UNIT 1

Digestive System

Structure

1.1 Digestive system of Ruminants

1.2 Digestions of Carbohydrates, Proteins and Fats in Ruminants.

1.3 Summary

1.1 Digestive System of Ruminants

Fig. 1.1 Sketch Diagram of Digestive System
1.1.1 Description of Digestive System

The digestive system of cattle consists of mouth, pharynx, oesophagus, stomach, intestine, liver and pancreas.

Mouth

The mouth is the first part of the alimentary canal. It consists of lips, teeth, tongue and salivary glands.

(a) Lips: There are two lips, upper lip and lower lip. The upper front portion of the upper lip up to nostrils is known as Muzzle, which is wet in health and dry when the animal is sick.

(b) Teeth: There are two types teeth present in cattle. Temporary/milk teeth present in calves and permanent teeth is present in adult animals. The conventional way of describing the number of each type of tooth present in each jaw is called “dental formula”.

a) Temporary teeth

\[ I - 0/4 \quad C - 0/0 \quad P - 3/3 \quad M - 0/0 = 10 \times 2 = 20 \]

b) Permanent teeth

\[ I - 0/4 \quad C - 0/0 \quad P - 3/3 \quad M - 3/3 = 16 \times 2 = 32 \]

I = Incisors
C = Canine
PM = Premolars
M = Molars.

The lower jaw, which is known as Maxilla, consists of `12 molars only. There are no incisors in upper jaw. The teeth in the upper jaw are replaced by dental pad.

(c) Tongue: The tongue is situated on ft floor of the mouth. It has three parts i.e. root, body and tip.

(d) Salivary Glands: The glands situated around and in the mouth of the cattle are known as salivary glands. They are parotid glands, mandibular glands, sublingual glands etc.
Pharynx

The pharynx is a funnel shaped passage situated at the back of the mouth, which is common for respiratory and digestive passage.

Oesophagus

Oesophagus is a muscular tube, which conveys the food and drink down to the stomach from the mouth.

Stomach

- The stomach of the cattle is very large and compound.
- It consists of four parts, Rumen, Reticulum, Omasum and Abomasum.
- The ruminating animals take the food plenty without chewing, and such food is stored in Rumen.

Stored food is brought back to the mouth for mastication and mixing of food with saliva to make a pasty material which is fit for digestion, this process is known as Rumination.

![Fig. 1.2 Organs that Comprise the Stomach of Ruminant](image)

(a) Rumen

- This is the first part of the stomach in ruminants.
- It is a big sac occupying the left side of the abdomen.
- The rumen is a large fermentation chamber (in adult cattle its volume is about 125 litres) which has a very high population of micro-organisms, mainly bacteria, but also protozoa.
- It is because the bacteria secrete the enzymes necessary for cellulose degradation that ruminants are able to utilize roughage.
· The rumen has a textured surface, lined with projections (up to 1 cm long), termed rumen papillae.

· The rumen, along with the omasum, absorbs the by-products of bacterial fermentation. These by-products are volatile fatty acids (VFAs).

(b) Reticulum

· This is the second part of stomach of ruminants, T

· The mucus membrane of this part is triangular or a square marking looking honey comb structure.

· The heavy or solid objects, which are swallowed by animal, are collected this portion.

· If these objects are sharp and pointed they may penetrate, the diaphragm and heart and causes a severe disease known as “Traumatic pericarditis”.

(c) Omasum

· This is the third stomach, of ruminants. It is in round shape, it has leafy rough portions through which the food passes crushed in between the leaves of this portion.

(d) Abomasum

· This is the fourth part of stomach of ruminants.

· This is also known as “True stomach”. It follows the third stomach and is pear shaped sac lying on the floor of the abdomen on the right side.

· It has digestive glands known as cardiac, fundus and pyloric.

· These glands secret the gastric juices which aid in digestion.

· The pH of the abomasum is normally in the range of 2.0 to 2.5. This low pH facilitates initial protein breakdown, and kills the bacteria which have spilled over from the rumen.

Intestine

· This is the part of the alimentary canal.

· In this portion the digestion and absorption of foodstuffs takes place.

· The first portion is known as small intestine and the rest is large intestine.
a) **Small Intestine**

- The length of the small intestine is about 130 feet in cattle and lies at the right side of the stomach.
- This is divided into three portions known as “Duodenum” “Jejunum” and “Ileum”.

b) **Large Intestine**

- The large intestine is divided into three portions called caecum, colon and Rectum.
- The caecum is about 2 1/2 feet and colon is about 35 feet which is just like coils of watch springs. The third last position is Rectum which ends with Anus.

**Liver**

- Liver is situated just close to the diaphragm.
- Its colour is dark red-brown. It is a large gland.
- The main function of this is to produce bile, which aids in digestion of foodstuffs.
- The bile is poured into small intestines through bile duct.

**Pancreas**

- It is situated in abdomen in front of the kidneys.
- The colour is reddish cream and it secretes pancreatic juice which is poured in small intestines and it helps in digestion.

1.2 **Digestion of Carbohydrates, proteins and Fats in Ruminants**

1.2.1 **Digestion of Carbohydrates**

- Plant tissues contain about 75 per cent carbohydrates of one kind or another, and provide the primary source of energy for both the ruminal organisms, and the host animal.
- In ruminants the major part of all carbohydrates, including the complex carbohydrates such as cellulose and hemi-cellulose, is digested by bacterial action in the rumen.
- During microbial digestion an appreciable amount of methane gas is produced.
· Approximately 6 to 7% of the food energy of the ruminant is lost as methane.

· The main end-products of carbohydrate digestion are volatile fatty acids. Of these, acetic acid forms the major proportion, followed in declining order by propionic, butyric, and valeric acids.

The VFAs are absorbed into the bloodstream through the rumen wall, and constitute 66 to 75% of the energy derived from the feed.

![Diagram of microbial digestion of carbohydrates in the rumen](image)

- Carbohydrates, such as sugars and starches, that escape ruminal digestion are digested in the abomasum, and the end-products are absorbed through the small intestine.

1.2.2 Digestion of Fats in Ruminants

- 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.

1.2.3 Digestion of Proteins in Ruminants

- Dietary protein, like dietary carbohydrates, is fermented by rumen microbes.
· The majority of true protein, and non-protein nitrogen (NPN), entering the rumen is broken down to ammonia, which bacteria require for synthesizing their own body protein.

· Ammonia is most efficiently incorporated into bacterial protein when the diet is rich in soluble carbohydrates, particularly starch.

· Ammonia, in excess of that used by the micro-organisms, is absorbed through the rumen wall into the blood, carried to the liver, and converted to urea, the greater part is excreted in the urine.

Fig. 1.4 Fig. Protein digestion in the rumen

· Some urea is returned to the rumen via the saliva, and also directly through the rumen wall.

· The undegraded true protein fraction, plus the microbial protein, passes from the rumen to the abomasum, where it is digested, and absorbed into the bloodstream through the walls of the small intestine.

1.3 Summary

The digestive system of dairy animal was discussed in detail with the help of neat sketch diagram which was labelled. The digestion of carbohydrates,
fats and proteins in ruminants were discussed well. The role of end products of carbohydrates, proteins and fats are explained well.

**Short Answer Type Questions**

1. Name the parts of ruminant stomach.
2. Which part of rumen is called honeycomb?
3. Which portion of stomach is ruminants are called True stomach?
4. What are the parts of small intestine?
5. What are the accessory glands present in digestive system?
6. What are the end products of carbohydrates digestion?
7. What is fate of end products of carbohydrate digestion in ruminants?
8. What is chyme?

**Long Answer Type Questions**

1. Draw and label the parts of ruminants digestive system?
2. Briefly discuss about parts of ruminant stomach?
3. Explain about various glands of digestive system of ruminants?
4. Write in detail the digestion of carbohydrates in rumen?
5. Briefly write about digestion of proteins and fats in ruminants.
6. What is the fate of end products of carbohydrate digestion in ruminants?
7. Briefly explain about the fate of end products of fats and protein digestion in ruminants?
UNIT 2

Common Feeds and Fodders

Structure

2.1(a) Classification of Nutrient and their role in Animal nutrition - water, crude, ether extract, Proteins, Minerals, Vitamins and Nitrogen free extract.

2.1(b) Importance of analysis of feeds

2.2 Classification of Feeds

2.3 Importance of Unconventional Feeds

2.4 Composition of commonly used Feeds and Fodders

2.5 Summary

2.1 (a) Classification of Nutrients and Their Role in Animal Nutrition

The nutrients in the feed classified in to

- Water,
- Crude fiber,
- Ether extract,
- Proteins,
• Nitrogen free extract
• Vitamins
• Minerals

2.1.1 Water

• The most essential nutrient. The cow’s body consist of 50-75% water and milk contains 87% water.

• Maintains body temperature, transports nutrients, involved in digestion, metabolism and removal of wastes.

• A dry cow needs 30 - 40 litres (L) of water per day.

• An extra 4 litres of water is needed per litre of milk produced.

• Requirements can increase in hot weather.

• A cow producing 20 litres needs 110 litres of water each day.

• All feeds contain some water, which is usually expressed as a percentage of the total feed.

• The percentage of water varies between feeds. Lush pasture contained 85% water and 15% Dry Matter, whereas cereal grains may be only 10-13% water and 87-90% Dry Matter.

2.1.2 Crude fibre

• Represents the fibrous components of a feed

• Crude fibre forms the physical bulk of the diet. It is Necessary for rumen function.

• Source of energy from digestion of the structural carbohydrates.

• Causes rumen movement and mixing of rumen contents with microbes, thus starting the breakdown process.

• Also allows rumination (cud chewing) to occur.

• Stimulates saliva production - saliva contains sodium bicarbonate, which acts as a ‘buffer’ to prevent the rumen becoming too acid.

• There are different ways of measuring fibre in the diet, which relate to the digestibility of different types of fibre. These include Crude Fibre % (CF%), Neutral Detergent Fibre % (NDF%) or Acid Detergent Fibre% (ADF%).
· Neutral Detergent Fibre (NDF) : A measure of all the fibre, both indigestible and digestible. Represents the cell wall component of feeds - including the structural carbohydrates (cellulose and hemicellulose, which are partially digestible) as well as lignin and silica (indigestible). As the NDF content of the diet increases (ie more bulk) animal intake decreases.

· Acid Detergent Fibre (ADF) : Measures the less digestible or indigestible parts of the cell walls, including the cellulose (more slowly digested than hemicellulose) and the lignin and silica (indigestible). The ADF% is used to calculate the digestibility of a feed - the higher the ADF value, the lower the digestibility of a feed.

2.1.3 Ether extract/Crude fat

· Crude fat content is estimated by extracting a ground feed sample with diethyl ether.

· The ether soluble components (ether extract) may include true fats and oils, fatty acid esters, compound lipids and fat-soluble vitamins or provitamins such as the carotenoids, all of which may have nutritional value.

· However, ether extract may also contain significant concentrations of indigestible waxes, resins and essential oils.

· The measurement of crude fat was an important part of the historical method of proximate analysis where it represented feed components with a caloric value 2.25 times that of carbohydrate or protein.

· Diets for baby calves that include large quantities of milk or milk replacer may contain 10 to 35 percent fat in the DM consumed.

· Fat may be added to the diets of adult ruminants to increase energy density and to reduce feed dustiness.

· Typical diets usually contain no more than 4 percent fat in the DM.

· Total fat and oil should be limited to less than 7 percent of the DM in lactating cow rations.

· Too much fat decreases feed intake, may depress fat and protein content of milk, and may cause scouring.

· Commonly fed sources of fat include whole cottonseeds, full-fat soybeans, sunflower seeds, tallow, and various rumen-inert fat products.
2.1.4 Protein

- Protein builds and repairs all body tissues.
- It makes up the muscle, skin and internal organs of the cow.
- Hormones and enzymes which assist digestion are all proteins.
- Protein is required for maintenance, growth, pregnancy and for the production of protein in milk.
- There are different measures of dietary protein, including Crude Protein % (CP%), Rumen Degradable Protein (RDP) or Undegradable Dietary Protein (UDP).

- All proteins are made of chains of amino acids, which contain Nitrogen.
- Crude Protein % of a feed is calculated by measuring the total amount of Nitrogen in a feed and applying the formula:
  \[ \text{Crude Protein %} = \text{Nitrogen content (%) x 6.25} \]
- Nitrogen in feeds can be found either in amino acids (True Protein) or in other forms (Non-Protein Nitrogen, or NPN). For this reason, Crude Protein % is a slightly ‘crude’ measure, as not all of the Crude Protein is True Protein. True Protein consists of chains of amino acids, whereas Non-Protein Nitrogen consists of simple forms of nitrogen, such as Nitrates.

- True protein can be further classified into two types – Rumen Degradable Protein (RDP) and Undegradable Dietary Protein (UDP).

- Rumen- Degradable Protein (RDP) : This protein is broken down (degraded) in the rumen by the rumen microbes to form peptides, amino acids and ammonia, which are then used to ‘build’ more microbes.

- Undegradable Dietary Protein (UDP) : This protein escapes or ‘bypasses’ the rumen without being attacked by the microbes. It is digested in the small intestine.

- Protein synthesis by rumen microbes will depend on feed intake, organic matter digestibility, feed type, protein level, and feeding system.

- Brewers grain, distillers grain, corn gluten meal, or heat-treated soybeans are examples of feeds that could be substituted in diets where excess rumen ammonia exists and less than optimal amounts of quality feed protein pass into the small intestine. Excess protein, above requirements, is used as a source of energy.
· Protein is costly, and the higher the percentage of protein in a feed, the greater the cost.

2.1.5 Nitrogen free extract

· Consisting of carbohydrates, sugars, starches, and a major portion of materials classed as hemicellulose in feeds.

· When crude protein, fat, water, ash, and fiber are added and the sum is subtracted from 100, the difference is NFE.

· It is the source of energy to the cattle.

2.1.6 Energy

Energy (includes primarily carbohydrates and fats, but protein also can be used as energy) in a feed may be separated into:

1. The losses that occur in digestion and metabolism,
2. The remainder that is available to the animal for maintenance and production.

![Fig.2.1 Partitioning of Ration Energy and Losses in Dairy Cattle](image)

2.1.7 Total Digestible Nutrients (TDN)

This is another method of expressing the energy content of feeds or the energy requirements of cattle. TDN is comparable to digestible energy. It has been in use longer than the net energy system and more values are available for feedstuffs.

\[
\text{TDN} = \text{Digestible nitrogen free extract (carbohydrate)} \\
+ \text{digestible crude fiber + digestible protein + (digestible ether extract x 2.25)}
\]
2.1.8 Minerals

Twenty-one minerals are considered to be nutritionally essential, or probably essential, to the animal.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Deficiency symptoms and associated problems</th>
<th>Feed sources for dairy cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (Ca)</td>
<td>Rickets; slow growth and poor bone development; easily fractured bones; reduced milk yield; milk fever is a disturbance of normal calcium metabolism.</td>
<td>Alfalfa and other legumes; ground limestone; dicalcium phosphate; steamed bone meal</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>Fragile bones; poor growth; low blood P (less than 4-6 mg/100 ml); deprived appetite (chewing of wood, hair and bones); poor reproductive performance.</td>
<td>Monosodium, monoammonium and dicalcium phosphates; steamed bone meal; cereal grains; grain byproducts; oil seed meals.</td>
</tr>
</tbody>
</table>

Following is the brief information of macro- and micro mineral functions in the body.
<table>
<thead>
<tr>
<th>Mineral</th>
<th>Deficiency symptoms and associated problems</th>
<th>Feed sources for dairy cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (Na)</td>
<td>Craving for salt; reduced appetite; if very severe: incoordination, weakness, shivering, and death.</td>
<td>Common salt and buffer products.</td>
</tr>
<tr>
<td>Chlorine (Cl)</td>
<td>Craving for salt; reduced appetite.</td>
<td>Common salt and commercial supplements.</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>Irritability; tetany; increased excitability.</td>
<td>Magnesium oxide; forages and mineral supplements.</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>Slow growth; reduced milk production; reduced feed efficiency.</td>
<td>Elemental sulfur; sodium and potassium sulfates; protein supplements; legume forages.</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Decrease in feed intake; loss of hair glossiness; lower blood and milk potassium.</td>
<td>Legume forages; potassium chloride; potassium sulfate.</td>
</tr>
<tr>
<td>Iodine (I)</td>
<td>Big neck in calves; goitrogenic substances may cause deficiency.</td>
<td>Iodized salt, trace mineralized salt and EDDI (ethylene diamine dihydroiodide).</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>Nutritional anemia.</td>
<td>Forages; grains; trace mineralized salt and commercial supplements.</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>Severe diarrhea; abnormal appetite; poor growth; coarse, bleached or graying hair coat; osteomalacia.</td>
<td>Trace mineralized salt and commercial supplements.</td>
</tr>
<tr>
<td>Mineral</td>
<td>Deficiency symptoms and associated problems</td>
<td>Feed sources for dairy cattle</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>Failure of appetite; anemia; decreased milk production; rough hair coat.</td>
<td>Trace mineralized salt and commercial supplements.</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>Delayed or decreased signs of estrus; poor conception.</td>
<td>Trace mineralized salt and commercial supplements.</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Decreased weight gains; lowered feed efficiency; skin problems; slow healing wounds; listlessness.</td>
<td>Forages; trace mineralized salt, commercial supplements, and zinc methionine.</td>
</tr>
<tr>
<td>Fluorine (F)</td>
<td>Maximum safe level is 30 ppm. Severe reduction in feed intake; stiffness in legs; enlarged bones. A problem with high fluorine phosphates.</td>
<td>Rock phosphate mineral. Oil meals; alfalfa; wheat; oats; corn (amount varies with content in soil); commercial supplements.</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>White muscle disease in calves; retained placenta; improve reproductive performance; lessen subclinical mastitis. Loss of weight; emaciation; diarrhea.</td>
<td>Widely distributed in feeds; deficiency is rarely a problem.</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.1.9 Vitamins

Vitamins are complex organic compounds that function as parts of enzyme systems essential for the transformation of energy and regulation of body metabolism, and are required in minute amounts for normal growth, production, reproduction and/or health. Based up on the solubility, vitamins are divided into fat soluble (Vitamin A, D, E and K) and water soluble (B complex and C vitamin). A considerable variety of these, namely all the B vitamins and vitamin K, can be synthesized by the ruminal microflora. Vitamin C deficiency has never been demonstrated in ruminants.

Brief information about fat soluble vitamins in ruminants

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Deficiency symptoms and associated problems</th>
<th>Common feed sources for dairy cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Night blindness; skin problems; blind, dead or weak calves; reproductive problems.</td>
<td>Carotene sources: green, leafy forages; hays; haylages (little weathering); unfrosted corn silage; synthetic A; vitamin premix; fish liver oil.</td>
</tr>
<tr>
<td>D</td>
<td>Ricket, osteomalacia.</td>
<td>Sun-cured forages; fish liver oils; synthetic premixes.</td>
</tr>
<tr>
<td>E</td>
<td>Oxidized flavor in milk; muscle problems; white muscle disease; cardiac muscle abnormalities.</td>
<td>Alfalfa; germ of cereals; wheat germ oil; cereal grains; synthetic premixes.</td>
</tr>
<tr>
<td>K</td>
<td>Hemorrhaging; moldy sweet clover disease.</td>
<td>Green, leafy forages. Ample amounts normally are synthesized in the digestive tract.</td>
</tr>
</tbody>
</table>
(b) Importance of Analysis (Proximate) of Feeds.

In order to formulate and produce animal diets it is necessary to gain information about nutritive value of the feeds.

The proximate or Weende analysis of feed is a quantitative method to determine different macronutrients in feed. Basically it is the partition of feed compounds into six categories by means of common chemical properties. The categories are moisture (crude water), crude ash (CA), crude protein (CP), ether extracts (fats or lipids; EE), crude fiber (CF) and nitrogenfree extract (NFE).

![Proximate Analysis of Feed](image)

- The feed sample is initially dried at 103 °C for 4 hours.
- The weight loss of the sample is determined and the crude water fraction is calculated.
- Ashing the sample at 550 °C for 4 hours removes the carbon from the sample, viz. all organic compounds are removed.
Again calculating the weight loss of the feed sample from the dry matter to crude ash (CA) content mathematically determines the organic matter fraction.

The nitrogen content of the food is the basis for calculating the crude protein (CP) content of the feed. The method established by Kjeldahl converts the nitrogen present in the sample to ammonia which is determined by titration. Assuming that the average nitrogen content of proteins is 16 percent multiplying the nitrogen content in % obtained via Kjeldahl analysis with 6.25 gives an approximate protein content of the sample.

Fats and lipids are extracted continuously with ether, after evaporation of the solvent the residue remaining is the ether extract (EE) fraction.

The carbohydrates in a feed sample are retrieved in two fractions (CF, NFE) of the proximate analysis. The fraction, which is not soluble in a defined concentration of alkalis and acids, is defined as crude fiber (CF). This fraction contains cellulose, hemicellulose and lignin. Sugars, starch, pectins and hemicellulose etc. are defined as nitrogen-fee extractives (NFE). This fraction again is not determined chemically it is rather calculated by substracting CP, EE and CF from organic matter.

In recent years, the over 100 year old proximate system has been advanced and improved. Especially the imprecision of CA, CF and NFE as well as CP had been criticized. Modern methods to determine the exact composition of the CA fraction via atomic absorption spectroscopy and the CP fraction via amino acid analyzers, near infrared spectroscopy (NIRS) etc. have been established. Improving the information gained from analysis of feedstuffs and diets also involves the determination of sugars and starch (polarimetric methods) contained in the NFE fraction of the proximate analysis.

2.1.10 Estimation of Fibre Fractions

Van Soest developed a procedure to detect the different components of the cell wall.

This helps specify the CF and NFE fraction. Thereby the complete amount of cell wall components is obtained by digesting (boiling) the feed sample in a neutral detergent solution and results in the neutral detergent fiber fraction (NDF).

The residue after digestion in a solution with sulfuric acid is called the acid detergent fiber (ADF) and contains mainly cellulose and lignin.
Finally the remaining sample is treated with a sulfuric acid with an even higher concentration resulting in a decomposition of cellulose leaving mainly lignin. This fraction is called acid detergent lignin (ADL).

![Fig. 2.3 Proximate Constituent in feed](image-url)
2.2 Classification of feeds

Animal feeds are generally classified according to the amount of specific nutrient they furnish in the ration. They are divided into three general classes:

- Roughages
- Concentrates
- Animal by-products.

