ELEMENTARY PRINCIPLES OF ANIMAL NUTRITION

THEORY NOTES

FOR

VETERINARY AND LIVESTOCK DEVELOPMENT DIPLOMA (1st year)

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COLLEGE OF VETERINARY SCIENCES
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CHAPTER - 1

NUTRITION TERMS AND THEIR DEFINITIONS

1. **Additives:** An ingredient or substance added to a basic feed mix, usually in small quantities, for the purpose of fortifying it with certain nutrients, stimulants and/or medicines.
2. **AD Libitum:** Free-choice access to feed
3. **Air dry (approximately 90% dry matter):** This refers to feed that is dried by means of natural air movement, usually in the open.
4. **Apparent metabolisable energy (ME):** It the gross energy of the feed consumed minus the gross energy contained in the feces, urine and gaseous products of digestion. For poultry the gaseous products are usually negligible, so ME represents the gross energy of the feed minus the gross energy of the excreta.
5. **Appetite:** This immediate desire to eat when feed present. Loss of appetite in an animal is usually caused by illness of stress.
6. **Ash:** The mineral matter of a feed. The residues that remains after complete incineration of the organic matter.
7. **Balanced Ration:** One which provides an animal the proper amounts and proportions of all the required nutrients.
8. **Biological value of a protein:** The percentage of the protein of a feed or feed mixture which is usable as a protein by the animal. Thus, the biological value of a protein is a reflection of the kinds of amounts of amino acid available to the animal after digestion. A protein which has a high biological value is said to be of good quality.
9. **By-product feeds:** The innumerable roughage and concentrates obtained as secondary products from plant and animal processing and from industrial manufacturing
10. **Cake (presscake):** The mass resulting from the pressing of seeds, meat or fish in order to remove oils, fats or other liquids.
11. **Cereals:** A plant in the gross family (Graminae), the seeds of which are used for human and animal food; eg. Maize and wheat.

12. **Coefficient of digestibility:** The percentage value of a food nutrient that is absorbed. For example, if a food contains 10 grams of nitrogen and it is found that 9.5 grams are absorbed, the digestibility is 95 per cent.
13. **Concentrate:** A broad classification of feedstuffs which are high in energy and low in crude fiber (under 18%). For convenience concentrates are often broken down (1) carbonaceous feeds and (2) nitrogenous feeds.
14. **Crumbles:** Pelleted feed reduced to granular form.
15. **Decortication:** Removal of the bark, hull, husk or shell from a plant, seed or root. Removal of portions of the cortical substance of a structure or organ, as in the brain, kidney and lung.
16. **Dehulled:** Grains or other seeds with the outer covering removed.
17. **Dehydrate:** To remove moist or all moisture from a substance for the purpose of preservation, primarily through artificial drying.
18. **Gross Energy (GE):** is the energy released as heat when a substance is completely oxidised to carbon dioxide and water. Gross energy is also referred to as the heat of combustion. It is generally measured using 25 to 30 atmospheres of oxygen in a bomb calorimeter.
19. **Hulls:** Outer covering of grain or other seed, especially when dry.
20. **Hypocalcemia:** Below normal concentration of ionic calcium in blood resulting in convulsion as in tetany or parturient paresis (milk fever).
21. **Hypomagnesemia:** An abnormally low level of magnesium in the blood.
22. **Malnutrition:** Any disorder of nutrition, commonly used to indicate a state of inadequate nutrition
23. **Nutrients:** The chemical substance found in feed materials that can be used and are necessary, for the maintenance, production and health of animals. The chief classes of nutrients are carbohydrates, fats proteins, minerals, vitamins and water.
24. **Ration(s):** The amount of feed supplied to an animal for a definite period, usually for a 24 hour period. However by practical usage the word ration implies the feed fed to an animal without limitation to the time in which it is consumed.

CHAPTER – 2

NUTRIENTS AND THEIR CLASSFICATION

Nutrient is a substance of any food constituent that nourishes the helps in maintenance, growth, production and reproduction of an animal.

The feed nutrients are divided into six classes as Water, Proteins, Carbohydrates, Fats, Vitamins and Minerals.

