation.

- Manual removal has long been a common practice but should not be used because of possible injury to the delicate lining of the uterus. In India, it is a common practice to remove the placenta manually even without allowing sufficient time to the cow to expel the membrane normally. This invariably results on uterine infection and associated complications.
- If the membranes are not released due to poor uterine contractions, the afterbirth may detached without damage by applying slight tension externally to the fetal membranes.
- In unavoidable situations, the membrane parts that are easily detachable can be removed gently and some type of antibiotic or antiseptic solution may be placed in the uterus as prescribed by a veterinarian.
- Based on recent research on RFM, the most common recommendation is to allow the membranes to separate naturally with or without the use of medication. Hormones such as prostaglandin $F_2\alpha$, and oxytocin may be used to hasten the process.

- A series of intrauterine infusions is usually more effective than a single treatment. The length and number of treatments considered should be determined on an individual basis as recommended by a veterinarian. In the experience of the authors, infusion into the post-partum uterus leads to complications like salphingio-ovarian adhesion. RFM and associated post-partum complications can well managed by systemic treatment with long acting antibiotics like Ceftiofur.
- Partial retention may go unnoticed until complications such as metritis or pyometra develop. When noticed, affected cows may have increased temperature; be off feed; be depressed; have lowered milk production and have a foul smelling vaginal discharge. These animals should be examined and can be systemically with antibiotics and locally with intrauterine medication (if unavoidable) by a veterinarian.

4. What is abortion?

Abortion in dairy cattle is commonly defined as a loss of the fetus, which has grown to a recognizable size, between the age of 42 days and approximately 260 days. A low rate of abortions is usually observed on farms and 3 to 5 abortions per 100 pregnancies per year is often considered "normal." However, the loss of any pregnancy can represent a significant loss of income to the producer and appropriate action should therefore be taken to prevent abortions and to investigate the cause of abortions that may occur.

Causes of abortion

Non-infectious causes

- Genetic
- Environmental: temperature
- Nutritional: phytotoxins including mycotoxins
- Iatrogenic: administration of abortifacient drugs

Infectious causes

- General infections with high fever
- Specific infections such as brucellosis, BVD etc.

Prevention of abortions

- Proper hygienic and biosecurity measures in the cow's environment and feed storage
- Isolation of aborting cows and immediate removal of aborted materials
- Systematic evaluation of the feed for mycotoxins and other phytotoxins
- Adequate immunization against infectious diseases causing abortion
- Maintenance of adequate breeding and treatment records to avoid insemination of

pregnant cows and administration of intra uterine drugs that may cause abortion to pregnant cows.

5. What is dystocia?

Dystocia, more commonly known as difficult calving, is a problem most dairy producers encounter. Consequences range from the need for increased producer attention to the loss of the cow and calf. Dystocia is a leading cause of calf death at or shortly after birth and leads to uterine infections, more retained placentas, and longer calving intervals.

The causes of dystocia spring from many management choices ranging from breeding genetics and nutrition to management of the cow or heifer during delivery.

- Breeding - genetics can play a role in dystocia through birth weight and heifer development.
- Over conditioned dam - too much fat around the pelvis can lead to a small birth canal.
- Malformation of the calf or the dam.
- Shortened or lengthened gestation.
- Heifers often have dystocia because the birth canal (mainly the vagina and vulva) does not stretch enough for the calf to be delivered.
- Fetal-maternal incompatibility (the fetus is too large or the cow's pelvis is too small) - most frequent cause of dystocia in beef cows/heifers.
- Malposition - more frequent in dairy animals.
- Other diseases - i.e. Milk Fever where there is a decrease in calcium which will decrease muscle tone causing the cow to become too weak to push out the calf, or uterine torsion where the cervix is twisted.

How to avoid dystocia?

- Feed heifers to calve with adequate size at 24 months and cows so that they are in good flesh to calve once a year but not over conditioned.
- Provide a clean, dry, well ventilated and accessible maternity area.
- Observe the calving.
- Give the cow adequate time to prepare herself for delivery.
- Observe strict sanitation procedures when examining a cow.
- Know your limitations and call for veterinary assistance when trouble occurs and before the cow becomes exhausted.
- Provide good neonatal calf care.

6. What is prolapse?

A prolapse is defined as the falling down or slipping of a body part from its usual position.

The complete uterine prolapse is most common at calving. This is when the uterus is completely expelled out behind the cow, and can hang down to the hocks when standing. This condition can be life threatening for the cow, and the uterus must be cleaned and reinserted as quickly as possible. The cow can go into shock quickly and die from blood loss.

A cervical prolapse is usually seen in older cows and occurs when the tissue around the birth canal becomes relaxed during the later stages of pregnancy. The increased pressure in the abdominal cavity will push the vagina or rectum out. If there is tissue trapped outside the birth canal, it can swell and become infected. The bladder can also be trapped in the expelled tissue, preventing the animal from urinating.

How to prevent prolapse?

- It is important not to allow cows to become overly fat during the last trimester of pregnancy.
- Prolapses can also be an inherited trait. If there is a high incidence in the herd, check the bloodliness of the cows and bulls in the herd.
- If large calves are a possible cause of the prolapse, use low birth weight bulls in the breeding program, and provide a ration to keep the cow herd in good condition and not over conditioned.
- When pulling a calf, do not use excessive traction.

Activity

1. Go to field and discuss with the farmers about the most common reproductive disorders with their animals
2. Got to nearby veterinary hospital and observe how the cases of reproductive disorders are being handled

Review Questions

1. Define repeat breeding.
2. What are the possible causes for anestrus in dairy animals?
3. How dystocia can be minimized?

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