2.2.a Roughages

Roughages are bulky feeds which have large amount of less digestible material, but have more than 18% of crude fibre. Roughages are of two types:

A. Succulent forage
B. Dry fodder.

A. Succulent Feeds

Succulent fodder crops have relatively high water content, approximately 75-90 per cent. Succulent feeds are further divided into following types:

1. Pasture
   - Pasture is the grazing land where animals are allowed to graze.
   - It is the only natural way of feeding livestock at a minimum cost.
   - Pastures may be natural or cultivated, perennial or seasonal.
   - The composition of pasture dry matter is highly variable.
   - The crude protein may range from 3 to 30 per cent. The crude protein content decreases as the grass matures. Similarly, the moisture content decreases from 75-85% in young plants to 60% in mature plants.

2. Cultivated Crops

For economical feeding of the animals, it becomes necessary to grow fodder crops. Fodder crops are of two types

(a) Leguminous
(b) Non-leguminous.
a. Leguminous fodder

· Leguminous fodder crops are regarded as the best cattle feed as they are rich in protein, carotene and calcium contents.

· They are nutritious and palatable and can be used for formulating cheap rations by replacing concentrates.

· Eg. (i) Cowpea (*lobia*) (ii) Cluster beans (guar), (iii) Peas (*matar*) (iv) Bengal gram (*chana*), (v) Horse gram, (vi) Moth beans (moth), (vii) Lentil, (viii) Berseem, (ix) Lucerne (*alfaalfa*).

b. Non-leguminous fodder

· The nutritive value of these crops depends on the time and stage of their harvesting. Their flowering stage is supposed to be the richest in nutrient contents.


3. Tree Leaves

· Tree leaves are usually used for feeding sheep and goats and sometimes are fed to cattle during fodder crisis.

· These are also suitable for use as maintenance ration for livestock.

· The young leaves have a fairly high content of crude protein and less crude fibre comparatively.

· The tree leaves and shrubs are generally rich in calcium but poor in phosphorus.

· E.g i) Ber, (ii) *Kachnar*, (iii) Pipal, (iv) Babul, (v) Bael (*bel*), (vi) Subabul, (vii) Jackfruit (*kadIal*), (viii) Banana (*kela*), (ix) Fig (*anjeer*), (x) Mulberry (*shahtoot*).

4. Silage

· Silage is a fermented feed which is made by storing green forages having a high moisture content (60-65%) in the pits under air-tight conditions.
In the absence of air, the forages undergo certain physical and chemical changes.

The entire process requires two to three weeks for getting converted into silage.

Crops suitable for silage are (i) Maize, (ii) Sorghum, (iii) Bajra, (iv) Napier grass, (v) Sudan grass.

5. Root Crops and Kernels

- Root crops have high moisture content (70 to 90%) and low crude fibre content (5 to 12%).
- Roots are generally low in crude protein content.
- Carrot is rich in carotene content and increases the vitamin-A value of the milk. Therefore, it is fed to milch animals during the winter season.
- E.g (i) Carrot, (ii) Potato, (iii) Seed kernels of mango, jamun, (iv) Tapioca, (v) Sweet potato.

B. Dry Fodder

1. Hay

- Hay means grasses or legumes that are harvested, dried and stored at 85-90% dry matter.
- Hay prepared by processing the leguminous crops is superior in quality to the hay prepared from non-leguminous crops.
- Legume hay has a high protein and vitamin content. It is particularly rich in carotene and sometimes, vitamin D and E. The legume-hay is also rich in calcium and is palatable.
- The most common legume hay are lucerne, berseem, cowpea and soybean. Among the non-legumes, hay made from oats and barley compare very favourably with the hay made from grasses.

2. Straw

- Straw is poor quality dry roughage.
- Straw is given to ruminants as fillers because straw hardly has any feeding value.
- It is highly deficient in minerals, vitamins, proteins.
- Even the carbohydrate present is of poor quality and provides between 40 to 50% in digestible energy.

- It is barely sufficient to yield adequate energy to meet their maintenance needs.


### 2.2.b Concentrates

The roughages alone cannot supply all the essential nutrients to the productive, growing and working animals. Therefore, for a complete ration, the roughages have to be supplemented with concentrates. A concentrate is a feed or a feed mixture which supplies protein, carbohydrate and fat at a high level, but contains less than 18% crude fibre with low moisture. On the basis of the crude protein content, the concentrates are classified as:

- (A) Energy rich concentrates (crude protein less than 18%)

- (B) Protein rich concentrates (crude protein more than 18%)

#### (A) Energy Rich Concentrates

**Grains and seeds**

- Grains are seeds from cereal crops.

- Cereal grains contain high amount of carbohydrate with starch as its main component.

- All cereal crops are annuals.

- Crude protein content of the grains and seeds vary from 8-12% and is deficient in two essential amino acids lysine and methionine.

**a. Maize or corn**

- Maize is one of the palatable and popular grains for all kinds of livestock.

- It contains 65% starch, 2% crude fibre, 85-90% TDN and about 10% proteins.

- Yellow maize has ample carotene (Vit. A).

- It has extremely low calcium content and is deficient in vitamin B-12.
b. Barley

- A palatable but fibrous (7% crude fibre) feed and commonly used for young growing and breeding animals.
- Barley is usually steam rolled (flaked) or coarsely ground before feeding.

c. Oats

- Oats has higher crude fibre (10-18%) and lower TDN (71%) than maize.
- It is usually rolled or ground before feeding.

d. Sorghum

- Sorghum grains are slightly higher in protein content and lower in oil content than maize.
- When sorghum grain is replaced by yellow maize, it should be supplemented with 3% dried green feed to compensate for carotene of maize grains.

e. Bajra

- Bajra resembles the feeding value of sorghum. It contains 8-12% of crude protein.
- It is also rich in tannins.

B) Protein Rich Concentrates

- Protein rich concentrates include oilseed cakes, pulse grains and animal by-products.

1. Oilseed Cakes

- The by-products left after the extraction of oil from seeds are used for feeding all kinds of livestock.
- Oilseed cake is in general a very good source of protein.
- It usually has a digestibility of 75-95%.
- Oilseed cakes have a high phosphorus content and vitamin B complex, but are poor sources of carotene, vitamin A and calcium.

a. Groundnut Cake

- Most widely used high protein feed, and can be fed to all livestock and poultry.
· It has about 45% protein and 10% oil content.
· Liable to contain a toxic factor called aflatoxin, particularly in warm rainy season.
· It tends to become rancid especially in warm moist climate.
· It should not be stored longer than 6 weeks in the summer or 3-4 months in winter.

b. Linseed Cake
· The cake is satisfactory for all classes of livestock except for poultry where if it exceeds 5 per cent, it has a depressing effect on the growth.
· DCP content is 30 per cent and TDN 65 per cent.

c. Mustard Cake
· Nutritive value is less than that of groundnut cake (DCP 27% and TDN 74%).
· It should preferably be mixed with other well liked feeds.
· It can be used for poultry birds up to 10 per cent and for pigs up to 20 per cent
· The calcium and phosphorus contents are much higher, being about 0.6 per cent and 1.0 per cent respectively.

d. Cotton Seed Cake
· It is an excellent high protein feed (about 40%) for ruminants but low in the amino acids such as cystine, methionine and lysine.
· The decorticated (dehulled) cottonseed cake contains less of fibre and more of protein than the undecorticated one.

e. Coconut Cake
· The crude protein content is low (20-26%) and poor in lysine and hystidine amino acids.
· The low oil content types (2.5-3%) should be preferred as the higher oil meals tend to get rancid and may cause diarrhoea
· Coconut meal has poor quality of protein and high fiber content.

f. Sesamum or Til Cake
· Widely used for all classes of livestock including poultry.
· The protein content varies from 40-50% and is rich in arginine, leucine and methionine amino acids but is low in lysine.

· Til cake has a high calcium content (2.3%) but the phytic acid present in til binds the calcium, making it unavailable.

· It can be used up to 15% mixed with equal amount of groundnut cake in chicks ration.

g. Soya Bean Cake

· Used for all kinds of livestock including poultry.

· DCP varies from 44-49% and has all the essential amino acids.

· Like some other oilseeds, soyabean also has some toxic substances, but these toxic substances can be inactivated by proper heat treatment during processing.

h. Sunflower Meal

· Sunflower meal is rich in protein (40-44%).

· It can replace groundnut cake totally. It can be included in animal ration up to 20% level.

i. Guar Meal

· It has good quality protein (40-45%) but unfortunately, it is quite unpalatable to animals and may cause diarrhoea.

· Therefore, animals have to be accustomed gradually to its taste.

2. Pulse Protein

· Pulses are the seeds of the leguminous plants.

· These can be fed to livestock at a time when it is available at a reasonable price.

· Most of the pulses should be processed properly to avoid toxicity. Some examples of pulses are a. Kidney bean, mung bean, Cowpea, Field pea Soyabean, Bengal gram etc.

3. Mill by-products

a. Bran

Outer coarse coat of grain separated during processing is called bran.

Eg. rice bran, wheat bran and maize bran. It acts as a laxative.
b. Germ

- Germ is the embryo of a seed. Wheat germ meal contains about 25% CP and 7% fat.

c. Polishings

- These are by-products of rice, consisting of a fine residue that accumulates during polishing of rice grains after initial removal of husk and bran.
  - It contains about 10-15% protein, 12% fat and 3-4% crude fibre.
  - It is an excellent source of energy and vitamin B complex though rancidity can pose problems because of high fat content.
  - This is an excellent feed ingredient for cattle, buffaloes, sheep, swine and poultry.

(C) Animal By-Products

1. Fish Meal

- Fishmeal is a highly nutritious feed supplement obtained from fish body.
  - It contains about 10% moisture, 55% protein, 6.9% fat and 25% mineral salt, especially calcium and phosphorus.
  - It also contains vitamin A, D and B12. Sterilized fishmeal should be used for feeding the growing and producing animals.

2. Meat Meal

- Meatmeal is prepared by boiling and drying the meat obtained from dead animals and powdering it.
  - It contains almost all the nutrients found in meat and is a rich source of animal protein.

3. Blood Meal

- Bloodmeal is prepared by drying the blood in vacuum pans.
  - It contains about 70% protein. The practice of feeding blood meal in India is not common.

2.2.c Feed supplements

Mineral Supplements

- Bone meal
Vitamin supplements

- $AB_2D_3$
- B complex

2.2.d Feed Additives

Feed additives and supplements have played a very important role in enhancing the performance of dairy animals. Today they are necessary in any feed formulation and essential for the formulation of a balanced diet. The additives and supplements used are antibiotic growth promoters (their usage is not banned in India), prebiotics, probiotics, enzymes, mould inhibitors, toxin binders, anticoccidial supplements, acidifiers, amino acids, by-pass fat, by-pass protein, non-antibiotic growth promoters, milk boosters, antioxidants, feed flavours and herbal preparations of Indian origin. A number of these products are imported from developed countries. These includes

Hormones

- Some of the hormones have growth promoting properties like oestrogens, androgens, progestogens, thyroxine and pituitary growth hormones.
  - Iodinated casein is a commercial product which has given variable response.
  - Synthetic oestrogenic hormones like stillboestrol and hexo estrol are being used in many countries as growth promoters. These are being used for poultry, beef and lamb production.

Probiotics

- Many microbial feed additives for ruminants have been used which include bacterial cultures from both ruminal and non-ruminal sources.
  - Most commonly used products are based on Aspergillus oryzae and Saccharomyces cerevisiae. These probiotics increase in milk yield to about 5-7%.
  - The mode of action is still not very clear.

Antibiotics

- Antibiotics are not classified under nutrients, but are considered as feed supplements.
They are chemical substances produced by the microorganism and have bactericidal or acteriostatic action on the other microorganism.

At lower intake the antibiotics are known to be effective in controlling the subclinical infections and stimulating the growth of animals when added to their feed and drinking water.

Other feed additives

- **Calcium Propionate** Increase blood glucose and calcium levels
- **Protected Choline** A methyl donor used to minimize fatty liver formation and to improve fat mobilization
- **Enzymes** Increase fiber digestibility by reducing fiber (cellulase and xylanase enzymes) and DM intake.
- **Magnesium Oxide** Alkalinizer (raises rumen pH) and increases uptake of blood metabolites by the mammary gland raising fat test
- **Methionine Hydroxy Analog** Minimize fatty liver formation, control ketosis, and improve milk fat test
- **Monensin** Improve feed efficiency for lactating cow, reduce ketosis and displaced abomasums in transition cows by shifting rumen fermentation and microbial selection
- **Niacin (B3, Nicotinic Acid, and Nicotinamide)** Coenzyme systems in biological reactions, improve energy balance in early lactation cows, control ketosis, and stimulate rumen protozoa.
- **Probiotics (Bacterial Direct-Fed Microbes)** Produce metabolic compounds that destroy undesirable organisms, provide enzymes improving nutrient availability, or detoxify harmful metabolites.
- **Propylene Glycol** Source of blood glucose, stimulate an insulin response, and reducing fat mobilization.
- **Silage Bacterial Inoculants** To stimulate silage fermentation, reduce dry matter loss, decrease ensiling temperature, increase feed digestibility, improve forage surface stability, and increase VFA (lactate) production
- **Sodium Bentonite** A clay mineral used as a binder, shifts VFA patterns, slows rate of passage, and exchanges mineral ions. Field claims to tie up mycotoxins have been reported.


- **Sodium Bicarbonate/Sodium Sesquicarbonate (Buffer)**: Increase dry matter intake and stabilize rumen pH.

- **Yeast Culture and Yeast**: Stimulate fiber-digesting bacteria, stabilize rumen environment, and utilize lactic acid.

- **Zinc Methionine**: Improve immune response, harden hooves, and lower somatic cell counts.

- **Aspergillus Oryzae**: Stimulate fiber-digesting bacteria, stabilize rumen pH, and reduce heat stress

- **Biotin**: Improve hooves by reducing heel warts, claw lesions, white line separations, sand cracks, and sole ulcers and increase milk yield through a metabolic route

- **Anionic Salts and Products**: Cause the diet to be more acidic, increasing blood calcium levels by stimulating bone mobilization of calcium and calcium absorption from the small intestine.

- **β-carotene**: Improve reproductive performance, immune response, and mastitis control.

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### 2.3. Importance of Unconventional Feeds

The feed ingredients, which are not commonly used in the formulation of rations even though they have fairly good nutritious value, are known as unconventional feeds.

#### 2.3.1 Why unconventional ingredients are used

- To minimize the competition of livestock with the human race for conventional food grains.

- To economise on the cost of feeding, as these are available at low prices.

- Because of the limited availability of conventional foodstuffs.

- At present in India there is a shortage of 11% Dry fodder, 38% of green fodder and 44% of concentrates. To bridge the shortage the remedy is only using unconventional feed ingredients in livestock feeds.

#### 2.3.2 Important Nonconventional Feeds

**a. Sal Seed Cake**

- Sal seed cake contains about 8-9% protein, but it is unavailable to the animals.
· Sal seed cake can be used as a feed for growing chicks up to 5% and for layers up to 10 per cent.
· It is a good source of carbohydrate.

b. Cassava Roots

· Cassava root is a very good source of energy and rich in carbohydrate.
· This can be safely used at a level of 10% in chick and broiler feeds.
· In ruminants it may be used in higher percentage with economic advantage provided it is mixed with other palatable feed stuffs.

c. Tapioca Starch Waste

· It has 2% DCP and 64% TDN on dry matter basis.
· It can replace at least 50% of maize as a source of energy for pigs.

d. Palm Flour

· Palm flour is low in protein and has 8% crude fibre.
· This can be used as a source of energy up to a level of 17.5% in chick ration and up to 11.5% in layer ration replacing polished rice completely.

e. Tamarind Seed Powder

· This has 13% DCP and 64% TDN and can be used in the cattle concentrate mixture.
· Chick ration may contain up to 10% of this powder. Tamarind seeds contain tannin but overnight soaking in cold water reduces the tannin content.

f. Babul Pods

· Babul pods have 10% DCP and 74% TDN.
· They can be used as a component of concentrate mixture in cattle ration.

g. Jackfruit Wastes

· Waste from jackfruit contains 7.9% protein, 14.1% crude fibre, 0.80% calcium and 0.10% phosphorus.
· It is a good source of energy.
h. Niger Cake

- Niger cake contains 36% DCP, 5.98% minerals and 18% crude fibre.
- It can be included in the ration along with other oil cakes.

i. Karanj Cake

- Karanj cake contains 30% DCP and 6.66% crude fibre. It is not suitable for chicks.

j. Neem Cake

- Neem cake contains 34% DCP and 4.4% crude fibre.
- It is bitter and unpalatable. However, it can be included in cattle ration up to 20% level and in chick ration upto 5% level.

k. Rubber Seed Cake

- Rubber seed cake can be successfully used in the feed of cattle and pigs.
- It can also be used in poultry ration up to 10% level.

l. Dhaincha Seed Cake

- Dhaincha seed cake contains 30 to 33% DCP.
- The seed can not be used as much because of deleterious factors.
- However, autoclaved dhaincha seeds may be used for cattle feeding in limited quantities.

m. Safflower Seed Cake

- Cake obtained from decorticated safflower seeds can be used as a cattle feed.
- It contains about 40-45% protein.

n. Other Unconventional Feeds

- Sugarcane bagasse, sugarcane tops and sugar beet pulp can be substituted for molasses up to certain extent.
### 2.4 Composition of Commonly Used Feeds and Fodders

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Item</th>
<th>DCP%</th>
<th>TDN%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Paddy straw</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>2.</td>
<td>Wheat straw</td>
<td>0</td>
<td>48.9</td>
</tr>
<tr>
<td>3.</td>
<td>Cow pea green</td>
<td>20.3</td>
<td>62.2</td>
</tr>
<tr>
<td>4.</td>
<td>Lucern green</td>
<td>16.2</td>
<td>60.2</td>
</tr>
<tr>
<td>5.</td>
<td>Oats (flowering green)</td>
<td>7.7</td>
<td>72.0</td>
</tr>
<tr>
<td>6.</td>
<td>Maize green</td>
<td>4.0</td>
<td>68.0</td>
</tr>
<tr>
<td>7.</td>
<td>Jawar green</td>
<td>4.0</td>
<td>68.0</td>
</tr>
<tr>
<td>8.</td>
<td>Maize grown</td>
<td>7.0</td>
<td>87.1</td>
</tr>
<tr>
<td>9.</td>
<td>Jawar grown</td>
<td>7.0</td>
<td>70.0</td>
</tr>
<tr>
<td>10.</td>
<td>Rice bran</td>
<td>9.1</td>
<td>76.1</td>
</tr>
<tr>
<td>11.</td>
<td>Wheat bran</td>
<td>15.0</td>
<td>82.2</td>
</tr>
<tr>
<td>12.</td>
<td>Ground nut cake</td>
<td>49.1</td>
<td>77.0</td>
</tr>
<tr>
<td>13.</td>
<td>Cotton seed cake</td>
<td>19.2</td>
<td>76.8</td>
</tr>
<tr>
<td>14.</td>
<td>Sesame cake</td>
<td>34.0</td>
<td>80.0</td>
</tr>
<tr>
<td>15.</td>
<td>Gram chuni</td>
<td>3.6</td>
<td>87.5</td>
</tr>
</tbody>
</table>

### 2.5 Summary

The nutrient present in the feeds and fodders are classified and their role in animal nutrition was explained well. Feeds and fodders were classified with suitable examples. The various feeds and fodders quality and importance was discussed in detail. The various unconventional feeds used in animal nutrition were discussed which will decrease the feed cost as well as animals competing with human goods is minimized. Hormones and Antibiotics were discussed. The feed analysis procedures for estimation of crude protein, crude fibre, ether extract, nitrogen free extract, Total ash were explained in detail.
Short Answer Type Questions

1. How to calculate NFE.
2. Give the formulae for crude protein estimation.
3. What is the principle involved in crude fibre estimation?
4. Mention the reagents used in estimation of ether extract?
5. What is the principle involved in total ash estimation?
6. What are animal digestion trials?

Long Answer Type Questions

1. Briefly discuss about the present status of feeds and fodder availability in our country?
2. Classify nutrients and briefly write about their role in animal nutrition?
3. Classify feeds with suitable examples?
4. Briefly write about roughages?
5. Discuss in detail various types of concentrate feeds?
6. Briefly discuss about various unconventional feeds?
7. Write short notes on Hormones and Antibiotics?
8. Explain how do you estimate crude protein content in a given sample of feed.
9. How do you estimate crude fibre of feed?
10. Briefly write about estimation of ether extract in feed?
12. How do you estimate total ash in feed?
Formulation of Rations

Structure

3.1 Definition of Ration and Feeding Standards

3.2 Desirable characteristics of good ration

3.3 Thumbs rules of feeding Cattle, Buffaloes, Sheep and Goat

3.4 Principles of ration formulation for different classes of animals.

3.5 Formulation of milk replacer and Calf stater

3.6 Formulation of Concentrate Feed

3.1.1 Ration

Ration is the feed allowed for a given animal during a day of 24 hours. The feed may be given at a time or in portion at intervals.

3.1.2 Balanced Ration

Ration which provides the essential nutrients to an animal in such a proportion and amount they are required for the proper nourishment of the particular animal for 24 hours is known as balanced ration.

3.1.3 Production Ration

Ration given to an animal for certain production i.e. milk, work, meat or egg is known as Production ration. It is in addition to the balanced ration.
3.1.4 Maintainance Ration

This is the minimum amount of feed required to maintain the essential body process at their optimum rate without gain or loss in body weight or change in body composition.

3.1.5 Feeding Standards

- Feeding standards are those which give the quantity of nutrients required by an animal to remain healthy and highly productive.

- Feeding standards are set in accordance with productivity (milk, meat, wool, eggs), composition of the product (fat content of milk), and physiological condition (growth, foetal development).

- Feeding standards differ for animals according to breed, age, and intended use. Consideration is also given to varying regional conditions.

- Modern feeding standards include the animal’s total nutritional needs, expressed in feed units - digestible protein, calcium, phosphorus, and carotene.

Standards of consumption of vitamins and trace elements have been established for each animal type; for swine and poultry, standards have also been established for amino acids.