Water

It is the most important single nutrient essential for the regulation of life.

Source of water.

(i) Drinking water
(ii) **Feeds and fodders:** the average water content of various feeds and fodders is as below –
a. Green fodders – 75-90%
b. Silage 65-70%
c. Dry fodders 8-10%
d. Cereals grains and their by products – 8-10%
e. Oilseed cakes 10-12%
(iii) **Metaboilc water :** it is a water produced in the body during oxidation or metabolism of proteins, carbohydrates and fats, -

Each gram of carbohydrate, protein and fat on oxidation, yields about 0.6, 0.4 and 1.1 ml of metabolic water respectively. It is approximately 5-10% of total water intake of animal.

Metabolic water –

- Metabolism describes all the chemical reactions in the cells of the body.
- Metabolic water means water that is product of metabolic reactions.
  e.g. aerobic respiration …….
  Glucose + Oxygen------- > Water + Energy + Carbon dioxide.

Functions of Water :

- It is an important constituent of every living tissue.
- It is a major component of various body fluids like blood, urine, lymph, saliva, tears etc.
- It helps in lubrication of joints,
- It is an ideal solvent for nutrients,
- It plays important role in thermoregulation of body,

- It maintains acid – base equilibrium in body.
- It plays important role in metabolism of nutrients
- It helps in the transportation of nutrients through blood to all tissues
- It helps in the excretion of metabolic waste products and toxicants the through urine
- It helps to maintain strength and rigidity of cell.
- It keeps the gastro – intestinal, reproductive and urogenital tracts moist.
- It helps in the transmission of sight and sound due to its refractive action.

PROTEIN

- Proteins are defined as the complex organic nitrogenous compounds consisting of various amino acids joined together **peptide linkages**.
- They are usually composed of carbon, hydrogen, oxygen and nitrogen.
- Sometimes they may also contain sulphur, phosphorus, iron or copper
- Protein, is the only nutrient that contains nitrogen in its structure.

Amino acids

Amino acids are building blocks of proteins,

The various amino acids that form the protein molecule are of two types.

a) Essential Amino Acids :

- These are **not synthesized in the body** in adequate amount to permit normal growth.
- These should be essentially supplied through diet.
- These are also called as indispensable amino acids.

e.g: Arginine, Valine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Tryptophan and Threonine

b) Non – Essential Amino Acids :-

- These are synthesized in the body in adequate amount to ensure normal growth.
- These are not essentially required to be supplied in the diet.
- These are also called as dispensable amino acids.

E.g. Gluatamic acid, aspartic acid, Serine, cysteine, Alanine, Tyrosine, Proline, Hydroxyproline, citruline, Glycine.

Classification of Proteins :

The proteins are commonly classified as below –

1. **Simple proteins –** they yield only amino acids or their derivatives upon hydrolysis. Eg, Albumins, Globulins.

2. **Conjugated proteins –** they consist of simple proteins combined with non protein radical ie. **Prosthetic group**.
   Eg. Glycoproteins, Lipoproteins, Nucleoproteins, Phosphoproteins, Flavoprotein.
3. **Derived Proteins:** These are the breakdown products of naturally occurring proteins.
   Eg. Proteoses, Peptones, Peptides.

Functions of Proteins :

- It is structural and functional unit of cell:
- It has a role in growth of new tissue and repair of old tissue
- It is constituent of antibodies.
- it is constituent of enzymes.
- It is component of hormone like thyroxine, adrenaline, insulin etc.
- It is component of milk (caesin), blood (haemoglobin and fibrinogen), wool (keratin)
- It helps in the synthesis of bile acids i.e. taurocholic acid and glycholic acid
- It supplies energy when carbohydrates and fat reserve of body is exhausted
- It is component of skin pigment i.e melanin.

The quality of feed protein depends on its amino acid make up, specially the presence of essential amino acid. In ruminant animals the quality of protein is of less importance as they synthesize microbial protein in the rumen. The various microorganism i.e. bacteria and protozoa in the rumen utilize nitrogen from the feed and prepare their own body proteins called as microbial proteins. Due to this fact non-protein nitrogenous substances like urea, Biuret also satisfy protein requirement of the ruminant to same extent.