Table 1. Daily Nutrient requirements for Maintenance, Pregnancy and lactation for Cattle and Buffalo (Ranjhan 1991)

<table>
<thead>
<tr>
<th>Body Weight (kg)</th>
<th>DM</th>
<th>DCP</th>
<th>TDN</th>
<th>Ca</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance of mature cows and Buffaloes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>3.5</td>
<td>150</td>
<td>1.7</td>
<td>8</td>
<td>7</td>
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<td>250</td>
<td>4.0</td>
<td>170</td>
<td>2.0</td>
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<tr>
<td>300</td>
<td>4.5</td>
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<td>2.4</td>
<td>12</td>
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<tr>
<td>350</td>
<td>5.0</td>
<td>230</td>
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<td>14</td>
<td>11</td>
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<td>550</td>
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<tr>
<td>650</td>
<td>8.0</td>
<td>370</td>
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<td>23</td>
<td>18</td>
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<tr>
<td>700</td>
<td>8.5</td>
<td>390</td>
<td>4.8</td>
<td>25</td>
<td>19</td>
</tr>
</tbody>
</table>
3.2 Desirable Characteristic of a Good Ration

- The ration should be such that it is fed liberally.
- It should be fed individually.
- It should be prepared properly balanced.
- It should be palatable.
- There shall be variety of foodstuffs in ration.
- The components of ration should be of good quality.
- It should contain sufficient mineral matter.
Dairying

- It should be fairly laxative
- It should have sufficient quantity of green fodder.
- It should be prepared properly.
- It should be fairly bulky, but not too bulky.
- It should be economical and consume less labour.

3.3 Thumb Rules of Feeding Cattle, Buffaloes, Sheep and Goat

- The requirements of the animals basically divided into maintenance requirements and production requirements.
  
  - Maintenance requirement is the requirement of nutrients to just maintain the animal without losing body weight. It depends on the size of the animal, which is usually measured in terms of its weight.
  
  - Production requirement is the requirement of nutrients for the various production functions. The different production functions require varying amounts of nutrients.

  - Growth: A young animal that is still growing requires more nutrients in addition to its requirement for maintenance.
  
  - A pregnant animal requires more nutrients for the growth of its calf (foetus) in addition to its own maintenance requirement. A young growing heifer which is also pregnant requires nutrients for maintenance, its own growth and the growth of its calf.
  
  - A lactating animal requires more nutrients for milk production in addition to its maintenance requirement. A young growing heifer which is in 1st and 2nd lactation requires 20 and 10% over and above the maintenance requirement.
  
  - An animal that is used for work requires more nutrients for work in addition to its maintenance requirement.

  - The nutrient requirements of dairy cattle have been worked out under experimental conditions.

  - Generally cattle require DM at rate of 2.0-2.5% and buffalo 2.5-3.0% of their body weight per day.

  - Sheep and goat requires 3 and 4% of the dry matter respectively.

  - Out of total DM requirement, 67% should be met by roughages (of which 45% dry and 22% green) and remaining 33% by concentrates.
3.3.1 Calculation of DM requirement

- For a cattle weighing 400 kg, DM requirement can be calculated as 2.5% of body weight.
  - Total DM requirement is \(2.5 \times 400\% = 10\) Kg
  - DM from concentrates = \(10\) kg x \(33\% = 3.30\) kg
  - DM from dry roughages = \(10\) kg x \(45\% = 4.50\) kg
  - DM from green roughages=\(10\) kg x \(22\% = 2.20\) kg

3.4 Principles of Ration Formulation for Different Classes of Animals

- Identification of the total nutrient requirements of the animals according to body size and the physiological functions to be satisfied.
  - Proper combination of available feedstuffs to supply these nutrients in the most economical manner.
  - Local availability and cost of ingredients will be the determining factors.
  - Roughages are normally the least expensive and are considered first. The remaining requirements are met with concentrates.

3.4.1 Requirements of cattle includes

- Maintenance
- Growth and live weight gain
- Pregnancy
- Milk production
- Work

3.4.2 Method of ration formulation

- Pearson square method
- Trial and error method
- Using computers

3.4.2.1 Pearson square method

The Pearson square or box method of balancing rations is a simple procedure that has been used for many years.
Procedure

- Rice bran and soybean meal were available as feedstuffs to prepare a diet for calves that was 25 percent crude protein.

- A square is constructed and the two feedstuffs are put on the two left corners along with the protein content of each.

- The desired protein level of the feed is placed in the middle of the square.

- Next, the protein level of the feed is subtracted from that of the feedstuffs, placing the answer in the opposite corner from the feedstuff. Ignore positive or negative signs.

![Fig. 3.1 Pearson Square](image)

To make the 27 percent crude protein calf feed, we must mix $\frac{17}{35.8}$ of rice bran with $\frac{18.8}{35.8}$ soybean meal.

Rice Bran $\frac{17}{35.8} = 47.5\%$

Soybean meal $\frac{18.8}{35.8} = 52.5\%$

So to make 100 kg of this feed we must mix 47.5 kg of rich bran with 52.5 kg of soybean meal.

- If more than two feedstuffs are used in a feed, they may be grouped into basal feeds (CP < 20 percent) and protein supplements (CP > 20 percent), averaged within each group, and plugged into the square method.

- For example, suppose shrimp meal and corn were also available for the calf feed mentioned above. The crude protein levels of the fish meal (52.7 percent) and of corn (10.2 percent) are averaged with soybean meal and rice bran, respectively.
Fig. 3.2 Pearson Square

Basal feed = 21.35/39.15 = 54.53%

Protein supplement = 17.8/39.15 = 45.47%

Thus, to make 100 kg of this feed one would mix the following:

- Rice bran 27.265 kg
- Corn 27.265 kg
- Soybean meal 22.735 kg
- Fish meal 22.735 kg

3.4.2.2 Trial and error method

To prepare calf feed containing 25% CP

- Choose a combination of ingredients that will provide a feed containing 25% CP for Calves.
- Calculate the required per cent CP in the feed, E.g. rice bran = 40X9.9/100 = 3.96 or 4.
- The mixed feed should contain 25% CP if 100 kg of the ingredients combined.
3.4.2.3 Ration Formulation With Computers

Today, almost all rations are formulated with the aid of computers. Use of computers has resulted in more complete evaluations of nutrient profiles in rations and allowed for economics to be included in ration formulation decisions.

3.5 Formulation of Milk Replacer and Calf Starter

Milk replacer is a constituted feed for dairy calves. Milk can also be substituted with milk replacer to make calf raising economical. Milk replacer resembles milk in biochemical composition and saves cost of calf rearing.

3.5.1 Objectives of Milk Replacer

- To raise orphan calves
- To supplement dam’s milk
- To wean calves at an early age.
- To make raising of calves cheaper
- To maintain normal growth of calves

3.5.2 Essential Points for Successful Results With Replacer

- Economical
- Sound management of calves
- Nutritionally adequate
- Proper sanitation in calf pen
- Easily mixable with warm water I milk

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
<th>% Crude Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice bran</td>
<td>40</td>
<td>9.90</td>
</tr>
<tr>
<td>Brewer Waste</td>
<td>20</td>
<td>22.80</td>
</tr>
<tr>
<td>Soya bean meal</td>
<td>28</td>
<td>46.20</td>
</tr>
<tr>
<td>Fish meal</td>
<td>12</td>
<td>57.70</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Ingredient

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
<th>% Crude Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice bran</td>
<td>40</td>
<td>9.90</td>
</tr>
<tr>
<td>Brewer Waste</td>
<td>20</td>
<td>22.80</td>
</tr>
<tr>
<td>Soya bean meal</td>
<td>28</td>
<td>46.20</td>
</tr>
<tr>
<td>Fish meal</td>
<td>12</td>
<td>57.70</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
• Adequate equipment and sterilized utensils
• Palatable
• Nearly similar to composition of milk
• Less crude fibre
• Contains additives like antibiotic mixture, vitablend / Rovi mix etc

It contains minimum 20% crude protein. The milk replacer is diluted with water in the ratio of 1:8.

3.5.3 The Following Composition of Milk Replacer Has been Worked Out at N.D.R.I Karnal

Wheat 10.0 Kg.
Fish Meal 12.0 Kg
Linseed meal 40.0 Kg. To make 100 kgs and contain Milk 13.0 Kg. 25.1 %
Coconut Oil 7.0 Kg. CP 21.2 % DCP 88.7 %
Linseed oil 3.0 Kg milk.
Citric acid 1.5 Kg.
Molasses 10.0 Kg
Mineral mixture 3.0 Kg
Butyric acid 0.3 Kg
Antibiotic mixture 0.3 Kg
Rovimix A, B2, D3 0.015

3.5.4. Calf Starter

Calf starter has been evolved for use with limited whole milk. An ideal calf starter contains 20 percent DCP and 70 percent TDN. It is a mixture of grains, protein feeds, minerals, vitamins and antibiotics. Misra and Singh (1993) has suggested that a good calf starter should be palatable enough, rich in energy content and should contain approximately 18-20% protein and fibre less than 7 percent.
3.6 Formulation of Concentrate Feed

The cheap feed prepared to meet the demands during drought and famin conditions. This feed is prepared with the locally available cheap food stuffs. The Animal Husbandary department with the co-ordination of A.P.D.D.C, Federation of Hyderabad, formulates and manufacturers the cheap feed for the benefit of the farmer during the drought conditions at a lower and subsidised rates.

The field staff of Animal Husbandary Department identify the local farmers who cannot afford to purchase a high balanced ration for their livestock in drought conditions and recommend to the Government for supply of cheap feed. A.P.D.D.C. federation manufacture the cheap feed in their feed mixing plants and supply to the Animal Husbandary Department for onwards distribution to the identified farmers at a subsidised cost.

The cheap feed is prepared with the following ingredients.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bajra</td>
<td>30</td>
</tr>
<tr>
<td>Pulse husk</td>
<td>58</td>
</tr>
<tr>
<td>Jagary or D.O.B</td>
<td>7</td>
</tr>
<tr>
<td>Mineral Mixture</td>
<td>3</td>
</tr>
<tr>
<td>Common Salt</td>
<td>2</td>
</tr>
</tbody>
</table>

Composition

Maize : 35 Kg
Barley : 15 Kg
Ground nut cake : 30 Kg
Wheat bran : 10 Kg
Fish Meal 7 Kg For 100 kgs
Mineral mixture : 2 Kg
Common salt : 1 Kg
Antibiotic mixture : 100 g
Vitablend AB2 D3 : 15 g
3.7 Summary

The various terms of rations well defined and various feeding standards were mentioned. The various desirable characteristics of good ration listed the various thumb rules of feeding cattle and buffaloes were explained which helps feeding under non scientific methods. The nutrient requirements for different purposes were listed and rations were formulated in detail for various classes of animal. Different methods of ration formulation were explained. The preparation of milk replacer; and calf starter explained in detail.

Short Answer Type Questions

1. What is Ration?
2. Define balanced ration.
3. Define maintenance ration.
4. What is production Ration?
5. What is pregnancy allowance given to cattle and buffalo as thumb rule?
6. What is milk replacer?
7. Define calf starters

Long Answer Type Questions

1. Explain feeding standards?
2. Mention various desirable characteristics of a good ration?
3 Explain various thumb rules of feeding cattle and buffalo?
4. Give nutrient requirement for maintenance for different weights of animal.
5. How do you balance the ration using Pearson square method?
6. Formulate milk replacer?
7. Formulate calf starter?
4.1 Importance of Feeding in Dairy Animal Production

Dairy cattle of all ages must receive sufficient quantities of nutrients to enable each animal to:

- Maintain good health;
- Meet their physiological requirements and production
4.2. Feeding of Newly Born Calf

4.2.1 Colostrum Feeding

- The calf must receive the first milk which the cow gives after calving and is called colostrum.
- The calf should be fed 2 to 2.5 liters daily for the first 3 days following its birth.
- The protein of colostrums consists of a much higher proportion of globulin than in normal milk. The globulins are presumed to be the source of antibodies which aid in protecting the animal from many infections liable to affect it after birth.
- The protein content of colostrum is 3 to 5 times as that of normal milk. It is also rich in some of the materials, of which copper, iron, magnesium and manganese are important.
- Colostrum contain 5 to 15 times the amount of Vitamin A- found in normal milk, depending upon the character of the ration given to the mother during the rest period.
- Colostrum also superior to milk in having a considerably greater amount of several other vitamins which have been found essential in the growth of dairy calves, including riboflavin, choline, thiamine and pantothenic acid.
- Colostrums act as a laxative to free the digestive tract of faecal material.

4.2.2 System of calf Rearing

4.2.2.1 Sucking method

In this method, the calf is allowed to stay with its mother and allowed to suckle only a little before and after of milking the cow. The calf gets whole milk throughout lactation.

Advantages

(i) This is natural system of feeding.
(ii) The calf gets contamination free milk.
(iii) No much care is required to take during feeding.
(iv) The mother-calf affection developed.
Disadvantages:

i) If calf dies, the cow refuses to let the milk.
ii) It can not be ascertained about over feed or under feeding of the calf.
iii) If milk is infected the infection may transmit to calf.
iv) The actual quantity of milk yield of cow can not be calculated.
v) The post partum heat is late.

4.2.2.2 Weaning method

In this system, the calf is taken away from its mother either just after the birth or after 2-3 days of birth, sometimes it is allowed till the period of colostrum feeding. After that, the calf rearing is entirely by isolation system.

The immediate step, after weaning of the calf is to teach it to drink milk is very important

1. Nipple System: Used for 3-4 days-aged calves. A pail containing milk equipped with rubber nipple used which the calf sucks.

2. Hand Feedling: When the calf develops appetite insert two fingers of right hand into the mouth while holding milk in left hand at convenient height for the calf. While calf suckles the fingers, the muzzle is gradually pressed down into milk pan. This way calf learns to drink milk.

Advantage

i) Cow continues to give milk whether calf is alive or not.
ii) The calf can be culled at an early stage.
iii) It can be fed scientifically as per requirements no problem of under feeding and over feeding.
iv) The actual amount of milk produced by cow can be determined.
v) Milking without calf is more hygienic & sanitary.
vi) Cow becomes regular breeder; the calving interval is less than the unweaned calves.

4.2.2.3 Milk feeding schedule to the calf

The calf after weaning from the dam, it should be fed with the whole milk, skim milk and re-constituted milk and also calf starters in gradual age. The
temperature of the milk must be body temp. i.e. 39°C, the utensils used must be clean and sterilized; the milk should be fed twice a daily.

<table>
<thead>
<tr>
<th>Body weight (kg)</th>
<th>Calf age (days)</th>
<th>Colostrums (litre. Per body wt.)</th>
<th>Whole milk (liters per body weight)</th>
<th>Skim milk (liters per body wt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 25</td>
<td>Upto 5</td>
<td>1/10th</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>20-30</td>
<td>6 - 20</td>
<td>-</td>
<td>1/10th</td>
<td>-</td>
</tr>
<tr>
<td>25-50</td>
<td>21-30</td>
<td>-</td>
<td>1/15th</td>
<td>1/20th</td>
</tr>
<tr>
<td>30-60</td>
<td>31-60</td>
<td>-</td>
<td>1/20th</td>
<td>1/25th</td>
</tr>
<tr>
<td>40-75</td>
<td>61-100</td>
<td>-</td>
<td>1/25th</td>
<td>1/25th</td>
</tr>
</tbody>
</table>

### 4.2.2.4 Calf Starters

It is a mixture of grain protein feeds, minerals, vitamins & antibiotics. It has been evolved for use with limited whole milk. An ideal calf starter contains 20% DCP, & 70% TDN.

If the calves raised with calf starter, the schedule is:

<table>
<thead>
<tr>
<th>Age (Day)</th>
<th>Whole Milk (Kg)</th>
<th>Skim Milk (Kg)</th>
<th>Calf Starter in Kgs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>Colostrum</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6-7</td>
<td>2.75</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8-14</td>
<td>3.25</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15-21</td>
<td>2.75</td>
<td>1.00</td>
<td>0.10</td>
</tr>
<tr>
<td>22-28</td>
<td>1.75</td>
<td>2.00</td>
<td>0.20</td>
</tr>
<tr>
<td>29-34</td>
<td>1.00</td>
<td>3.00</td>
<td>0.30</td>
</tr>
<tr>
<td>35-42</td>
<td>0.50</td>
<td>3.50</td>
<td>0.50</td>
</tr>
<tr>
<td>43-56</td>
<td>-</td>
<td>3.50</td>
<td>0.75</td>
</tr>
<tr>
<td>57-84</td>
<td>-</td>
<td>2.50</td>
<td>1.00</td>
</tr>
<tr>
<td>85-112</td>
<td>-</td>
<td>0.50</td>
<td>1.25</td>
</tr>
<tr>
<td>113-140</td>
<td>-</td>
<td>-</td>
<td>1.75</td>
</tr>
<tr>
<td>141-182</td>
<td>-</td>
<td>-</td>
<td>2.00</td>
</tr>
</tbody>
</table>
Calf starter should contain 22% CP and 70-75% TDN and it should be prepared from good quality feeds i.e. easily digestible low fibre feed and has to be free from any kind of toxins or antimetabolites.

10 g vitamin supplement (A, B2, D3) should be added in 1 quintal of the mixture if green fodders are not fed.

### 4.3 Feeding of Calves From 6 Months to One Year

- For calves below one year of age it is always desirable to give sufficient concentrates in addition to good roughage so that they make optimum growth.

- Feeding concentrate can be considerably reduced in the case of calves over one year of age fed on high quality roughage.

- A judicious mixture of roughage and concentrate is essential for obtaining optimum growth without undue fat deposition. From six months onwards, calves can be given the same type of concentrate mixture (14-16% Digestible Crude Protein and about 70% Total Digestible Nutrients) as used for adult cattle. Examples of concentrate mixtures are given separately.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percent composition (Kg per 100 Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1  2  3  4  5  6  7  8  9</td>
</tr>
<tr>
<td>Crushed maize</td>
<td>30 42 38 50 10 - - 50 49</td>
</tr>
<tr>
<td>Crushed barley/oat</td>
<td>10 - - 10 10 - - -</td>
</tr>
<tr>
<td>Crushed ragi/jowar</td>
<td>10 - - - - 20 - -</td>
</tr>
<tr>
<td>Crushed wheat/rice</td>
<td>- - - 30 40 30 - -</td>
</tr>
<tr>
<td>GN cake/soybean meal</td>
<td>30 28 20 40 20 30 30 27 20</td>
</tr>
<tr>
<td>Til cake/linseed meal</td>
<td>- - - - 8 10 10</td>
</tr>
<tr>
<td>Mustard cake</td>
<td>- - - 10 - - - -</td>
</tr>
<tr>
<td>Fish meal</td>
<td>10 8 - - - - - -</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>7 19 26 10 10 10 10 10</td>
</tr>
<tr>
<td>Molasses</td>
<td>- - - 7 7 7 - - -</td>
</tr>
<tr>
<td>Skimmed milk powder</td>
<td>- - 13 - - - - -</td>
</tr>
<tr>
<td>Mineral mixture</td>
<td>2 2 2 2 2 2 2 2 2</td>
</tr>
<tr>
<td>Common salt</td>
<td>1 1 1 1 1 1 1 1 1</td>
</tr>
</tbody>
</table>
4.4. Feeding of Heifer

- Heifer is growing animals and so the requirements for growth is of higher order than for more maintenance during early stage relatively more protein is required than energy.

- Most young heifers grow well if excellent hay is given as much as they eat.

- The amount of growth depends upon the quality of forage in unlimited amounts.

- No grains need to fed after the calf is 9 months.

- Feed ad libitum of green fodder so that the animal gets enough carotene.

- If leguminous fodders are fed it gives enough calcium, and other minerals.

- When the heifer is fed with adlibitur of roughages and concentrates, now and then check for its growth.

- Fat animal should be discouraged and feeding is practice to become non-fat animal.

- The heifer with Pregnancy should be fed very carefully, because the animal is still growing and for compensation for the growth of foetus.

- An extra amount of 1.215 kg to 1.75 kg concentrate may be provided to allow the growth of the foetus normally. 6 weeks before calving 2-3 kgs of concentrates should be given.

---

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>Approximate body weight (kg)</th>
<th>Concentrate mixture (kg)</th>
<th>Grass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-9</td>
<td>70-100</td>
<td>1.5-1.75</td>
<td>5-10</td>
</tr>
<tr>
<td>9-15</td>
<td>100-150</td>
<td>1.75-2.25</td>
<td>10-15</td>
</tr>
<tr>
<td>15-20</td>
<td>150-200</td>
<td>2.25-2.50</td>
<td>15-20</td>
</tr>
<tr>
<td>Above 20</td>
<td>200-300</td>
<td>2.50-2.75</td>
<td>15-20</td>
</tr>
</tbody>
</table>
Dairying

- Laxative feeding should be given from two weeks before calving which prevents consumption and difficulty in parturition.

- Unless the heifer is the calf will not be healthy, and also causes dystocia, retained placenta etc. the production of the animal during first lactation and also subsequently solely depends upon the conditions of the animal at the time of first calving.

4.4.1 Nutrient requirement for heifers

The following nutrients are required for the heifers at different stages of their growth.

**Table 4:** Daily nutritional requirements for growth of calves and heifers

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Live wt (kg)</th>
<th>Age (wks)</th>
<th>DM (kg)</th>
<th>DCP (kg)</th>
<th>TDN (kg)</th>
<th>Ca (g)</th>
<th>P (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>16</td>
<td>1.2</td>
<td>0.2</td>
<td>1.2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>80</td>
<td>24</td>
<td>1.9</td>
<td>0.23</td>
<td>1.5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>32</td>
<td>2.4</td>
<td>0.25</td>
<td>1.7</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>150</td>
<td>48</td>
<td>3.4</td>
<td>0.29</td>
<td>2.3</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>200</td>
<td>54</td>
<td>4.8</td>
<td>0.32</td>
<td>2.7</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>250</td>
<td>80</td>
<td>5.8</td>
<td>0.33</td>
<td>3.0</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>300</td>
<td>98</td>
<td>6.8</td>
<td>0.40</td>
<td>3.6</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>350</td>
<td>118</td>
<td>7.2</td>
<td>0.42</td>
<td>4.0</td>
<td>14</td>
<td>13</td>
</tr>
</tbody>
</table>

4.5 Feeding of Milch Animal

Nutrient requirements of milch animal vary with the stage of lactation and gestation.

**Figure** below illustrates the shape and relationship of curves for milk production, fat percentage, protein percentage, DM intake, and body weight change during lactation. Five distinct feeding phases can be defined to attain optimum production, reproduction and health of dairy cows: Early lactation—0 to 70 days (peak milk production) after calving (postpartum). Mid lactation—70 to 140 days (declining milk production) postpartum. Late lactation—140 to 305 days (declining milk production) postpartum. Dry period—60 to 14 days.
before the next lactation. Transition or close-up period—14 days before to parturition.

Fig. 4.1 Lactation Curve of Milch Animal
4.5.1 Phase 1. Early lactation—0 to 70 days postpartum.

- Milk production increases rapidly during this period, peaking at 6 to 8 weeks after calving.
- Feed intake of the animal does not increase with nutrient needs for milk production, especially for energy, and body tissue will be mobilized to meet energy requirements for milk production resulting loss in body weight.
- Adjusting the cow to the milking ration is an important management practice during early lactation.
- Protein is a critical nutrient during early lactation. Rations may need to contain 19 percent or more crude protein to meet requirements during this period.
- Low peak production and ketosis problems occur when nutrient levels are not met.
- Low peak production results into low lactation production.
- To increase nutrient intake feed good quality forages and concentrates should be fed ad libitum for the high yielding animals.

4.5.2 Phase 2. Peak DM intake—second 10 weeks postpartum

- Cows should be maintained at peak production as long as possible.
- Feed intake is maximum and no loss body weight (Fig. 4.1).
- DM intake should not exceed 2.5 percent of the cow’s body weight.
- Feeding the animal as per the milk production i.e. 1 kg concentrate feed for every 2kg of cow milk and 2.5kg of buffalo milk.

4.5.3 Phase 3. Mid- to late lactation—140 to 305 days postpartum

- This phase will be the easiest to manage. Milk production is declining, the cow is mostly pregnant, and nutrient intake will easily meet or exceed requirements.
- Concentrate feeding should be at a level to meet milk production requirements and begin to replace body weight lost during early lactation.
- Young cows should receive additional nutrients for growth (1st lactation, 20 percent more; 2nd lactation, 10 percent more than maintenance).
· Milk production should slowly decline at an 8 to 10 percent drop per month. Avoid over-conditioning cows.

### 4.6. Feeding of Dry and Pregnant Animal

A Cow in dry period should be fed a well balanced ration during this period for the following purposes.

- Maintenance of the cow
- Growth of the animal if she is pregnant
- Growth of the foetus
- For the production of colostrum when she calves next
- Forming sufficient reserves of nutrients in the body of the cow for ensuring lactation.

- The recently calved high producing cow is unable to eat enough feed to support her milk production. This means that she should have enough reserves of stored nutrition to be drawn to tide over the period of heavy demand in the early lactation during which period the cow loses weight.

- Many of the problems resulting in ketosis, displaced abomasum, fatty liver, retained placenta, prolapsed etc., can be minimized by resorting to an all roughage feeding during the dry period,

- The roughage should be tough enough to stimulate and restore rumen muscle tone.

- During dry period cows can be fed only good quality green fodder with 1 1/2 kg concentrate.

- During the dry period cows should receive enough of high quality green, fodder to provide enough of the precursor for Vitamin A. They also need salt, calcium, z phosphorus and whenever deficiencies occur, other minerals.

- When leguminous roughages are fed in large quantity, all that is needed is a. source like wheat bran. But when non-leguminous roughages predominate, sources of calcium and phosphorus like bone meal or dicalcium phosphate may be added to the ration.

- Other trace minerals may be needed if the soil and consequently the crops are deficit in them. Under normal circumstances, however addition of such minerals is not necessary in some cases.
4.7 Feeding Newly Calved Cows and Buffaloes

4.7.1 Challenge Feeding (Early post-calving feeding)

Just a week or two before calving one should start feeding the cows with high milk production, increasing the quantity of concentrates to challenge them to produce at the maximum level. This challenge feeding will condition her digestive system for the increased amount of concentrates of early lactation and provide enough nutrients to initiate lactation on a higher place. The challenge feeding should be done in following way:

- Challenge feeding of the cow starts 2 weeks before calving. Increase 0.5 kg of the concentrate every day till the animal calves.
- Immediately after calving, challenge feeding continues for the cows and encourage high peak yields by increasing the concentrate feed offered.
- Most cows can tolerate an increase of 1 kg every day during the first week, 0.5 kg every other day in week 2 and 0.3 kg every day in week 3 till the animal takes ad libitum.
- This schedule will get cows to their maximum concentrate and protein intake by 3 to 3 1/2 weeks into lactation.
- This practice continues till the animal reaching the lactation. Protein requirements in early lactation are high, at 19% of the diet DM.
- Increase the concentrate feed gradually.

4.7.2 Tips for Feeding Newly Calved Cows and Buffaloes

- Concentrate must be feed individually according to production requirements.
- Good quality roughage saves concentrates. Approximately 20 kg of grasses (guinea, napier, etc.) or 6-8 kg legume fodder (cowpea, lucerne) can replace 1 kg of concentrate mixture (0.14-0.16 kg of DCP) in terms of protein content.
- 1 kg straw can replace 4-5 kg of grass on dry matter basis. In this case the deficiency of protein and other nutrients should be compensated by a suitable concentrate mixture.
- Regularity in feeding should be followed. Concentrate mixture can be fed at or preferably before milking – half in the morning and the other half in the evening – before the two milkings.
· Half the roughage ration can be fed in the forenoon after watering and cleaning the animals. The other half is fed in the evening, after milking and watering.

· High yielding animals may be fed three times a day (both roughage and concentrate). Increasing the frequency of concentrate feeding will help maintain normal rumen motility and optimum milk fat levels.

· Over-feeding concentrates may result in off feed and indigestion.

· Abrupt change in the feed should be avoided.

· Grains should be ground to medium degree of fineness before being fed to cattle.

· Long and thick-stemmed fodders such as Napier may be chopped and fed.

· Highly moist and tender grasses may be wilted or mixed with straw before feeding. Legume fodders may be mixed with straw or other grasses to prevent the occurrence of bloat and indigestion.

· Silage and other feeds, which may impart flavour to milk, may be fed after milking. Concentrate mixture in the form of mash may be moistened with water and fed immediately. Pellets can be fed as such.

· All feeds must be stored properly in well-ventilated and dry places. Mouldy or otherwise damaged feed should not be fed.

· For high yielding animals, the optimum concentrate roughage ratio on dry matter basis should be 60:40.

4.8. Feeding of Animals During Drought and Cyclone

The importance of feeding of livestock during draught period was recognised long back, when the country faced with a severe drought and shortage of livestock feeds. During drought conditions effort should be made to utilize unconventional feed ingredients. These are divided into

· Unconventional concentrates: Mango seed kernel, tamarind seed, sun hemp seed, rubber seed cake, Tobacco seed cake, neem seed cake, Babul pods etc.,

· Unconventional rangelages: Tree leaves, groundnut straw, rice husk, coffee seed husk, sugar cane tops, forest grass, cotton straw, sunflower straw etc.,

· Unconventional industrial by products: Sugar cane bagasse, Fruit and Vegetable wastes, Distillation wastes slaughter house waste, poultry
droppings, pulp and paper industry wastes, rumen contents, molasses from alcohol industries.

· During drought and famine conditions, when there is a shortage of green grass or dry grass, the animals are fed with silage which is preserved, when greens are plenty.

· Sometimes conducting cattle camps in severe drought conditions, providing dry fodders to the animals is also a regular practice.

· In protein deficiency animals due to continuous drought, providing urea mixed water in the cattle camps is also helpful (@3kg urea in 100 litres of water) to prevent protein deficiency.

· Other sources of feeding materials are tubers, forest leave, urea, molasses are fed to the animals.

· Enriched paddy straw with urea can be well utilized during drought.

· Feeding fats at high levels during summer should be combined with calcium compulsorily because calcium form foam with fats in the rumen, sodium bicarbonate, sodium chloride along with vitamin A,C, yeast, Lactobacillus, antioxidants, vitamin E should be added to the feeds.

· The animals should have free access to water at all times during summer.

Urea molasses feeding: Water 2.5%, Urea 2.5%, Molasses 92.0%, Mineral mixture 2%, Common salt 1%

4.9. Feeding of Different Classes of Sheep

The feeding of ewes important during:

· Flushing or during the breeding season.

· Maintenance or early gestation phase.

· Late gestation or the last 4 to 6 weeks before lambing.

· Lactation or the 6 weeks after lambing.

· Feeding of lambs

· Feeding of breeding rams

4.9.1 Flushing

· Flushing increases the energy and nutrient intake prior to and during breeding.
This results in an increase rate of ovulation and an increase in lambing rate.

To “flush” a ewe one can provide a ewe with fresh pasture or supplement with 200-250 g of grain per ewe daily for 2 weeks prior to breeding and continue 2-4 weeks into breeding season.

Response can be affected by age of ewe, breed, body condition, and stage of breeding season.

4.9.2 Maintenance or early gestation phase

- The maintenance period is when the ewe is not lactating and lasts up to about 30 days before breeding.
- Once the ewe flock has been bred, the first two-thirds of gestation is also considered a maintenance phase of nutrition.
- During this production phase sheep can be fed economically without lowering production levels.
- Provide the ewes with adequate amounts of moderate to low quality forage, salt and mineral, water, and treat for internal parasites.

4.9.3 Late gestation or the last 4 to 6 weeks before lambing

- Late gestation is a very important time nutritionally for ewes.
- Ewes need adequate nutrition for foetal growth and mammary tissue synthesis.
- Inadequate nutrition leads to weak lambs, low milk, and increased death loss.
- Ewes need to be gaining between 200 to 250 g per day.
- This can be done by feeding higher quality forages or supplementing with a grain ration.
- Mineral feeding is the most critical during late gestation.

4.9.4 Lactation

- Early lactation generally takes place between weeks 6 and 12.
- Peak milk production is around 3-4 weeks after lambing.
- When a ewe is nursing twin lambs she will produce 20-40% more milks then a ewe nursing a single lamb.
Ewe’s nutrition during this time is important not only for herself but for her offspring survival.

The growth of the lamb(s) depends highly on the quality of the milk produced by the ewe.

During this time it is common to see ewes that are not fed enough feed for the number of lambs they are raising.

If they are fed deficient diets the body will remove the necessary nutrients from her body reserves which effects ewe health.

A general rule of thumb is to use is good quality hay along with mixed grain of 500-800g per ewe per day.

Alfalfa hay is a good quality hay to use; it is high in energy and protein.

Overall the diet should contain 70% TDN (total digestible nutrients) and 14% protein.

Free access to drinking water is important since milk is 82% water. On average a lactating ewe will consume 2-3 gallons of water daily, compared to an adult ewe average of 1-2 gallons

4.9.5 Feeding of lambs

Feeding lambs up to two weeks: There is no substitute to the ewe’s milk for putting rapid gains on young lambs.

<table>
<thead>
<tr>
<th>Feeding Ingredient (%)</th>
<th>Pre-weaning period (upto 3 months)</th>
<th>Growing period (3-6 months)</th>
<th>Finisher ration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ground maize</td>
<td>65</td>
<td>27</td>
<td>25</td>
</tr>
<tr>
<td>2. Groundnut cake</td>
<td>10</td>
<td>35</td>
<td>20</td>
</tr>
<tr>
<td>3. Wheat bran</td>
<td>12</td>
<td>35</td>
<td>52</td>
</tr>
<tr>
<td>4. Fish meal</td>
<td>10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5. Common salt</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6. Min. mix.</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Expected growth rate per day (gms)</td>
<td>110-125</td>
<td>100-120</td>
<td>100-120</td>
</tr>
</tbody>
</table>
Lambs depend entirely on dam’s milk upto 2 weeks.

- Feeding lambs beyond two weeks: The recommended rations are given above.

<table>
<thead>
<tr>
<th>Body weight (kgs)</th>
<th>when leguminous fodder is available</th>
<th>when leguminous fodder is not available</th>
<th>Roughages (kgs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 12-15</td>
<td>50</td>
<td>300</td>
<td>ad lib.</td>
</tr>
<tr>
<td>2. 15-25</td>
<td>100</td>
<td>400</td>
<td>ad lib.</td>
</tr>
<tr>
<td>3. 25-35</td>
<td>150</td>
<td>600</td>
<td>ad lib.</td>
</tr>
</tbody>
</table>

(5) Feeding breeding rams: Good quality green fodders like maize, cowpea, oat, doob grass, lucerne, berseem etc. would meet all requirements of breeding rams. If forages fed are of poor quality like straw or sorghum hay, then 150-200 gms concentrate should be fed daily. During the breeding season, the concentrate increased to 300-400g daily.

4.10 Feeding of Different Classes of Goat

4.10.1 Feeding habits of goats

- Sheep and goats differ in their feeding habits.

- Goats prefer to consume a wide variety of feedstuffs. Goats are more selective and browse more, especially under extensive conditions, than sheep. The selectivity of goats is reduced under intensive management.

- Goats generally have better body condition compared to sheep under the same grazing conditions, mainly due to their ability to select a nutritious diet.

- Goats prefer to eat feed at a height of 20–120 cm. They have the ability to stand on their hind legs for long periods and can even climb trees in order to reach parts of trees they prefer.

- They also have mobile upper lips and tongues that enable them to consume leaves between thorns.

- They are fastidious about cleanliness and like frequent change in the feed. Feeds given must be clean and fresh, since goats eat nothing that is dirty or foul-smelling. They dislike wet, stale or trampled fodder. For this reason, it is
advisable to feed them in hay-racks or hang the feed in bundles from a peg in the wall or from a branch of a tree.

- Goats are very fond of leguminous fodders. They do not relish fodder like sorghum/maize silage or straw. Goats do not relish hay prepared from forest grasses, even if cut in early stages, but very much relish hay prepared from leguminous crops.

- Some of the common green roughages liked by goats are: lucerne, berseem, napier grass, green arhar, cowpea, soyabean, cabbage and cauliflower leaves, shaftal, senji, methi, shrubs and weeds of different kinds; and leaves of trees such as babul, neem, ber, tamarind and pipal.

- The common dry fodders liked by goats are straw of arhar, urid, mung, gram, dry leaves of trees, and lucerne/berseem hays (which are the main forage crops for milch goats).

4.10.2 Feeding of goats

- Goats generally produce more milk than a cow from the same quantity of nutrients. The nutrient conversion efficiency for the production of milk in goats is 45.71 per cent, whereas a dairy cow averages 38 per cent.

- It has been observed that goats are 4.04 per cent superior to sheep, 7.90 per cent superior to buffaloes, and 8.60 per cent superior to cows in crude fibre utilization. The goat uses more useless feeds for its maintenance than a cow.

4.10.3 The ration of goat divided into

**Maintenance ration:** For its size, a goat can consume substantially more feed than cattle or sheep, i.e. 4-5 per cent of its body weight in dry matter when compared with 2.5-3 per cent for cattle or sheep. This means that the goat can satisfy its maintenance requirement and produce milk from forage alone.

**Production ration:** The nutritional requirement of a goat weighing 50 kg and yielding 2 litres of milk with 4% fat may be met by feeding 400gm of concentrate mixture and 5 kg of berseem or lucerne. The ration should have 12-15% protein content.

**Pregnancy ration:** The foetal growth in the last 2 months of pregnancy is rapid and the metabolic rate of the goat rises rapidly. During this period, the content of ration should be increased to the level of production ration. A week before she kids, the doe should be provided with more succulent type of food. For three or four days after kidding, the level of diet should be lowered and
made more fibrous. This is necessary to minimize the shock to the goat’s udder. After this period, the feeding should be done at a normal rate.

The following concentrate mixtures may be used to feed the goat:

- 1 part of wheat bran, 2 parts of maize grain, and 1 part of linseed cake
- 2 parts of maize grain, 1 part of barley, 2 parts of mustard-cake, and 2 parts of gram husk or
- 1 part of wheat bran, 2 parts of barley grain, and 1 part of groundnut cake.
- 2 parts of gram grain and 1 part of wheat bran.
- The above mixtures should also contain 2% each of mineral mixture and salt.

4.10.4 Feeding of Young Stock

Performance of the adult stock depends on how they are reared when young. Feeding schedule for kids should be such that a weekly growth rate of 0.6 kg is obtained. The kids should be fed 56-112 gm of colostrum 4-5 times a day, depending on its birth weight.

4.10.5 Mineral Mixture

Goats require slightly larger quantities of calcium than sheep. The mineral mixture may be included in the concentrate ration at the rate of 2 per cent.

4.10.6 Salt

Salt licks or lumps of rock salt of fairly good size should be hung up in some suitable place where the goats can easily get them. This is important as goats secrete a good amount of sodium and chloride ions in the milk.

4.10.7 Vitamins and Antibiotics

Goats particularly need vitamins A, D and E. Vitamin A can be supplied by feeding green forage and yellow maize; 1 kg of lush-green fodder will provide 1500 IU. Vitamin D can be obtained by exposure to sunlight. Vitamin E is present in adequate amounts in most normal rations. Synthetic vitamins A and D may be supplemented in the ration of growing kids. Feeding of aureomycin or terramycin increases the growth rate of young kids, reduced the incidence of scours and other infectious diseases and improves the general appearance of the kids.
4.11 Summary

Feeding of calf up to one year was explained in detail, which helps to build up good quality of future stock for dairy animals. Feeding of heifer, milch animals and pregnant animals, dry animals, bulls and bullocks are explained well which helps in giving guidelines for feeding of dairy animals. Feeding of different classes sheep and goat including their nutrient requirements was explained.

Short Answer Type Questions

1. What is Colostrum?

2. How much whole milk should be fed to the young calves?

3. At what age calf starter should be started to the calf?

4. What is the DCP and TDN in good calf starter?

5. What are the DCP and TDN requirements for a heifer weighing 150 kgs body weight?

6. In cattle how much extra DCP and TDN should be given for pregnancy?

7. Define heavy work for bullock.

8. Define light work for bullock.

9. How much extra concentrate should be given during advanced stage of pregnancy?

10. What is the difference between feeding habits of sheep and goat?

Long Answer Type Questions

1. Explain in detail the feeding of calf up to one year.

2. How do you feed a heifer for optimum growth?


4. What feeding practices are recommended for dry animal?

5. Give feeding schedules for working bullock.

6. Explain feeding of breeding bull.

7. Explain feeding of different classes of sheep and goat.

8. Explain about different types of goat rations.
5.1 Procurement and storage of Feed ingredients

The objective of quality control of feed stuffs is to ensure that the feed produced is unadulterated, true to their nature and produce desired results. The quality of the feed mainly depends on the selection of raw materials. In our country, the feed ingredients used are of second quality which is often unfit for human consumption. The grains stored in warehouse godowns for long time are spoiled grains that are released for livestock & poultry feed. Besides this, the postharvest technology is not developed properly with poor harvest,
Dairying

processes and drying of grains. Often the moisture with grains increases the growth of moulds and mycotoxins. The drying area often contaminated with a variety of dirt and fecal matter especially of other avian species, rats, dog and cat or even human or animal origin. These grains further stored into an already used gunny bags, which are usually contaminated with a variety of dust, bacteria, virus, cysts and spores of fungus of both human and animal origin. Therefore, the quality of ingredients used for feed production is often not satisfactory. While procuring and storage of the feed ingredients for dairy animals, the following factors are important.

- The raw materials either of animal or plant origin should be obtained from known sources of repute, with a supplier warranty.

- Monitoring of ingredients includes selection, inspection and sampling of ingredients for contaminants using risk based protocols.

- The laboratory methods used for testing the ingredients should be of standard method.

- The ingredients should meet acceptable standards for levels of pathogens, mycotoxins, herbicides pesticides and other contaminants which may give rise to human health hazard.

- Raw materials found to be high incidence of salmonella should be treated with bactericidal organic acids.

5.1.1 Storage of feed ingredients

- Feed ingredients should be procured in good condition and kept dry and cool and used on a first-in, first-out basis.

- The raw material is to be stored for long duration without loss of quality.

- The sacs of grains, a variety of cakes, soya and whole fish or fishmeal are stored in gunnies and stalked in lots without any proper ventilation, often infested with pests including mice and rats.

- In the modern feed mills the ingredients are stored in bulk bins, therefore it is essential to construct these bins with moisture exhaustion and proper ventilation facility.

- In godowns, the gunnies containing feed materials should be stored one foot away from the walls to allow adequate room for cleaning and pest control.
• The quality of raw materials can be affected by growing, harvesting, and post-harvest handling and processing. They should not be lumpy or mouldy or heavily infested with insects.

• Feeds can become contaminated accidentally with chemicals and disease-causing organisms if they are not stored properly. Safe storage of feeds includes protection from chemicals, rodents or other animals as well as maintenance of quality.

• To keep feeds from becoming contaminated, products such as fertilizers, herbicides, insecticides, fungicides and other chemicals should be stored in separate facilities.

• The room in which these ingredients are commonly stored should be cleaned regularly to prevent the build-up of dust and fragments of feedstuffs. Such build-up creates mould growth and insects which will quickly destroy the food value of the products being stored.

• Bins, silos, warehouses, and ingredient handling systems should be designed so that moisture, rodents, birds and other pests should not have access.

• Heat, light, and moisture can damage feed ingredients and should be stored off the ground on pallets/wood racks and out of direct sunlight due to the damaging effects of ultraviolet rays.

• Liquid ingredients such as tallow, amino acids, and molasses should be stored in accordance with manufacturers’ recommended procedures to protect freshness.

• Fats and oils may need to be heated for ease of handling and/or have antioxidants added) to maintain quality.

• Proper scheduling of the arrival of ingredients so as to minimize storage time and handling of the ingredients.

• Quality of ingredients like bulk maize, soybean meal etc. may lose nutrient value or efficacy from excessive handling. Handling also invites problems with shrink. The moisture percentage should be less than 13%.

5.1.2 Quality of the stored ingredients effected by

5.1.2.1 Moisture Content

• Moisture content of stored produce is closely related to ambient relative humidity.
Oil-free materials such as grains have higher moisture contents than those containing oil, in equilibrium with the same ambient relative humidity. However, differences in moisture content/relative humidity relationships are small for oil-free feed materials, and it is possible to generalize for these to some extent with moisture contents which are critical for different types of biological activity.

- Moisture content in equilibrium with a given relative humidity varies with temperature, and for a 10°C rise decreases by 0.6-0.7% for the oil-free material.

- Biological activity both within the materials and of pests is greatly affected by moisture content.

- Insect pests will not develop on feeding stuffs at relative humidities outside the range 30-90%, while bacteria will only develop at relative humidities of over 90%.

- Fungi generally grow only at relative humidities of over 70%, while seed germination normally requires relative humidities of more than 95%.

- Expressing these in terms of approximate moisture contents of oil-free material stored at temperatures of 20-30°C, the following can be anticipated:

  - Up to 8% moisture (30% relative humidity): no significant biological activity;
  - 8-14% (30-70% relative humidity): insect infestation possible; mites can infest at relative humidities of over 60%;
  - 14-20% moisture (70-90% relative humidity): insect infestation and mould growth can occur;
  - 20-25% moisture (90-95% relative humidity): mould and bacterial growth possible;
  - above 25% moisture (more than 95% relative humidity): bacterial growth and seed germination possible.

5.1.2.2 Mycotoxins

- Almost all vegetable compound feed materials of tropical origin are liable to contamination by the aflatoxins, a group of highly toxic mould metabolites, produced by certain strains of the moulds Aspergillus flavus and Aspergillus parasiticus.
The aflatoxins can be formed during the pre-and post-harvest stages of raw material production provided that a suitable environment for mould growth exists.

Samples of oilseed cakes from groundnut, cottonseed, palm kernel and copra, together with cereals like maize have been found to contain high levels of aflatoxin.

The acute toxicity of the aflatoxins and their ability to induce liver cancer in animals varies according to the sex and age of the animal and a number of other factors. Young animals are more susceptible to aflatoxin intoxication than older animals, and males usually require a smaller dose of the toxin than females to produce a similar effect.

A variety of analytical and big-assay methods have been developed for determining the levels of aflatoxin in animal feeds.

5.2 Methods of Detection of Feed Adulterants

Physical Inspection

(Visual inspection) will give a good assessment of quality of feed ingredients. Quality Control of Feeds

Items of physical inspection

- Colour
- Odour
- Taste
- Evidence of wetting
- Evidence of deleterious substances or foreign material
- Storage pests and
- Evidence of damaged grain.

First 3 items can be done with reference to normal and abnormal by experience of having normal things in mind. Eg. Maize, Jawar, Wheat; Rice etc.

- Evidence of wetting: Normally grain contains below 10% moisture. Moisture level is less than 13% is considered as safe for storage. More than 13% moisture creates hot spots, which causes mould growth.

- Evidence of deleterious substances like dust, sand, straw, clay, nails etc., can be fined out by visual appearance.
• Storage pests: We can see the insects and faeces and eggs of insects by visual inspection and by smell especially in wheat bran; rice bran etc. If we suspect, we can test and observe the insect eggs under microscope.

• Evidence of damaged grain: Damaged or broken grain in unsafe for storage. Broken material will absorb more moisture and sometimes we see insects. In unbroken grain, seed coat is intact and will be resistant for moisture absorption.

5.3 Quality Control of Finished Feed

It is important that representative samples of batches should be taken for check analyses to monitor the composition of the finished feeds. If results show deviations from the required composition, the reasons for this must be sought and rectified.

5.3.1 Quality Control Methods

The various methods include:

5.3.1.1 Physical Tests

• Colour - Colour of desirable quality
• Odour - Odour of a desirable quality ingredient
• Texture’ - Fine, Coarse or medium
• Test weight - Cubic food weight
• Miscellaneous - Adulterants, contaminants etc.

5.3.1.2 Chemical Tests

• Total digestible nutrients (TDN)
• Crude fat
• Crude fibre
• Minerals
• Moisture

5.3.1.3 Toxicological Tests

• Aflotoxin
• HCN (Hydro cyanic acid)
5.3.1.4 Microscopic Tests

(a) Done under low magnification.
   - Particle size
   - Softness
   - Hardness

(b) High magnification:

   - Requires more skill, but accurate results are obtained. The use of microscopy in feed quality control can give even the smallest feed manufacturer some measure of protection against adulteration and contamination of ingredients. Products may be examined for the presence or absence of basic ingredients and by means of spox test or tracer ingredients which give much information on the presence of drugs or other micro ingredients.

5.4 Packing and forwarding of feeds

- Compound feeds, whether in meal or pellet form, are usually packed in bags.
- Bags may be filled directly from mixers or from holding bins and may be weighed on a scale balance of 25 or 50 kg.
- Bags may be of jute or cotton and can be hand or machine-stitched or tied with a string or metal tie.
- Polythene bags are not normally recommended for storing animal feeds because of the risk of sweating and mould growth.
- If old bags are re-used, care should be taken that they have not been used previously for the storage of fertilizers, pesticides, or other chemicals.

5.5 Storage of Concentrates - Space Requirement

Bagged ingredients should be stored in a well constructed building or room. These areas should be free of batteries, petroleum products, or other nonfeed items. Good manufacturing procedures require bags to store in bird- and rodent-proof areas. Bags should be stored near the weighing centre to minimize handling. An unloading dock may be required for mills handling bags.

Most standard pallets require a storage space of 4 foot by 4 foot. These wooden or plastic pallets can hold about 600 pounds of material by stacking ten to twelve 50-pound bags. Bags can be stored along the exterior walls while maintaining an 8-foot walkway between the bags. Ingredients are unloaded into
the building at the unloading dock at the end of the building. A 2-foot walkway is allowed between pallets and walls for access and rodent control.

There are four common problems with bag storage areas:

1. Rotation of stocks,
2. Excessive moisture,
3. Torn bags, and
4. Rodent control.

**Precautions during storage**

- a. The moisture content of feed should be <12%.
- b. Store feed in closed bags in a cool dry place.
- c. Prevent rodent and insect exposure.
- d. Add an antioxidant to the feed (or with the added fat) at time of preparation
- e. If no antioxidant is added, store feed in a cool location for a limited period of time.

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**5.6. Cleaning and Fumigation of Stores**

**5.6.1 Cleaning**

- Cleaning includes removal of dust, remnants of feed ingredient, dirt and spider webs etc., in the feed store rooms.
- The floor, walls and roof should be properly cleaned using broom sticks or with vacuum cleaner.
- Repair the holes made by rodents by plugging with cement and chips.
- For cleaning of roofs it is better to clean by sucking operation with vacuum machines, which will squeeze dust, dirt, insect eggs or insects, spider webs easily.
- Clean the floors with washing with, detergent solution and let it dry without any moisture. After wards follow sanitization procedures.

**5.6.2 Fumigation**

- Fumigation is the introduction of a toxic gas into a space—whether a warehouse, godown, or a rat burrow, in high enough concentrations so that the gas fills all areas & kill target pests.
Fumigation is quick acting, effective against various stages of the pest, highly penetrating into the packaging and commodities.

- Leaves no residue of toxicant and undesired odour. The gas being inert does not react directly with commodity
- Normally Fumigation carried out by production of formaldehyde gas by adding required quantity of formaldehyde solution (40% formalin) to potassium permanganate.
- Use 40 ml formaldehyde solution to 20 g of potassium permanganate for every 100 cft air space.
- The other method is to dip a piece of cloth in 100 ml of formaldehyde and hang near to fan in the relative humidity at above 75%.
- Formaldehyde gas is irritant to eyes and skin hence handle carefully and wear protective cover.
- Close air vent and exhaust. Min. 30 mts gas contact for disinfection. If necessary use ammonium hydroxide 25% to neutralize formaldehyde.

**Qualities of ideal Fumigant**

- Low cost for effective dosage and application.
- High toxicity to insects; low to man.
- High volatility and penetration; low absorption.
- Non-corrosive
- Non-Explosive, non-flammable
- No damage to product quality
- Aerate rapidly, no residue.
- No damage to germination
- Residual spraying

**5.7 Use of Pesticides in Feed Stores to Control Biological Agents**

The main biological agents are

(a) Insects
(b) Fungi
(c) Rodents

(a) Insects

At temperature 32 °C rate of multiplication is 50 times. The nutritive requirements of insects are same as those of vertebrates. Dead and live insects and their excreta cause the commodity unpalatable and unacceptable.

Control

(1) Good hygiene

(2) Cleaning and checking of storage containers as well as the stored food as far as possible.

(3) New dry grain should be kept separate from old grains.

(4) Store should be remote from the field to reduce the risk of infestation.

(5) Traditional pest control system such as use of local herbs. Mixing as with grain and smoking are effective and should be encouraged.

(b) Fungi

Fungi produce metabolities like aflotoxin which is toxic to animals. The fungus development occurs in the stored feed ingredients due to high humidity and wetting.

Control: Losses due to fungi can be reduced by applying drying and storage technology.

(c) Rodents

They not only consume feed but also foul with their excretions. Further they destroy containers by growing holes that results in leakage and wastage of feed.

Control

(1) Rodent exclusion efforts in store construction.

(2) Improved sanitation

(4) Trapping and hunting

(5) Use of cats and dogs

(6) Rodent repellents and

(7) Poisson baiting such as chlorofacamone, warfarub, comabin zinc phosphate, barium carbonate etc.
5.8 Spoilage of Feeds During Storage

- Spoilage is most often caused by improper storage of the material.
- There are many reasons for improper storage: the moisture content and temperature of the material at binning might have been initially too high for safe storage or moisture was allowed to locally increase during storage either due to moisture migration or through leaky roofs and walls.
- Feed spoilage is caused by the growth of undesirable molds and bacteria. Their rapid growth can cause heating of feed, which reduces the energy as well as the vitamins A, D3, E, K and thiamine available to the animal.
- Mouldy feeds tend to be dusty, which reduces their palatability.
- In addition to spoilage reducing the feed value and palatability, it can also increase the exposure of livestock to harmful moulds and bacteria.
- Animal sickness symptoms may be associated with the presence of mycotoxins.

5.9 Summary

The procurement and storage of feed ingredients were explained. The various methods of detection of feed adulterants were detailed in simple way. Various methods of testing quality of finished feeds are furnished. Packing, forwarding and storage of feeds explained. Cleaning and fumigation procedures explained to keep feeds in good condition. Use of pesticides explained to use in feed stores to control biological agents.

Short Answer Type Questions

1. What are the common feed adulterations?
2. What are the physical tests in Quality controls methods?
3. What are the chemical tests in quality control methods?
4. What is packing of feeds?
5. What are the pesticides used in feed stores?

Long Answer Type Questions

1. How do you procure and store feed ingredients.
2. Explain in detail about the methods of detection of feed adulterants.
3. Explain various quality control methods for finished feed?
4. Briefly write about packing and forwarding of feeds.
5. Explain cleaning and fumigation process in feed store?
6. Briefly write about storage of concentrates?
7. How do you control biological agents in feed stores by using pesticides?
**6.1 Methods of Purchasing, procurement of feed ingredients and their physical evaluation.**

- In order to ensure a continuous supply of raw materials at the mill, the feed ingredients purchased during the season to avoid price fluctuations.

- Proper storage of feed ingredients in bags will be preferable due to ease of handling.
Raw materials should arrive in good condition and in sacks which have not been used for the storage of fertilizer, pesticides or chemicals.

Contamination by string, large pieces of metal, wood or stones which could cause extensive damage to machinery can normally be removed on a coarse metal grid fitted over the sack tipping-in point of the feed mill and permanent magnets will normally remove any tramp ferrous metal which may enter the system, particularly before entering the grinder, mixer or pelleteer.

Storage areas must be waterproof and well-ventilated, and provide protection against infestation by insects and vermin which can quickly cause substantial losses in weight.

If materials are to be stored in bags they should be kept in a building having a concrete floor.

The roof and walls need only to be lightly constructed provided that they are pest and waterproof.

The bags should be stacked a few inches above floor level, for example, on wooden pallets (see Figure 1), and away from walls.

Raw materials may also be stored in bulk either in silos constructed from concrete or steel or in bins formed with partitions in conventional stores.

Bulk storage normally entails a greater investment in capital equipment but lower operating costs.

Proper storage of raw materials and of finished feeds is not only essential to prevent physical losses, but is also an important aspect of quality control.

Physical Evaluation of the Feed Ingredients

Sensory property evaluation, including inspection of ingredient color, odor, texture, moisture, temperature, and a visual inspection for physical purity (absence of foreign material and insect infestation) enables one to quickly assess whether the ingredient should be accepted or rejected.

Physical property evaluation usually involves testing incoming grain and feed ingredients for bulk density, purity, and texture. All of these properties will determine how the material unloads, conveys into and out of bins, stores, and performs during processes.

- **Bulk density** of a material represents the mass per unit volume. This characteristic is commonly expressed as kilograms per cubic meter (kg/m³). The bulk density of a material is measured by weighing the amount of material
that fills a one-cubic-foot box. Bulk density can vary significantly for the same ingredient due to differences in particle size, moisture content, or compaction. Bulk density of a feed ingredient is important for inventory control purposes and will determine how the ingredient will perform during batching and blending. When a feed ration requires blending ingredients that differ widely in bulk density, the feed processor should ensure that the particle size of the feed ingredients is similar, use a binding agent (fat or molasses), and load the mixer using an ingredient sequence that optimizes the blending action of the mixer. For example, high density ingredients should be added early to vertical mixers and late in the batching sequence for horizontal mixers.

- **Purity** refers to the absence of contaminants. The source of these contaminants may be physical (e.g., glass), chemical (e.g., seed treatment), and microbial (e.g., mycotoxin). The use of hand sieves to inspect for physical contaminants enables rapid evaluation of material.

- **Texture** of an ingredient is measured visually and with sieves.

### 6.2 Grinding of Feed Ingredients - Equipment

- The machine most commonly used in the feed manufacturing industry is the hammer mill and is illustrated in Figure.
- Inside the grinding chamber, hammers, which may be fixed rigidly to the central shaft, or more often swinging on steel pins, rotate at high speed.
- The impact of the raw material on the hammers and the continual high-velocity impact of particle on particle results in material breakdown until it is small enough in size to pass through a perforated screen.
- The smaller the screen size the more work will be required to reduce the particles to the desired size and the larger the grinder motor required.
- Raw materials also have different grinding properties somewhat related to their bulk density and flow characteristics. In general those of high bulk density grind more easily than fluffy, fibrous low-bulk density materials.
- Grinders are most efficient when they are running at maximum capacity for a given raw material and screen size.
- Many small grinders have suction fans fitted to the grinder shaft which bring about cooling and conveying of ground material in one operation. Other grinders discharge directly into conveyors and the air drawn in during grinding is released through filter bags.
- Grinders may operate in a horizontal or vertical direction according to design.
- The moisture content of raw materials to be ground in a hammer mill should not normally exceed 13-14%.
Large, lumpy, hard materials such as dried cassava roots and expeller oil cakes should be pre-crushed in a cake breaker to a particle size suitable for the dimensions of the hammer mill intake throat.

Figure 6.1 Grinding Equipments

6.3 Mixing of Feed Ingredients - Equipment

It is the job of the mixer to produce a homogenous blend of all the raw materials desired in a formulation, such that at each feeding period each animal receives a balanced mixture of nutrients. Mixing often improves feed palatability if one or more of the raw materials is unpalatable to livestock. Mixing can be carried out with

6.3.1 Shovels

- Limited quantities of animal feed can be mixed on a concrete pad with a shovel, in a manner similar to the dry mixing of cement and sand.

- Raw materials should be layered one above each other and then mixed and turned to form an adjacent heap.
• An efficient shovelling and mixing of the heap at least three times should produce an uniform product with the even distribution of small quantities of vitamins and minerals.

• The evenness of colour of the mixture will often give a fair indication as to the homogeneity of the mixed feed.

6.3.2 Concrete Mixers

• Small concrete mixers with electric or petrol engine drives are mobile low cost machines suitable for the manufacture of mixtures of dry ingredients or mixtures of wet feeds.

• Pre-ground raw materials should be mixed for a minimum of five minutes to achieve a satisfactory blend.

• For larger-scale feed mixing however it is advisable and probably cheaper to use one of the conventional feed mixers described below.

6.3.3 Conventional Feed Mixers

The mixers most commonly used in the feed industry are

• Vertical (or fountain) mixer

• Horizontal (or U-trough) mixer.

• Conveyor mixer. Vertical mixers

6.3.3.1 Vertical Mixer

It is a slow action, long-dwell time mixer which relies upon the continuous tumbling and intermingling of raw materials as they are discharged in a fountain-type action from a vertically running screw of approximately 8-10" diameter as illustrated in Figure 2.

• Raw materials may enter the mixer either at the top, from a cyclone or auger feed from the grinder, or at the base of the screw at a sack tipping point.

• After mixing for a pre-determined time, normally 10-15 minutes the mixture is discharged into a bag or conveyed by auger or bucket elevator to a storage bin or pelleteur.

• Since many raw materials are dusty it is often desirable to include materials such as molasses, oils and fats in the formulations to reduce dustiness as well as to provide a source of nutrients.

• Vertical mixers, because of their slow-running action, are generally less effective in distributing liquids throughout the mixture, and liquids tend to
form balls, coated with fine particle material, rather than produce a surface coating on the solid material.

- For coarse cattle rations where large quantities of feeds are consumed per animal the need for a completely homogenous distribution of liquid is less critical than for poultry feeds or feeds to be pelleted, where it is desirable that liquids be well mixed with minimal lumping.

- Vertical mixers have a general tendency to encourage particle size segregation, especially if too long mixing times are used. They are tall units which may not readily fit into buildings with low roofs or ceilings. However, they can
be easily loaded manually at floor level, and are relatively low capital-cost machines widely used in feed manufacture where liquid addition is not required, or for blending raw materials prior to grinding.

### 6.3.3.2 Horizontal Mixers

- As the name suggests, horizontal mixers operate with a horizontally turning mixing shaft.
- The shaft may carry paddles or agitators of various designs which come in very close proximity to the wall of a U-shaped trough.
- Raw materials are lifted, folded and abraded against each other resulting in a relatively short mixing time, typically of the order of 3-6 minutes, though it may vary depending on the nature of the mix. The mixer is suitable for blending up to 8% liquids into a dry mix and therefore offers greater versatility if a wide range of rations are to be offered from one feed mill unit.
- It is preferable that fats and molasses be warmed before addition to the raw materials in the mixer and they should be added as the last ingredients.
- Because the horizontal mixer is a faster mixing machine than a vertical mixer, two or three mixes can be achieved in the same time as one mix in a vertical mixer.
- A half-tonne capacity horizontal mixer could possibly replace a 1-tonne vertical mixer since two half tonne mixes could be made in a horizontal machine including loading and unloading in the same time as one tonne in a vertical mixer.
- A horizontal mixer is more sophisticated in terms of its engineering construction and thus more expensive to purchase than a vertical mixer of equivalent capacity.

### 6.3.3.3 Conveyor Mixers

- Conveyor mixers consist of a trapezoid metal box in which mixing is effected by slats extending almost the full width of the machine and which are carried on a pair of endless chains.
- Like the vertical mixer, this machine is limited in its ability to blend liquids thoroughly into the mixture.
6.4 Pelleting Process - Advantages - Disadvantages

Pelleting involves the compression of a mixed feed through holes in a hardened steel ring or plate (a die) by means of hardened steel rollers. The die forms the feed into pencil-like extrusions which are cut by knives into pellets of desired length on leaving the die. The principle of operation of a ring die is given in Figure 6.3 Pelleting Process.

- In a ring die pelleting, the rollers or the die may be driven but in a plate die pelleting the rollers only are driven.
- The die and rollers of a ring die pelleting may operate in a horizontal or vertical plane according to machine design.
- The pelleting process is very energy intensive, demanding up to 50% of the total power required for feed manufacture.
- The diameter of feed pellets is governed by the diameter of the holes in the die ring but the smaller the die holes the greater effort is required to force meal into these holes, hence the greater the power demand, that is, the smaller the pellet, the greater the cost of manufacture.
6.4.1 Tyres of Pelleters

Pelleters may also be divided into two further groups according to the pre-treatment of mixed feed prior to compression or extrusion in the die head. Pelleters may be considered as cold pelleters or conditioner pelleters.

6.4.1.1 Cold Pelleters

- In cold pelleting, mixed feed is fed directly from a bin or auger into the die head at normal atmospheric temperatures.

- Some water may be added, preferably in the mixer if the meal is too dry to bring it to approximately 15-16% moisture, but there is no heat treatment of the mixed meal before it enters the die.

- The frictional forces generated during pellet extrusion cause the temperature of the pelleted feed to increase from ambient to up to 60-70°C.

- Pellets must be cooled to ambient temperatures before storage by spreading thinly over a large area of floor, or preferably cooled in a bin fitted with a cooling fan.

- During cooling the moisture content is reduced to approximately 12% by evaporation in order to reduce the risk of sweating and mould growth.

6.4.1.2 Conditioner Pelleters

- During conditioner pelleting, the mixed meal is directly pre-heated with dry steam in a small high-speed mixer called a conditioner or in a slow turning mixer called a kettle or ripener.

- The steam preheats or conditions the meal to the preferred temperature and moisture content for pelleting according to the formulation of the mixture. During pelleting the temperature of the meal rises by approximately 10°C, hence the final temperature of pellets from a conditioner pelleter is similar to that of pellets from a cold pelleter. Cold air is drawn through a moving mass of pellets either as they fall through the vertical machine, or as they pass along an open mesh belt through a horizontal cooler.

- Generally, the quality of pellets of a given mixture from a conditioner pelleter is marginally better than that from a cold pelleter, but the conditioner pelleter requires a boiler and associated water treatment plant to treat the feed water for the boiler.
6.4.2 Pellet Quality

- Pellets should have a desired degree of hardness, and should also show high resistance to abrasion during handling and transport.

- Pellet quality depends largely on the amount and nature of starch and protein in the raw materials.

- Their binding effect is modified by a number of other factors including the moisture content, fibre content, oil content, and fineness of grinding of the raw materials.

6.4.3 Pellet Binders

- Some mixtures of raw materials do not bind well together when pelleted and require the addition of special binding agents.

- Molasses is often added at 2-5% to aid binding, but other binders include bentonite clays and lignosulphonates, and are added at the suppliers’ recommended dosage levels, usually about 1-2%.

6.4.4 Advantages

- The use of pelleted feed is often popular with farmers because it is convenient to handle and reduces dustiness.

- It prevents segregation of raw materials during handling and selection by animals, especially poultry, during feeding.

- This may be particularly useful where less palatable raw materials are included in the formulation.

- Pellets also reduce feed losses during feeding, and may help to maintain, or increase, feed intake under certain conditions.

- The heat generated during pelleting can inactivate some pathogenic bacteria which may be present in raw materials.

- Finally pelleting can assist in preventing adulteration of feed by unscrupulous traders.

6.4.5 Disadvantages

- Pelleting increases the cost of feeds because the capital cost of pelleters is relatively high compared to grinders or mixers, the energy requirement is high.

- Additional care and skill is necessary for their maintenance and operation.
6.5 Compounding of Feeds - Objectives - Advantages

- Individual ingredient feeding will result in imbalance of ration and the animal gets whatever nutrients present in that ingredient only and may suffer from deficiency of nutrients which are lacking/low quantity in that particular feed.

- Without any processing feed ingredients, the digestibility and assimilation will be less. If these ingredients are ground into small particles, the surface area available for enzymatic action will be increased and so the digestibility increased and also digested quickly.

- The requirement of nutrients for different classes of animals is different. i.e. growing, pregnant, milch animal, working, dry animals, etc. No single ingredient will satisfy all the requirement of nutrients. So different ingredients are selected and proportions of each ingredient selected and are calculated to make a definite quantity which will satisfy the nutrient requirement for that class of animals.

- If all the ingredients are mixed and fed without processing individual ingredient, there is a chance of picking only certain ingredients by the animals selectively leaving others. To counteract this disadvantage, all the ingredients are ground into smaller particles (grinding) and mixed very well (mixing) so that the animal takes all the ingredients mixed in that feed.

Objectives

- To improve the nutritive value of feed
- To balance the protein and energy requirement.
- To balance minerals and vitamins
- To mask the non-tasty food ingredients
- To utilize the agro industrial and livestock industry by-products
- To have uniform protein and energy and other nutrient per unit weight of feed.
- To improve the palatability.
- To avoid wastage by binding and pelletization process.
- To improve the digestibility of nutrients.
Advantages

- Compound feeds are complete feeds containing all the necessary nutrients at optimum level.
- Compound feeds can be prepared for different class of animals and quantity of feed given can be calculated depending on the production.
- Feed wastage can be minimized.
- Compound feeds will have high digesting and assimilation properties due to processing methods.
- Agro Industrial by products and livestock industry by products can be mixed without affecting the palatability. Otherwise these ingredients will not consumed by the animal
- The cost of nutrient per unit weight is cheap “by utilizing wastes / by products.
- The animal will be healthy, as they receive all the vitamins and minerals at optimum quantities.
- Production of milk will be increased due to balance of protein and energy.
- By using molases no feed wastage will be occurred.
- No wasting of feed by dusting by using pellets.

6.6 Summary

The process of grinding and mixing of feed ingredients were furnished. The equipment used for grinding and mixing of feeds was explained. The process of pelletization which limits feed wastage was discussed with advantages and disadvantages. The objectives and advantages of compounding of feeds mentioned and the equipment used for compounding of feeds explained.

Short Answer Type Questions

1. What is grinding?
2. Define mixing.
3. Mention different types of grinders?
5. What is compounding of feeds?
6. Mention the equipment used for compounding of feeds?

7. What is the binding ingredient used in pelletization?

**Long Answer Type Questions**

1. Explain grinding of feed ingredients.

2. Briefly write about various types of pellets.

3. Explain mixing process of feed ingredients?

4. Discuss about various types of mixers

5. Explain pelleting of feeds.

6. What are the advantages and disadvantages of pelleting process?

7. Give tips for efficient management of feed plant.

8. Give objectives and advantages of compounding of feeds?


10. Explain about the machinery used for compounding of feeds.
Structure

7.1 Study of soils for fodder production
7.2 Importance of green fodder feeding for economic milk production.
7.3 Crop Rotation.
7.4 Study of Different Forage farm equipment - Ploughing, Harrowing, Planking etc..
7.5 General, Principles of Irrigation, Fertilizers requirement in fodder production.
7.6 Cultivation Practices
7.7 Silvi Pasture - Hortipastures
7.8 Summary

7.1 Study of Soils for fodder Production

Generally soils plays an important role in increasing fodder production. So to know about different soils which are suitable for different crops is most essential. The soils are mainly divided into two group i.e. Red and Slack. These are again divided as sandy soil, loamy soils and clay.
7.1.1 Red soils - General Characteristics

Red soils occupy 65% of the cultivated area in Andhra Pradesh. They are found in Chittor, Anantapur, Visakhapatnam, Karimnagar, Medak and Hyderabad district.

They are derived from rocks like granite and genesis. They are red in colour. The red colour is due to the presence of iron. Rich sandy loamy soils but clay is very less. These soils are suitable for jawar and maize production.

7.1.2 Black Soils (General Characteristics)

They occupy 25% of the cultivated area in A.P. They are called as black cotton soils, as they are best suited for cotton under rainfed cultivation. Guntur, Krishna and Rayalaseema districts have large area as of black soils. They are clay in nature. They absorb water slowly. Their water holding capacity is high. They are rich in plant nutrients. The water table is low. The water contains salts and so the water is not useful for irrigation.

They shrink in summer and swell on wetting. They form deep and wide cracks during summer. Their P.H. is 8.5 to 9. Jonna (Jowar) is the main food crop. They are good for cotton.

7.1.3 Soil Texture and Structure

Soil texture indicates fineness or otherwise of the soil depending upon the relative proportion of the particles of varying sizes.

The soil particles which resulted from weathering vary greatly in size. They are classified into gravel, sand, silt and clay on the basis of their size.

1. Coarse and : 2.00 to 20 mm
2. Fine sand : 0.20 to 0.002 mm
3. Silt : 0.02 to 0.002 mm
4. Clay : less than 0.002 mm

Clay particles are so small that they are not visible even under ordinary microscope. Sand grains feel gritty and are easily visible by naked eye. Gravels range from pebbles to particles of 2.5 mm diameter. The various size groups are termed as soil separates. Most soils are mixtures of the soil separates in different proportions. Depending on the proportion of the solid particles of different sizes, soils are grouped into 3 main textural classes viz. Clays, Loams and Sand.
1. Sandy Soils

They contain more of coarse fractions. They absorb moisture quickly, permits sowings early. Hence they are called “Early Soils”. They are loose and friable, in village is easy. Hence they are called “Light Soils”. They contain less of organic matter. They are poor in plant nutrients. They are called hungry soils. They do not crack in summer and deep cultivation is necessary. Addition of organic matter increases their water holding capacity. They are suited for heavy rainfall areas.

2. Clay Soils

Fine fractions are more in clay soils. They absorb water slowly. Their water holding capacity is high. They are hard and sticky. Tillage is difficult, hence they are caned heavy soils. They permit sowings late and for this reason they care called “Late Soils”. They crack deep in summer, and swell on wetting. They are called self tilled soils. Addition of organic matter improve the structure drainage and aeration of the soils. They are suited to low rainfall regions.

3. Loamy Soils

They contain coarse and fine fractions in equal proportions. Water absorption and movement is not slow and not rapid. Soil is not too loose nor too stiff. They contain good amount of organic matter and plant nutrient. Good drainage is present. They hold moisture sufficiently. They are suited to all crops and all types of climatic conditions.

Within each group of textural classes, there are 3 to 4 sub-groups recognised. They combine the properties of more than one group.

7.1.4 Study of Soils for Fodder Production

The following table shows suitable soils for fodder.

<table>
<thead>
<tr>
<th>Name of soils</th>
<th>Type of Fodder</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (a) All types of Soils</td>
<td>Jowar</td>
</tr>
<tr>
<td>(b) Well levelled loamy soil</td>
<td>Maize (NLA)</td>
</tr>
<tr>
<td>Deep detentive fertile loams to</td>
<td></td>
</tr>
<tr>
<td>2. Clay loams</td>
<td>Napier (NLP)</td>
</tr>
<tr>
<td>3. Loamy soils</td>
<td>Low pea (LA)</td>
</tr>
</tbody>
</table>
4. Clay loamy soils (Sandy not suitable)  Beerseem (L.P)
5. Deep and well drained loamy soil  Lucerne (L.P)
6. Sandy to clay soils  Paragrass (NLP)
   (Water logged soil)
7. Neutral to alkaline soils  Subabul (FT)
8. Rich fertile deep loamy to clay  Guinea grass (NLP)
   loamy
9. Feely drained light texture soils  Stylo (Legume pasture)

NLP  -  Non Legume Perinal
NLA  -  Non Legume Annual
LA   -  Legume Annual
LP   -  Legume Perinal
FT   -  Fodder Trees

7.2 Importance of Green Fodder Feeding For Economic Milk Production

(a) Green ferage is essential in the feeding of dairy cattle for economic milk production.

(b) Green fodder feeding practice maintains the normal health and reproduction of all herbivores.

(c) The longevity and production are adversely affected when cattle are reared without green ferage, even though they may be provided with best quality of concentrates. Such animals usually give birth to weak, stunted or blind calves.

(d) Green forages are also praised for their over all cooling effect on the body due to the nature of being easily digestible, more palatable, being slightly laxative in action and above all provide fresh nutrients in most natural form resulting in efficient utilization of these feed without any strain on the body organs.

(e) Dairy cattle yielding as high as 10 litres of milk can easily be maintained solely on green fodder without any complaint. By this the feed costs are reduced by 20% over a normal dry roughage (straw) and a concentrate mixture.
The good characteristics of green fodder are

1. These are highly digestible mostly when harvested at a proper time (55 - 65%).

2. The crude protein may range from as little as 30% in very mature forage to over 30 per cent in young heavily fertilized grass (on dry matter basis).

3. The soluble carbohydrates of grasses include fructanes and sugar glucose, fructose, sucrose, raffinose, etc ranging in the dry matter from 4 percent to 30 percent. The cellulose is generally within the ranges of 20-30 percent of the dry matter.

4. Grass proteins are particularly rich in arginine, and also contain glutamic acid and lysine.

5. Lipid content hardly exceeds 4 percent.

6. The mineral content of pasture is very much dependent on soil type, stage of growth, species and cultivation of condition.

7. Green ferages are excellent sources of carotene, the precursor of vitamin A and quantities are high as 250 mg 1kg may be present in the dry matter.

Thus a dairy farmer will be economically in a safe portion if he maintains his cattle mostly on forages. If on has irrigation facilities, he may adopt intensive crop rotations for the production of quality fodders.

### 7.3 Crop Rotation

Growing two or more crops in a sequence one after the other, on the same piece of land is termed as sequential cropping. Depending on the number of crops grown in one year, the systems are called double cropping, triple cropping, quadruple cropping, etc. If the same crop is grown after season or year after year. It is termed as Mono culture and if different crops are grown it is termed as crop rotation.

Eg:     Maize-Berseem
        Sorghum - Oats - Maize
        Maize - Cow Pea - SSG (Multi cut sorghum)

Availability of irrigation water is more important to adopt this system.
Normally in crop rotation on legume crop is followed by non leguminous followed by leguminous is followed to have beneficial value of

a) The leguminous crops will fix nitrogen in the soil, which will be utilized by successive non leguminous fodder. So we can reduce the fertilizer for non-leguminous crops.

b) With this rotation the amount of biomass production will be increased.

c) This system will alter the soil condition, so that next crop is easy on soils.

d) The forage quality in crop rotation system will be improved.

e) The cost of production of forage production for one year will be decreased at 30-40%.

Inter cropping i.e. growing one or more crops simultaneously on the same piece of land together for their entire life cycle or at least for part of their life cycle is also beneficial.

Eg: Sorghum + Cowpea+Cucumber -> Mixed cropping
    Sorghum + Cowpea, Maize+Cowpea -> Row cropping.

In mixed cropping in the system in which two or more crops are mixed and sown by broad casting without distinctive spacing. Sowing two or more crops in distinct rows with narrow ratios of 1:1 or 1:2 or 2:2 is termed as row inter cropping.

The system of sowing two or more crops in alternate strips (slightly larger ratios’ such as 10:10 or so) is termed as strip cropping.

Eg: Stylosanthesps + Guinea grass

For crop rotation one system of the above three systems after another system can also be practiced.

Eg: Mixed cropping - Row Cropping - Strip Cropping.

7.4 Study of Different Forage Farm Equipment - Ploughing, Harrowing, Planking, etc.

1. Ploughing

Ploughs are used for primary tillage. Implements used for opening and loosening of the soil are known as ploughs. Ploughs are of three types i.e. Wooden ploughs, Iron or Inversion ploughs and Special Purpose ploughs.
A. Indigenous Plough or Wooden Plough

It is made of wood with an iron share point. It consists of body, shaft pole, share and handle. ‘V’ shaped funow is cut and opens the soil, but there is no inversion. Ploughing operation is not perfect because some unploughed strip is always left between funows.

Types of Wooden Ploughs

3 Varieties on size and purpose. Peddamadaka of Rayalaseema is a heavy plough, which ploughs 15-20 cm depth and is drawn by 3-4 pairs of cattle. Also called black soil plough. Dryland plough is smaller ploughs. Wornout dryland plough is used as a wetland plough. Since black soils after more resistance for opening, the head of the body is smaller, the angle between the shaft and share is acute, but the length of the body is more than light soil plough. The above three types covers 0.1 to 0.15, 0.15 or 0.25 and 0.24 to 0.28 hectares per 8 hours day.

B. Soil Turning Ploughs

Mould Board Ploughs

This type of plough leaves no unploughed land as the furrow slices are cut cleaned invested to one side resulting in better pulverisation. The parts of the type are frog or body, mould board or wing, share, landside, connecting, rod, bracket and handle. Two moulded board plough are attached to tractor where as simple one is animal drawn. This is used when soil inversion is necessary.

Disc Plough

It resembles mould board ploughs. A large revolving concave steel disc replaces the share and the mould board. The disc turns the furrow slice to one side with a scooping action. This is useful where there is much fibrous growth of weeds, as disc cuts and incorporated the weeds. No harrowing is necessary to break the clods of the upturned soil as in a mould board plough.

Turn - Wrest or Reversible or One Way Plough

Plough bottom in this is hinged to the beam such that the mould board and the share can be reversed to the left or to the right side of the beam. This adjustment saves the trouble of turning the plough in sylly tracts, but yet facilitates inversion of the furrow slice to one side only.

C. Subsoil Ploughs

Subsoil Ploughs
This is designed to break up hard layers or pans without bringing them to the surface. The body of the subsoil plough is wedge shaped and narrow while the share is wide so as to shatter the hard pan and making only a shot on the top layers.

Chisel Plough

It is used for breaking hard pan and for deep ploughing with less disturbances to the top layers. Its body is thin with replaceable cutting edges so as to have minimum disturbance to the top layers. It contain replaceable share to shatter the lower layers.

Ridge Plough

It has two mould boards, one for turning the soil to the right and another to the left, with a common share, i.e. double winged. It is used to split the field into fidges and funows and for earthing up of crops. It is used to make broad bed and funows by attaching two ridge ploughs on a frame at 150 cm space in between.

Rotary Plough or Rotary Hoes

It cuts the soil and pulverises it cutting of soil is done by blades or tynes. It is suitable for light soils. Blade types are widely used.

Basin Lister

It is heavy important with one or two mould boards or shovels. Shovels are mounted on a special types of frame, on which they act alternatively. It is used to form listed ferrows (broker furrows with small dams and basins) to prevent free run off of rain fall and blowing of the soil in low rainfall areas.

II Harrowing

Harrows are used for shallow cultivation in operations such as preparation of seed bed, covering seeds and destroying weed seedings. Harrows are two types i.e. disc harrow and blade harrow.

Disc Harrow

It consists of a number of concave discs of 45-45 cms in diameter. Discs are smaller than disc plough, but no are more, which are tilted 15 cm apart on axles. Two sets of discs are mounted on two axles. All the discs revolve together with axles. The discs cut through the soil and effectively pulverises the clods.
**Blade Harrow**

It is used for removal of weeds and stubbles, crussing of clods, working of soil to shallow depth, covering the seeds, intercultivation and groundnut harvesting etc. Blade harrow are 2 types

(i) **Indigenous Blade Harrows:** It is known as as ‘Guntaka’ consists of a beam to which two pegs are attached at the ends. A blade is attached to these two pegs. Two shaft poles and a handle are other parts depending on the beam length and weight, this again have two sub types i.e. pedda guntaka and Guntaka.

Pedda Guntaka is a blade harrow with a heavy beam of 100-120 cm length. It is used for summer deep harrowing to control weeds.

Guntaka or Blade Harrow is smaller than Pedda Guntaka. It is used for removed of weeds and stubbles and covering crop seeds.

(ii) **Improved Guntaka:** Indigenous have the problems of clogging and lack of penetration into hard soil. When weeds are more, they twist round the blade and subsequently, the blade can not cut through the soil. Soil and clods do not pass through the blade harrow. To avoid this R.E guntakas and H.M. guntakas developed. R.E. guntaka was developed by research engineer at Coimbatore. Blade is fixed at angle, whose angle can be changed to get required depth.

H.M. Guntakas developed by hills on and munro. Depending on the length of blade these are called 0,1 and 2.0 size is used for intercultivation, while other sizes are used for other purposes.

**III Planking**

Plank is a very simple implement and consists of a heavy wooden beam of 2m length. In addition, shafts and handle are fixed to the beams. When it is worked most of the clods are crushed due to its weight. It also helps in microlevelling and slight compaction necessary after sowing.

Rollers are used mainly to crush the hard clods and to compact the soil in seed rows.

Plank is made of wood. It is economically cheap. The various of plank are Handle, Beam and Shaft.

Planks can be made locally according to their own design.
Fig. 7.1 Plank

Fig. 7.2 Harrow

Fig. 7.3 Wooden plough
Like many field crops, most of the fodder crops are also season bound. They perform well only in a particular season. The requirements of all the fodder crops are also not similar. They differ very widely. The fodder crops and their varieties have to be selected for any particular situation after carefully considering various aspects such as season, soil, availability of resources like irrigation water, manure and fertilizers, credit etc. apart from other things like number and type of the animals, their nutritional requirements.

Green and dry fodders and available from two different situations 1. Cultivated Fodder 2. Pasture Lands.

**Irrigated Areas**

Crops intensification through inter cropping as well as sequential cropping is possible in irrigated areas. It is also easy to cultivate perennial fodders when there is adequate irrigation. The following are some of the productive cropping systems for irrigated areas.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Kharif</th>
<th>Rabi</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Surgham/Maize/Bajra + Cow pea/Lab-Lab</td>
<td>Maize+ Cow Pea</td>
<td>Maize+ Cowpea</td>
</tr>
<tr>
<td>2.</td>
<td>Amaranthus</td>
<td>Berseem/Oats</td>
<td>Cow Pea</td>
</tr>
<tr>
<td>3.</td>
<td>Sorghum/Maize /Lab-Lab</td>
<td>Maize+Cow</td>
<td>SSG 59.3+ Cow pea</td>
</tr>
</tbody>
</table>

**Fertilizers Requirement**

<table>
<thead>
<tr>
<th>Name of the Crop</th>
<th>Fertilizer</th>
<th>Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jowar</td>
<td>Farmyard Manure</td>
<td>4-7</td>
</tr>
<tr>
<td></td>
<td>20-25 tonnes</td>
<td>1-2 (rainfed)</td>
</tr>
<tr>
<td></td>
<td>N-60 kgs (2 doses)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P_2O_5 - 30 Kgs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>K_2O - 30 Kgs.</td>
<td></td>
</tr>
<tr>
<td>Cowpea</td>
<td>Farmyard manure</td>
<td>3-4(summer)</td>
</tr>
<tr>
<td></td>
<td>10 tonnes</td>
<td>1-2 (kharif)</td>
</tr>
</tbody>
</table>
7.6 Cultivation Practices

(a) Legume Annuals

Cowpea (Vigna Sinensis)

Cowpea varieties are numerous differing in habit from erect to prostrate. Cowpea can be grown on a wide range of soils but moist medium loams with pH range of 5.0 - 6.5 are the best for this crop. It can also be grown on sandy soils and heavy soils. It can be grown in any month of the year.
Two or three ploughings are needed before beds of suitable sizes are formed. The seeds are sown broadcast and watered immediately after. Seed rate of 30-40 kg/ha is used. It can also be grown as a mixed crop with maize, jowar or bajra. The seed rate is 15 kg/ha.

Irrigations are needed depending on the soil moisture. As a fodder crop, it can be cut in 60-70 days after sowing the yield about 12-15 tonnes/ha of green fodder. Plant protecting measures are needed for cowpea crop such as dusting of B.H.C. 10% powder.

The Cowpea fodder is cut and fed as green or preserves and fed as Hay.

**Sunnhemp (Crotalaria Juncea)**

An erect shrubby annual 1,2,3 in height with simple, narrow subsessile leaves and bright yellow flowers. It is quick growing and fairly drought resistant. It can frow on wide variety of soils but thrives best on light, well drained loans. Heavy clays and water logged or saline are detrimental of crops.

It is grown both in the kharif and rabi seasons, the actual time of sowing varies according to local conditions. It is grown popularly as a rice fallow crop.

A seed rate of 28-30 kg/ha is used. Seeds are sown broadcast. Harvesting at 45 days (50% bloom) after sowing give good quality forage. The yield is 20-30 tonnes/ha of green forage.

Sunnhemp is a nutritious forage can be fed as green or has Hay. It is popularly used as a Hay, storing in alternate layers with rice straw. Feeding of rice straw along with supplementary feeding of sunnhemp hay provides balance diet for cattle and buffaloes.

**Phillipesar (Phaseolus Trillobus)**

This is a popular legume of the rice growing tract, grown primarily as a rice fellow crop to enrich the soil and obtain good fodder. It comes up well on all types of soils, from sandy to heavy black soils. It is annual blooms of some four to five months duration. The land is given 2 to 3 ploughings and the seeds broadcast at 17 to 20 kg/ha when thee is sufficient moisture in the soil. As a rice fallow crop, seeds are broadcast in the standing rice crop prior to five to six days of harvesting.

One or two irrigations will improve the growth of the plants. It can be cut at flowering stage and fed green or converted into hay or grazing may be allowed.
It provides a good leafy nutritious forage for livestock.

**Berseem or Egyptian Cover (Trifolium Alexandrium)**

It is one of the most important fodder crops and has been rightly been described as the king of fodders. It is highly esteemed fodder which has a special place in Animal Husbandary programmes throughout the Indian subcontinent. Though a migrant from Egypt it has established in this region for the last 60 years and may well be considered as a native of India. It has many desirable qualities. 10-15kg of fodder alone with straw constitute a maintenance ration. It can support growth and milk production on adlib feeding, balanced by straws. It does not tolerate acidic soils but grows in other kinds of soils except user lands.

![Fig. 7.2 Berseem](image)

(i) Time and Method of Sowing: The crop is sown from middle of September to end of October in plains and from middle of August to first week of September in hills. This crop requires a thorough preparation of land. After harvesting of Kharif Crop, the field is to be ploughed once with mouldered or disc-plough which should be followed by two or three harrowings and finally completed by planking.

For satisfactory results in a big plot is divided into number of smaller plots for convenience of irrigation. If the crop is cultivated for the first time, inoculation with bacterial culture is necessary. The seeds are inoculated just before sowing and the inoculated seeds should not be exposed to sun.
Berseem is now available in another form called Giant Berseem. The advantage of giant berseem is that lesser irrigation is required. While the seed rate of ordinary diploid berseem is 20-25 kg that of giant berseem is 30-35 kg per hectare.

It is sown by broadcast which is then followed by irrigation.

(ii) Manuring and Irrigation: Like all legumes it requires phosphatic manures. An application of 150 kg of ammonium sulphate or Kisan Khad along with 500 kg of superphosphate per hectare at the time of sowing is necessary for good yield.

It requires irrigation after every 10-12 days in early winter and 15 days during the full swing of winter. After every cutting the crop is normally irrigated.

(iii) Yield and Nutritive Value: The crop is ready in 55-60 days after sowing for the first cutting. Subsequent cuttings are taken at 30 days interval during winter and spring. In all 5 to 6 cuttings can be obtained up to middle of May. The total yield obtained may vary between 500 to 600 quintals per hectare. For taking the seeds, plots are left uncut after February and in that case 4 to 5 quintals seeds per hectare may be obtained. Though tetraploid betseem has been considered high yielding, but the trials conducted at UP Veterinary College, Mathura did not show any difference in yield between ordinary berseem and so-called giant berseem or tetraploid berseem.

(b) LEGUME PERNIAL

Lucern (Medicago Sativa)

It is perennial crop. Once grown it continues to supply nutritious fodder for 3-4 years. It is sown both as an annual and perennial crop. The crop is generally grown in irrigated areas of dry tracts and gives yield in well drained sandy loam soils.

i) Time and Method of Sowing: The best time of sowing is between early October to end of November. The land should be prepared thoroughly like that of Berseem. The seed rate is between 15 and 18 kg per hectare. It can also be sown like berseem by broadcasting. It doesnot, however, require culture as is the case with Barseem. The Lucerne can also be sown on the boundaries as well. When the seeds are sown, the field is irrigated immediately after sowing. Another method of sowing specially when the field is not properly prepared is to fill the land first with water and then the seeds are sown by broadcasting. This operation is followed by planking.

ii) Manuring and Irrigation: An application of about 100 kg of nitrogen (500 kg of ammonium sulphate) and 100 kg of P₂O₅ (700 kg of sulphur phosphate)
gives the best yield, per hectare. It is better if half of the nitrogen requirement is met with compost of Farm yard manure and the other half with ammonium sulphate or Kisan Khad.

Irrigation depends upon the climate and soil conditions. In summer, it is required after every 10 days and in winter (when taken as perennial) after 15-20 days. Usually after every cutting the crop should be irrigated.

(iii) Yield and Nutritive Value: First cutting is ready after 2-2½ months of sowing. During rainy season its growth is affected by other monsoon grasses. After rains when soil is dried-up, it is harvested or else there are chances of roots coming out while harvesting. If taken as a perennial crop it may yield up to 1000-1200 quintals/hectare, when taken as an annual (up to June), the yield is 700-900 quintals/hectare.

This is a productive fodder which can support not only growth but milk production up to 8 kg when fed ad lib. Experiments at the UP Veterinary College, Mathura have shown that Haryana calves grow at the rate of 0.5 kg per head per day on this fodder alone without any concentrate supplement. Experiments at IVRI have shown that like berseem it can also support 8 kg of milk yield in the cows and buffaloes when fed and lib.

**Field Beens (Dolichos Lablab)**

It is a vigorously growing annual legume. Its vines attain a length of 3-5 m. The leaves are trifoliate with large ovate leaflets. The flowers are white.
It may be grown under rainfed conditions and requires hot and humid climate for its preliminary growth. It grows in every type of soil even under neglected conditions. The seed rate is 15-20 kg per hectare. The yield is about 130 quintals of green fodder per hectare in one cutting. The second cutting of the crop may also be obtained if it is irrigated once. When irrigated during the dry season it may produce sufficient fodder.

Besides its high yielding capacity D lablab var. lignosis is more palatable and a productive type of fodder like other legumes. It can also be converted into excellent quality hay.

There are many varieties of D. lablab. One of these is an Australian strain Rongali which is prolific yielder.

(C) Non Legume Annual

Jowar

**Popular Varieties:** M.P. Chari, CO-27, S.S.G. 59-3 X 989.

**Cultural Practices:** It has juicy stems, high tillering and ratooning ability and hardliness.

Land is prepared well to fine tilth. Farm yard manure of 20-25 tonnes / ha is applied. N,P&K of 30:40:20 is applied as basal dressing, seed rate is 40 kg/ha a spacing of 30 cm between the rows and 15 cm within the rows should be followed. 30 kg N is applied as top dressing after 30 days of sowing.
Irrigation is to be given at every 15 days interval. The crop should be harvested at 60-70 days after sowing (Flag) leaf stage to 50% flowering stage. Subsequent cuttings can be taken at 40-50 days interval. Yield of 50-70 tonners/ha of green fodder obtained in 3 cuttings.

Maize

**Popular High Yielding Variety**: African tall maize. It can be grown on all types of soil, but the performance will be best in sandy loams with good drainage.

Warm climates with fairly high day temperature suit the crop ideally. It can be grown all round the year yielding as many as four crops a year (the crop gives single cutting only).

![Fig. 7.5 Maize](image)

It can be raised as a pure crop as well as in mixture with some legumes. As a pure fodder crop the seeds can be sown in rows 30 cm apart continuously in the furrows. Seed rate is 15-40 kg/ha.

When sown in combination which legumes with cowpea, seed rate of 30 kg is enough and 15 kg cowpea seeds can fill up the rest of the area.

The crop should be irrigated regularly. As basal dressing 50 kg/ha is to be applied for the fodder crop.
Bajra (Pennisetum Typhoides)

Popular Variety: Gaint Bajra (Improved Variety). It can be grown on light to medium type of soil or sandy loam to clay loam.

Land is prepared well to fine tilth, ploughing and 2-3 harrowing. Farm yard manure of 5 tractor, trailer (10-12 tonnes/ha) is applied. Fertilizer 60 M : 30 P : 20 K kg / ha.

Sowing time: Kharif - June to August and Summer - March to April.

Sowing Distance is 30 cm. It can be raised as a pure crop as well as in mixture with some legumes. As a pure fodder crop the seeds can be sown in rows 30 cm apart continuously in the furrows. Seed rate is 10 kg / ha.

Yield: 1st cutting at 50 - 60 days
2nd - 3rd cutting at 30 - 35 days

Intervals: Average yield 40-50 mt / hectare

Fig. 7.6 Bajra
(D) Non-Legume Perennial

Para Grass (Bracharia Mutica)

Also known as buffalo grass is a good fodder crop spreads rapidly as runners when there is enough water. Para grass can be grown in waterlogged lands. For this reason the crop can be grown quickly by the side of tanks, canals and field bunds. The crop can also be grown with sewage water irrigation. The stems and leaves are succulent with hairy nodes. It can be cut to cattle or used as pasture. The crop is best grown in hot and humid climates with a precipitation of 1000-1500mm. It is not suitable for dry and semi arid lands.

Cultivation method: The crop can be multiplied with stem cuttings or seeds. Prepare the land thoroughly by 2-3 ploughings and remove the weeds. Planting can be done as soon as the starting of the rainy season. 15-20 cm sized stems with 2-3 nodes are taken for planting and they are planted 50-60 cm spacing. If seeds are used they can be directly sowed but due to poor germination seed propagation is not in much use. The stems quickly develop roots and establish.

Seed rate: About 30,000-40,000 slips would be required per hectare.

Fertilizers: 40 tons of FYM and 30 Kg of potassium and 30 Kg of Phosphorous are given as topdressing. Nitrogen also can be supplemented for better yield @40 Kg per hectare.
**Irrigation**: After planting 2-3 irrigation should be given for a better establishment of the crop.

**Fodder yield**: The first cut can be taken in about 3 months time when the grass reaches to a height of 60-70 cm height. Subsequent cuts can be made 20-40 days depending on its growth. The crop gives an annual yield of 60-70 tons per hectare.

**Method of feeding**: Fodder can be fed as it is or mixed with other fodders and fed. The fodder is not suitable for hay making but can be made into silage and fed to cattle when there is surplus fodder.

**Guinea grass (Pannicum Maximum)**

A popular fodder crop of the tropics and can be grown in varied agro climatic conditions. The crop can be grown even in shades as such it can be cultivated under coconut and mango gardens. It is a perennial fodder crop can be grown by seeds or grass slips. The germination by seeds is poor as such the farmers prefer cultivation by fodder slips. The fodder can be cut and fed to cattle or it can be used as a pasture grass. The grass is nutritious, palatable and can be made into hay or silage.

![Fig. 7.8 Guinea Grass](image)

**Varieties**: Tanzania, Mombasa, colonial, Hamilton, Macuni
Lands suitable: It can be grown in any type of land but preferable sandy loams or loams. It cannot be grown in heavy water logged areas.

Cultivation method: Land should be prepared well by ploughing 2-3 times to uproot all weeds and to make the soil more porous. After ploughing trenches are made of 10-15 cm and 20 cm depth for filling with farm yard manure potassium and phosphorus fertilizers. After filling, the trenches are covered. After fertilizer treatment 50×50 cm wide ridges are made and the slips are planted.

Seed rate: Approximately 50 thousand slips are required for one hectare of land. About 10 -15 tons of FYM, 50 Kg of Potassium and 50 Kg of phosphorus is also required for better growth of the crop. The fodder can be grown best in May, June and July months of the year.

Irrigation: After planting the slips two irrigation are required for better establishment of the slips. Subsequent irrigation depends on the rainfall. But the crop requires irrigation at 7-15 days interval. If the cattle sheds waters are diverted to the crop for better yield of fodder.

Fodder yield: The first cut can be made in about 60-75 days. From then onwards crop can be harvested for every 2 months. About 7-8 cuts can be made in a year with annual yield of 100- 120 tons of fodder per hectare.

Hybrid Napier grass

It is a perennial fodder crop grows in all agro climatic conditions. Waterlogged lands are not suitable for this crop. Light rain and sunshine alternately is very suitable for the crop to grow well. Hybrid Napier grass is also called as Elephant grass because of its vigorous growth. The leaves of Napier grass are coarser and hairy the edges are rather sharp. The stems are fibrous and hard. The grass has been developed by crossing Napier and Bajra. The leaves and the stems are softer making more palatable for the cattle.

Varieties: APBN-1, NB21, Co3, Co4.

Lands suitable: Sand loamy soils are best suitable, waterlogged areas are not suitable.

Cultivation of the crop: The land should be prepared well with 2-3 ploughing to remove all the weeds followed by disc harrowing. Planting can be at the onset of rains (June-August) with rooted slips. Mature stems of 3 months old with 2-3 nods also can be used. The rooted slips or the stems should be planted with a spacing of 60×60 cm apart. The stems while planting at least two
nodes should be in the soil. The stems should be planted in an angle so that shoots from the outside nodes sprout.

![Hybrid Napier](image)

**Fig. 7.9 Hybrid Napier**

**Fertilizers:** Farm yard manure @ 25 tons per hectare and Chemical fertilizers potassium and phosphorous @ 50 kg per hectare should be applied at the time of land preparation.

**Irrigation:** Irrigate the land before planting the slips. 15,000 slips are required for planting one acre of land. Once or twice inter cultivation is required for better establishment of the slips. Further inter cultivation can be done if required.

**Cutting:** The first cutting will be obtained in 3 months and subsequently cuttings can be made every 6-8 weeks. In winter the growth of fodder will be reduced.

**Fodder yield:** At least about 6-8 cuts can be expected from an average crop with an annual yield of 200-250 tons per hectare.

**Method of feeding:** The fodder can be fed to the cattle by chaffing. It is also suitable for making silage or hay also. The silage can be mixed with leguminous fodders to enrich it.
(e) Legume Pasture

Stylo (Stylosanthes SP):

Stylo is a leguminous fodder crop grown generally as a pasture grass. The crop can be grown under shady areas as such it grown under coconut and other trees as an inter crop. The crop protects the soil from erosion and controls the weed growth. The plant has a deep rooting system and therefore thrives well even if the animals are allowed to graze the fodder.

Fig. 7.10 Stylo

Lands suitable for cultivation: The crop can be grown in sandy, sandy loam soils, areas with less rain fall, less fertile soils and acid soils. The crop is to some extent draught resistant and can be grown in shades. In less fertile soils phosphorous fertilizer should be applied along with seeding for a quick development of nodules. Land should be prepared well by 2-3 ploughings and sowing of the seed can be done from June-July months with the onset of monsoon.

Seed Rate: The seed requires pre treatment of soaking and treatment with rhizobium culture. The seed should be soaked in water overnight and applied rhizobium culture and dried in shade. Only treated seed should be sown for a good germination. Manuring @ 20 Kg N and 60 Kg P/ha should be done. Regular deweeding has to be done till the plant is established well. Proper drainage has to be made since the crop cannot withstand excess of water.

Harvesting: The crop generally raised as a pasture crop.
**Yield:** If harvesting is done 2-3 cuts can be made with an annual yield of 20-30 tons/Ha fodder.

**Siratro**

Siratro is also a drought tolerant legume fodder suitable for low rainfall dry regions. (400-1200 mm rainfall/annum). It can be cultivated in all types of soil quite successfully round the year. However, sowing during the monsoons is recommended as it helps in easy germination and establishment.

The plant is spreading and twinning type. It can improve soil fertility by fixing the atmospheric nitrogen.

**Time of Sowing:**
- June - July (rainfed crop)
- February - May (irrigated crop)

**Seed Rate:** 8-10 kg/ha to be sown in lines with 45 cm spacing

**Establishment**

Plough the field to good tilth. Sowing should be done in well prepared beds at a shallow depths. The row spacing must be 45 cm with continuous seeding in each.

As a basal application, 50 kg N, 75 kg P and 40 kg K, can be applied in irrigated conditions. For a dry crop half of this will be sufficient.

Since these crops cover the top soil, no weeding or after cultivation is needed.

Plant protection measures are not needed. For irrigated crops, irrigation once in 15 days will ensure a good yield.

**Yield**

The crop is ready for the first harvest 90 days after sowing and the subsequent harvestings can be had in 45 to 50 days. In dry conditions, the frequency of harvesting is delayed due to a slower growth rate.

After each harvest, 15 kg p/ha should be applied to activate growth.

The yeild of green fodder is 15 to 25 tonnes / ha annually.

(f) Non Legume Pasture

**Anjan Grass**

**Synonyms:** Dhaman grass, Kusa Gaddi, Anjan Grass
It is an indigenous, perennial, tufted pasture grass 15 to 40 cm in height. It is commonly seen in dry areas. It comes up best on calcareous red soils.

**Seed Rate:** 5-7 kg / ha

**Establishment**

Soaking of seed in fresh water for 8 to 10 hrs before sowing gave better germination. Broadcast the seed on a well prepared soil. Line sowing may also be followed. For planted crop, nursery is raised using 1 kg seed percent and the seedlings are pulled out at 20-25 cm height (3 weeks old) and transplanted in the field on ridges made at 45 to 60 cm apart. Ammonium sulphate and superphosphate are applied 112 kg/ha. For raising a pasture, 18-30 kg / ha of seed is broadcast with monsoon rains with proper manuring.

![Fig. 7.11 Anjan Grass](image)

**Yield**

First cutting is taken at 90-100 days after sowing. Irrigated crop yields 22-30 t/ha in 10 cuttings in a year. Rainfed crop yields 9-10 t/ha. It can be used for grazing as well as a cut fodder.

**Rhodes Grass (Chloris Gayana)**

It is an excellent perennial grass and its native to South Africa. It grows luxuriantly and covers large areas and thus helps in checking soil erosion. It contain 6-9 percent protein and thus a maintenance quality roughage. This grass is reported to be useful in reclaiming saline tracts.
The seeds of this grass are light and difficult to sow evenly. It may be mixed with about double its weight of saw dust and sown through a grain seed drill. It should not be sown deeply. Broadcasting into a prepared surface and rolling May gives best results.

If sown, about 8-10 kgs of seeds are required per hectare. The sowing season is either spring or monsoon. It gives an yield of about 450-600 quintals of fodder in 5-6 cuttings per year. The grass also spreads by means of running branches which root and produce tuft at every node.

(G) Fodder Trees

Subabul fodder tree (Leucaena Leucocephalus)

It is a leguminous fodder tree and a very useful for fodder and fuel. It can be grown on the bunds and on boundaries. The fodder trees can be grown in tropical and sub tropical climates. Well drained neutral soils, sandy loams, fairly saline and acid soils are suitable for growing the trees. It can be grown on steep slopes and hilly regions also. Since the plants have deep roots they can resist draught conditions.

Cultivation of the Plants: the plants can be cultivated by planting the seedlings. The seeds require pre treatment since they are hard and cannot be grown by direct sowing of seeds. The seedlings can be planted at the time of onset of rains. Seedlings are raised in polythene bags in a nursery preferably in March- April months and when the plants are of 2-3 months old with 8-10 leaves they can be planted in the places selected for growing. The land should be prepared well by ploughing to clear the weeds and bushes. 1-2 M spacing has to be given for the plants to grow well. A basal application of P, N and K fertilizers can be given for better growth and yield of fodder.

Fodder Harvesting: The fodder is highly nutritious contains 25-30% of protein. The first cutting can be done in 5-6 months and the subsequent cuttings can be made at 50-60 days interval depending on the growth of the plant. About 25-30 tons of fodder can be obtained per hectare land.

Avisa (Sesbania Grandiflora)

It is a very useful fodder tree cultivated for supplementing the regular feeding. The leaves and tender branches are used as fodder by pruning. Excess feeding (More than 30%) with this forage is not advisable since it produces bloat. It is a perennial leguminous fodder tree and can be grown easily. Besides of its use as fodder, the green leaves are also useful as green manure. Sesbania plants can grow up to about 15 m height.
Lands suitable for cultivation: Avisa is suitable to be grown in hot and humid climates and can be cultivated in waterlogged lands. Acid soils are not suitable for cultivation. A minimum of 500 mm rainfall is required for a good growth of the plant however it can tolerate up to 2000 mm. The plants can be cultivated even in poor soils and can be grown in fallow lands to improve the soil fertility.

Cultivation: The plants can be cultivated by direct sowing of the seed without any treatment. The seeds can be sown deeply in about 20-25 cm depth with a spacing of 1×1 m. The plant grow rapidly and can reach to a height of 4-5 m in six months. First pruning can be done in 10-12 months time. The annual yield would be around 15-20 tons per hectare. However the annual production of fodder depends on the age of the plant, climatic conditions and the soil fertility. Sesbania can be cultivated as an intercrop with Napier. It can be planted on the bunds and also on the boundaries of the farm without wasting the land.

Nutritive value: The nutritive value of the sesbania is high because of its rich protein content of about 20-25% crude protein.

Hedge Licerne

It is a protein-rich legume fodder. This plant will become woody, if it is allowed to grow tall. Hence it has to be clipped off when it is 10-12” height to obtain good quality tender green fodder.

Time of Sowing

It can be grown all through rainfed crop, it flourish well when sown between June and October.

Seed Rate

15 to 20 kg / ha for line sowing with 50 cm of row to row spacing.

Establishment

Plough the field to obtain fine tilth and form ridges and furrows at 50 cm apart. Apply 15-25 tonnes / ha of FYM at the last ploughing and N.P.K at 10:60:30 kg / ha by opening a furrow 5 cm deep besides the ridges. Seeds are sown in lines at a depth beside the ridges. Seeds are sown in lines at a depth of 1 cm in solid stand on the side of the ridges over the lines where fertilizers are applied.

Nursery can also be raised and seedlings may be transplanted. Irrigate the field once in a week or depending upon the weather conditions. It is resistant to pests and diseases.
Yield

First harvest can be done at 50 cm height (70-80 days after sowing) and subsequent cuts at every 40 days up to 125 tonnes of green fodder / ha / annum are obtained. (at the same height) with irrigations kids.

Hedge lucerne can be grown both as pure and mixed crop. As a mixed crop, it can be raised with hybrid papiers grass at 1:3 (one row legume and three rows grass).

7.7  Silvi Pasture - Hortipastures

Selvi pasture system of forage production involves growing of multipurpose nitrogen fixing trees with added fertility resources on waste lands along with grasses and legumes.

Grasses will conserve the soil and moisture the legumes benefit soil by nitrogen fixation and in the mixture they help growth of grasses and trees besides improving the forage quality. Trees and bushes besides providing fire wood and timber, supply fodder during lean period. The system work well with improvement land productivity by 2.5 times compared to the traditional system at use. After 5 years grazing could be allowed thus reducing the cost of the grass harvesting.

The trees selected for these system should be fast growing, hardy with multiple use with the rural population.

In areas no grasses are available in the fields are ploughed and grass seed may be spread and fertilizers are applied to encourage grass growth.

In areas where potential grass are present introduce legume varieties.

Proper utilization is known to be the most important management factor influencing productivity and sustenance of a grass land. Therefore utilization and management has to be so manipulated that it allows sufficient time to the plants to rebuild their roots preserve as well as the forage is available for longer periods continuous grazing or rotational grazing system may be followed depending upon the type of grass grown. Besides practicing grazing of grass lands their harvesting for stall feeding in lean periods is also important for the efficient management of grass lands. In many studies it is reported that the grass lands can be harvested at every month interval at 10-15 cms height during growth periods.

The grasses should be of high quality highly productive, long duration with high palatibility. The legumes should be hardy, palatable, nutritious with strong regeneration through roots or self seeds for semi-arid and dry topics species like acacia and subabul trees are recommended. In saline conditions
species like dichrostachys cinerea and prosopis, juliflora, are recommended. Under grasses species like cenchrus ciliaris, cichanthium annulatum are recommended for dry areas and for saline areas brachiaria mutica is recommended under legume varieties.

7.7.1 Horti Pastures

Horti-pastures are one of the numerous agro-forestry systems aimed at utilizing the limited resources (land and water) more efficiency. In this system fruit trees such as mango, guava, cashew and other orchards species like coconut, rubber are cultivated with pasture grasses occupying the inter spaces. The important grass species that can be used for pasturing in orchards include anjan grass (Cenchrus ciliaris), guinea grass (Panicum maximum var. trichoglume stylos stylosanthes hamataor S. Seabra) etc. The pasture species should be chosen in such a way that their requirements for growth match with that of the orchard species, and at the same time they are not competitive to the trees. The recommended techniques and management practices should be adopted to establish and grow the pasture species. Depending upon the growth of pastures and the conditions of the tree species the grass can be either cut or allowed for grazing. In the present day circumstances, rearing of sheep with the help of the pasture component in horti-pasture systems appears to be more enterprising and economical.

Some suitable examples of horti-pastroval system are grass and stylos-in mango orchards grasses and clovers-in apple.

Blue panic grass + siratro

OR

Cynodon + stylo

Deenanath grass + Horse gram - is also in cashew

Guinea grass or ruzi grass + stylo - In coconut orchards

Stylos in citrus orchards etc.

7.8 Summary

This study of different soils suitable for various crops were studied very much. The system of crop rotation to increase the fodder production was explained. The importance of green fodder feeding for economic milk production was discussed. Cropping programs were prepared for different seasons in a year. The various fodder crops commonly cultivated were discussed for their yield, seed rate, fertilizers etc. The layout principles for fodder farm were explained.
Short Answer Type Question

1. Which soil is preferred for Berseem Production?

2. Which crops can be cultivated in water logged are define crop rotation.

3. Give two examples for crop rotation?

4. Give on cropping program for summer season.

5. What is yield of paragrass per acre?

6. Which fertilizer is recommended for Napier grass?

7. Give the yield of Napier grass per acre?

Long Answer Type Question

1. Briefly write about various soils preferred for fodder cultivation?

2. Explain crop rotation system?

3. Briefly explain the importance of green fodder for economic milk production.

4. Prepare cropping program for a year?

5. Explain about layout for fodder farm?

6. Write in detail the cultivation, yield, seed rate and fertilization in the following crops?

(a) Napier grass

(b) Maize

(c) Para grass

(d) Cow pea
Chaffing of fodders - Advantages - Disadvantages

Chaffing

Making the folder stems or leaves into pieces by manual or mechanical means is known as chaffing. Manually cutting the roughage fodders into small pieces manually with the help of an axe or a knife is known as manual chaffing.

Mechanical

There are two types of chaff cutters.

1. Hand operated chaff cutter.
2. Electrical chaff cutter.
For small quantities or chaffed material a hand operated chaff cutter is used and for large quantities an electrical operated chaff cutter is used.

8.1.1. Advantages of Chaffing

1. The stems of grass can be made into pieces of any small size.
2. The leafy material and tender part of fodder shoot is eaten away by the animal and the thick or hard stem is left, which goes waste. By this chaffing whole plant or stems are fully consumed by the animal.
3. While eating the animal the un-chaffed grass or fodder is wasted by throwing it in the surroundings by the animal. The chaffed pieces are completely eaten by the animal.
4. Chaffed material can be packed in bags.
5. The chaffed fodder consumes less space for storage.
6. Feed additives or other feed supplements can easily mixed with the chaffed fodder.
7. The leafy portion, shoots and stems pieces are mixed while chaffing, hence it increases the palatability of the fodder.

8.1.2 Disadvantages of Chaffing

1. It requires separate chaffing equipment.
2. Too much decrease of particle size decreased salivary secretion due to chewing.
3. Decreased particle size reduced fat % in milk
4. Separate megeus are required to feed the chaffed fodder.

8.2 Improvement of low quality roughages and non-conventional feeds

Grinding of roughages like straw decreases the digestibility but increases the intake. The chaffing of the straw also increases the intake by the animals. Soaking of wheat straw increases the intake of dry matter by the animals but has not effect on the digestibility of the nutrients. Soaking of paddy straw removes some of the soluble oxalates and may improve the nutritive value of straw. The alkali treatment of straws has been dealt in detail as lot of work has been done in this country on this particular aspect.

(a) Alkali treatment of cereal straws.

The straws in general form the basal roughage in India. They do not contain any digestible crude protein and are poor in energy, minerals and vitamins. The only advantage of straws in that they contain large quantities of complex
polysaccharides like cellulose and hemicellulose which are poorly digested because of the complex formed with the lignin. Therefore many efforts have been made to improve their digestibility.

A considerable amount of work was done at the Indian Veterinary Research Institute, Izatnagar to improve the nutritive value of straws. In these investigations two types of cereal straws, namely, wheat and paddy were treated with dilute solution of caustic soda (1.25 per cent) in which straws were soaked overnight. The excess alkali was washed with water. The results indicated that alkali treatment of straws resulted in a significant loss of dry matter varying between 25 to 30 per cent. There was a loss in crude protein, either extract, total ash and nitrogen free extract content of treated straws; consequently the crude fibre content was increased.

The digestibility of the treated straws was improved. The digestibility of total carbohydrates was improved by about 30-35 per cent. Consequently the total digestible nutrients in treated straw was also improved. Though the protein digestibility in the treated straw was reduced but the utilisation of protein was improved.

In the case of paddy straw the general trend with regard to loss of dry matter and improvement in the nutritive value was the same as of wheat straw. The paddy straw in rich in oxalates, the major portion of which is present in the form of soluble potassium oxalate, a small fraction is present in the insoluble ration. At central Institute of Research on buffaloes, high producing buffaloes are fed with urea treated straw when green fodder is not available.

(b) Bio-degradation of Fibrous Crop Residues.

Fungi like phanerochaete chrysosporium, Dichomitus squalens, etc. have been used to degrade lignin content in the straw and increase the dry matter digestibility. The treatment leads to a loss of dry matter also. Spent straw from mushroom cultivation could be used for feeding. Its protein content is increased after mushroom cultivation.

8.2.1 Methods of Making silage from straws.

In pit soil the bottom and sides of the pit are covered with straw and the cut green fodder crop is staked in layers adding molasses or jagary sprinkle. In order to compress it thoroughly the material should be trampled and all air from it is excluded. The silage pit is filled up to about 2/3 above ground level and a layer of paddy straw is put and the material is covered with polythene sheet and to for weight put soil over it. The fermentation occurs in 2-3 months.
8.3 Aims of Fodder Conservation - Advantages and Disadvantages

With the availability of high fodder yielding varieties of season bound and perennial fodder crops, there is glut of fodder during the peak periods of growth and scarcity during other periods. The best way to regulate the supply of palatable and nutritive fodder during the lean periods of October and November and May to July is to conserve the surplus fodder in the form of hay and silage. A similar situation is also experienced in the case of grassland species which essentially comprise the monsoon grasses. These grasses give abundant fodder during the monsoon period and summer the forage production is almost negligible owing to their dormancy with the advent of winter and acute moisture stress. Thus it is essential that surplus fodder should be conserved during the period of excess growth, in the form of hay and silage. The need for the conservation of fodder is all the more warranted in the drought-prone areas, where crop failures are frequent.

Advantages

1. It is less at risk from the weather than hay-making.

2. The ensiling process is the only means by which the entire forage plant can be preserved in a succulent form. The crops can be harvested and stored at the time of its development when it has the maximum nutritive value.

3. Retains higher performance of nutrients than hay because losses due to shattering and bleaching are minimized. Silage preserves 85 percent of feed energy. Hay under best condition preserves only 80 percent and under poor condition 50-60 percent.

4. Silage crops have more yield than other hay-crops. Earlier cuttings at higher levels of digestibility are possible and regrowth are quicker. Thus, more feed nutrients can be grown on an acre of crops used for silage than an acre used for most other purposes.

5. The crop can be preserved as silage more cheaply, more quickly and with less labour.

6. Mechanization from field cutting to feeding is easier with silage.

7. It requires less storage space then hay.

8. Fear of fire is voided.

9. Practically any forage crop is fit for ensiling. Weedy crops and crops with thick stalks can be ensiled equally well.
10. Many by-products can be economically used.

11. Where conservation is incidental to or integrated with grazing, silage making is more dependable as a method of cleaning up soiled swords and ensuring aftermath grazing.

12. Converting crop into silage clears the land earlier.

13. It is palatable and slightly laxative.

14. It is a better source of protein and carotene than hay.

15. There is a wider choice of feeding methods for silage.

16. Ensiling ensures better storage for a long time.

**Disadvantages**

1. Requires soil and special equipment.

2. Less amount of Vitamin D in silage than hay.

3. Additional expenses are involved for preservatives.

4. Due to moisture content, tonnage and transporting charges are increased.

5. Wet silage can present difficult problem of disposal of effluent.

6. Smell from poorly fermented silage can create problems.

7. Wastage may be high when only small amounts are made at one time.

**8.4 Design of Silage Pit**

There are two types of silipits

1. Pit Silo

2. Tower Silo

A pit of 3 x 15 x 1 meter dimension is prepared (or) drug. For 100 quintals of green grass. The bottom and sides of the pits are covered with paddy straw. The silage pit is filled with green fodder upto about 2.73 above the ground level and covered top make silage.
Fig. 8.1 Tower Silo

Tower silo is round. Cylindrical an is constructed above the ground level. The height varies from 5 to 10 meters with a diameter of 10 to 15 meters. The construction of tower silo is expensive. In tower silo the filling of fodder crop material and sealing is the same as in pit silo. The material is well preserved in this.

8.5 Methods of Silage Making

8.5.1 Selection and Harvesting of Crop for Silage

Crops suitable for making silage to be used viz. Maize, sorghum, all green grasses, lucerne, Berseem, cow peas, soya beans, Oats, Barley, Red clover, Lavidoclover etc.

Almost all forage crops are suitable for silage making. Even some crops that are unsuitable as green fodder (or) hay due to bitterness or off flavour are suitable as silage as they appear to lose these qualities during ensiling.

Maize is a popular crop for silage - it yeilds highly. Besides, at the stage of cutting for ensiling, it possesses the required dry matter percentage and available sugars. Thus normal fermentation is ensured without the addition of any preservation. The fodder can be harvest at 60-70 days cutting and yield 20-25 tonne per acre. Three crops can be obtained in a year. Sorghum is another important silage crop. The sweet sorghum is better for silage than grain sorghum. It should be cut in the dough stage. Grasses and legumes when used for silage are usually referred to as hay crop silages. Ensiling them requires special methods.
8.5.2 Requisites of Silo:

(a) The walls should be unpermeable.

(b) Should be sufficiently deep.

(c) Must be located in an elevated ground.

(d) The size of the silo should be calculated on the basis of the number of animals to be fed and length of the feeding period.

For 100 quintols of grass 3 x 1, 5 x 1 meter dimensions pit is required.

![Fig. 8.2 Pit Silo](image)

8.5.3 Silage Making

(a) Crops suitable for making silage to be used viz. Maize, Sorghum which do not require special treatment (or) preservative like molasses (or) mineral acids but almost any green crop can be converted into silage by special method.

(b) The crop to be ensiled should contain about 75% moisture.

(c) For the preservation of silage, the crop has to be packed will so that there is not air left over in the silo, microorganisms involved in the fermentation desirable in silo. The object of the making silage is to promote conditions favourable for lactic acid producing. Microorganisms to develop: Therefore for efficient packing the green crop is cut into “1 to 1 1/2” pits by means of chaff cutter then packed layer by layer. After the silo is filled and packed well the top of the silo is covered with a one foot layer of wet paddy straw. This layer is then plastered with a clay or clay and cow dung. (10:1) to keep the silo air tight and
water tight (or) a polythene sheet and for weight put soil over it. This will provide necessary compression to the top layers of silage.

If air gains entry into the silo pit yeast fungi and aerobic organisms being to multiply which will destroy the lactic acid and silage putrifies.

(d) Addition of Molasses:

For grasses 10-20 kg per tone.

For legumes 30-35 kg per tone.

8.6 Importance of Feeding Silage to Animals

8.6.1 Characteristics of Good Silage

(a) A good silage should be yellowish green in colour.

(b) It should not have strong objectionable odour.

(c) It should be palatable to live stock.

(d) It should have less than 75% moisture.

8.6.2 Advantages of Silage

(1) Silage can be stored in less cubic space than hay.

(2) Silage supplies the green succulent roughages through out the year.

(3) Nutrition loss in silage making is less than hay making.

(4) Silage is more palatable than hay.

(5) Silage can be made even in rainy season when they cannot be made.

(6) All most all fodder crops can be converted into silage.

(7) More number of animals can be maintained on a given area of land when silage is fed when compared to hay.

(8) Many undesirable things present in a fresh-crop eliminated after ensiling.

(9) Fear of fire is avoided.

(10) It is less at risk from the weather than hay making.

8.6.3 Disadvantages of Silage

When once silo pit is opened it has to be used continuously.
8.6.4 Importance of silage feeding to dairy animals

(a) Green fodder can be kept in a succulent condition for a considerably long period. Silage furnishes high quality forage in any desired season of the year at a lower expense. As there is an acute shortage of green fodder during the summer months, silage can meet this deficiency during that part of the year.

(b) Grass silage preserve 85 percent of more of the feed value of the crop.

(c) It is the most economical from in which the whole stalk of maize or sorghum can be processed and stored on the other hand, a considerable part of this cop is wasted during the courses of feeding in dry condition even if it is of good quality.

(d) During mansoon months, preserving food as silage is the only method as it is not possible to make hay.

(e) The ensiling process kills practically all weeds that are present in the field because of their harvest before seed formation and there by stopping dissemination of their seeds.

(f) It is very palatable feed and slightly laxative in nature.

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

(h) It makes for less waste, the entire plant being consumed which is an important consideration with coarse, steamy forages.

8.7 Method of Hay Making

8.7.1 Selection and Harvesting if Crops for Hay Making

Preparation of hay by sun curing depends on the type of crop available and the climatic conditions. Thic stemmed crops like maize and jowar are not suitable for hay making as it will take longer time for the stems to dry. Thin stemmed crops like Lucerne, Oates and grasses are suitable for hay making.

The stage of maturity of the crop at the time of cutting is very important as far as nutritive value of the hay is concerned. An early cut means more nutritive value but less yield. Late cutting on the other hand will result in less nutritive value but more bulk.

Legume hays are made out of leguminous plants like lucerne and other clovers. They are rich in proteins, vitamins and minerals. The nonlegurriinous ha contain less proteins, minerals and vitamins. These hay may be from grass.
8.7.2 Hay Making

The fodder crop is cut when 2/3 of the entire crop is in flowering stage. The cutting should be done in cool hours of the morning and protected grass from sun rays. It is put in small heaps in shade, so that it is easy to take turning process - it is than stacked on an elevated ground. The heaps of the hay is put to a height of 7 to 9 meters. Around the heap a channel of 20cm deep and 30cm wide is provided to drain the rainwater. The hay can also be stocked in a well ventilated shed.

8.7.3 Characteristics of Good Hay

1. Hay must be leafy. Green to brown in colour.
2. It should be soft and pliable stems.
3. It should be free from moulds, weeds and dust.
4. It should be palatable and have pleasant smell and aroma.
5. It should not contain more than 20% moisture.

8.7.4 Advantage of Hay

1. Hay is less expensive to prepare.
2. More quantity can be stocked on less space.
3. It is nutritious compared to straw.
4. It is palatable and animal eats it greedily.

8.7.5 Disadvantages of Hay

1. It acquires more space, when composed to silage.
2. Vitamin A is less in Hay when compared to silage.

8.7.6 Importance of Hay Making

Hay refers to grasses or legumes that are harvested, dried and stored 85-90 percent dry matter. When harvested in the proper physiological stage of growth and well, cured to 20 percent or less moisture at the time of storing, hay can be utilized as an excellent feed for daily cattle, particularly when fodder is scarce or pasturage is insufficient. Many contains more nutrients compared to poor quality of straws, as it is prepared before harvesting. So nutrients which goes to grains and seeds are retained. In India during monsoon, there is lot of scope far growing of excess of fodder crops. These excess fodder crops can be
cut and made into hay which retains most of the nutrients of green grass and can be fed during lean season.

During the time of harvesting there is sudden interruption of the transportation stream. The shutting off the water supply from the roots and a continued evaporation from the leaf surface leads to withering, drying and death. However while the forage is being dried, plant respiratory enzymes activity will continue resulting in the oxidation of some valuable plant nutrients. Some biochemical changes during hay preparation and storage at ambient temperature are 1) Soluble carbohydrates which are highly digestible will be oxidized causing loss of dry matter. 2) Total soluble nitrogen of amino acids as opposed to protein nitrogen increases as a result of proteases. 3) Cyanogenic glycoside of Jowar, White Cloves and few other forages have been shown to loose their toxicity property during drying which may be due to denaturation of the enzymes responsible for liberation of hydrocyanic acid 4) Rapid drying of hay tends to protect the carotene content due to quick inactivation of the concerned enzymes. 5) The exposure of ultraviolet rays of sun converts ergosterol into ergocalciferol (Vitamin D2) in plants thus the process of hay making by sun drying increases the value of Vitamin D. 6) Hay stored may undergo some fermentation which gives silage type of flavour.

On a whole better prepared hay is better than very mature green crops. Nutritive properties of hays are then similar to those of forages. Maintenance ration for all classes of animals can be feeding solely hay. Upto 5 litres of milk production hay can be use of soil feed without any concentrates. Hay is excellent source of cellulose, sufficient ruminant termination, and increase butter fat production.

### 8.8 Preparation of Vermi Culture From Compost

Earthworms maintained as cultures on organic waste feed on the substrate. The bed material, therefore, undergoes physical and chemical breakdown in the earthworm gut by the action of the digestive enzymes and the residing microbes. The undigested matter is excreted out through the anus as mucus coated granules. The feeding and excretion is a continued process.

Earthworms used in culture tanks consume three to five times their body weight of material every day. About 5 to 10% is absorbed into their system for their growth and development and the rest is excreted. The accumulated, excreta of the earthworms has become a value based product in agriculture. Thus, vermicompost is a physically, chemically and biologically degraded organic material produced by earthworms which consists mainly of digested soil and organic matter. It is rich in all major and micronutrients, such as nitrogen,
phosphorus, magnesium, zinc and calcium in simple forms so that the plant root systems can readily absorb them. To the advantage of the common man to understand the practical utility of material in the field of agriculture, it is given the name “Vermicompost”.

8.8.1 Rate of Compositing

Earthworms like Eudrilus eugeniae, Eisenia fetida and Perionyx excavatus introduced into 8 x 4 x 3 ft. pits filled with 800 to 1000 kg of organic waste will convert much of the added material to composit in 60 to 70 days time. The biomass or total weight of the earthworm population required for this process is about 8 to 10 kg of earthworms. The weight of the finally recovered compost will be 400 to 500 kg by the end of second month. Depending on the number of pits and the number/weight of earthworms; and availability of waste in the surroundings, vermicompost can be produced to an extent of 3 - 10 tonnes per month on farm land. In other places such as parks, kitchen gardens, etc., as the waste collection is done in tanks, it is advisable to place PVC pipes (2.5 cm diameter) with a series of holes at 30 cm apart into the collected waste. This helps to aerate the waste and remove the bad smell. After filling the tank with
waste, 1 to 1.5 cm thick soil paste has to be applied over the waste leaving holes to provide aeration. After two to three weeks of collection, earthworms have to be introduced. This care and attention is essential from hygienic and aesthetic point of view. The quantity of vermicompost produced depends on the nature of the waste product used, species of earthworm and the environmental factors during the process of composting.

8.8.2 Precautions

(i) The tank/plastic tub should be thoroughly cleaned with fresh water before use.

(ii) Grease should be applied all around the tank to prevent the attack of crawling insects on earthworms.

(iii) Proper moisture should be maintained in the bedding waste material during composting.

(iv) Waste material should be placed layer by layer as described in the following procedure.

(v) Water should be sprinkled once or twice a day on the gunny cloth till approx. 25-30% moisture is attained.

(vi) When compost is ready for composting, sprinkling of water should be stopped.

8.8.3 Materials Required

(i) Tank made of cement, plastic or wood.

(ii) Grease

(iii) Waste oil

(iv) Agricultural waste/Kitchen garden waste

(v) Gardening shovel

(vi) Mason’s sieve with pore size 3mm

(vii) Soil

(viii) Cow Dung

(ix) Earthworms

(x) Gunny cloth
8.8.4 Procedure

Construct a cement tank or use a plastic tub. A wooden tank may be constructed using slender poles of Eucalyptus or Bamboo. Tie the poles in horizontal and vertical rows in the form of a tank.

Keep the tank above the ground level so as to prevent infestation of predators.

To prevent entry of ants, a layer of grease or oil can be applied all around the tank. A channel filled with waste oil can also be put around the tank for preventing entry of ants.

Place a 2-3S’ thick layer of soil on the surface of the tank.

Fill the tank with waste material such as leaves, coir from coconut trees, saw dust, rice hust, sugarcane, trash, wheat, straw, etc. over the top layer with loose dry litter or straw to prevent loss of moisture. The straw can be used as a bedding material in successive rounds of composting.

Place a layer of kitchen waste and 1/2 -1 kg T-8 days old cow dung.

Release about 150-200 earthworms on the piled up waste material.

Cover the material with a moist gunny cloth and leave it for 2-3 months.

Successive vermicompost can be harvested after every 4 to 6 weeks.

Push aside the compost in the tank and collect decomposed compost with any gardening spatula, shovel or hand.

Separate unfed material, cocoons and worms.

Dry the compost in shade for on or two days and pass through a sieve of 3 mm.

Transfer separated cocoons and worms back to culture.

Sieve the compost again and dry in shade to remove moisture before packing.

Prepared vermicompost is in the form of a fine loose powder or fine granular dark substance which can be easily separated from the material which is not fed by the earthworms.
8.9 Summary

The conservation of fodder is important, as the green fodder will not be available in winter and summer season. There are two methods of preservation that is Silage making and Hay making for better utilisation of fodder it is chaffed and fed to animals and preparation of vermi culture from compost were discussed.

Short Answer Type Questions

1. What is Chaffing?
2. What is Hay?
3. What is Silage?
4. What are the aims of Fodder Conservation?
5. What is Varmi compost?

Long Answer Type Questions

1. What are the advantages and disadvantages of Chaffing?
2. What are the principles of Fodder Conservation and mention the advantages and the disadvantages?
3. Draw a neat sketch diagram of Silage pit and write the methods of Silage preparation.
4. What are the Characteristics of the good Hay?
5. How is Varmi Compost prepared?
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