Carbohydrates

Carbohydrates are defined as the polyhydroxy aldehydes or ketones. They are composed of carbon, hydrogen and oxygen. These are chemically represented as (CHO). Most important carbohydrates are commonly known as sugars.

Classification of Carbohydrates:

A) Based on their chemical Structure of presence of sugar unit.

- **Monosaccharide :** They consist of single polyhydroxy aldehydes or ketone unit also called as simple sugar.
  E.g. Hexoses like Glucose, Fructose, Galactose, and Mannose. Pentoses like Ribose, Xylulose, And Arabinose.
- **Oligosaccharides:** They contain more than one and less than ten monosaccharide units.
  E.g. disaccharides like
  Sucrose – Glucose + Fructose

Lactose – Glucose + Galactose
Maltose – Glucose + Glucose
Trisaccharide like
Raffinoses– Glucose + Glucose + Galactose

- **Polysaccharide :** They are made up of many or multiple monosaccharide units hold together by **glycosidic linkage.**

Homopolysaccharides, like Starch Dextrins Glycogen, Cellulose.

a) Structural homopolysaccharides – **Cellulose-** (β – D Glucose)
Most abduant polysaccharide
Component of plant cell wall
Chitin - (N – acetyl glucosamine)
2nd Most abduant polysaccharide
Component of fungi cell wall
Component of arthropods skeleton

b) Storage homopolysaccharides- **Starch -** (α - D Glucose)
Plant storage polysaccharide
Glycogen - (α - D Glucose)
Animal storage polysaccharide

Heteropolysaccharides like Hemicelluloses, Pectin, Gum, and Mucilage.

B) Based on their relative solubility and digestibility:

(i) Crude fibre (CE): This is insoluble or les digestible Portion of carbohydrates eg. Hemicellulose, Cellulose, pectins.
(ii) Nitrogen Free Extract (N.F.E) : this is soluble or more digestible portion of carbohydrates E.g. Sugars, Starches, Soluble portion of cellulose hemicelluloses.

Functions/Importance of Carbohydrate

- These are major source of energy to animal body
- These are component of amino acids and glycoproteins.
- These are constituent of nucleic acids ie. RNA and DNA.
- These are also component of glycolipids and fatty acids.
- Carbohydrates are present in milk in the form of lactose.
- They increase sweetness of feed.

- Crude fibre forms bulk in the rumen and satisfy hunger.
- Crude fibre increases peristaltic movements of intestine and there by helps toxin and undigested excreta expel outside the body.
- **Crude fibre has a role in milk fat synthesis.**

LIPIDS (Fatty Acid + Alcohol)

Lipid is a collective term used for a wide variety of substances that vary from simple short chain fatty acids to large – very complex molecules; they are insoluble inwater but soluble in ether and other organic solvents like benzene, chloroform or acetone. Fats and oils are the commonly found lipids in nature. Fats are defined as the esters of fatty acid with alcohols fats are solid where as oils are liquid at room temperature (25°)

Classification of lipids:

A) Based on chemical structure:

Simple lipid: These are the esters of fatty acids with various alcohols.

(a) Neutral Fats / Oil – These are esters of fatty acids and glycerol.

(b) Waxes – These are esters of fatty acids and alcohols other than glycerol.

Compound lipids: They consists of simple lipids combined with non lipids, e.g.,
Phospholipids – Fatty Acid + Alcohol + Phosphorous (eg. Lecithan, sphinogomylein)

Glycolipid – Fatty Acid + Alcohol + Sugar (eg. Cerebroside)

Derived lipids: They include substances derived from simple or compound lipids.,

E.g. Fatty acids, Alcohols, Sterols.

B) Based on their saponification nature:

Saponifiable lipids: They form soaps when treated with alkali

e.g., Fats, Oils, Phospholipids, Glycolipids,

Non – Saponifiable lipids: They do not form soaps when treated with alkali. E.g., Steroids, Prostaglandins, Fat soluble vitamins, Terpenes

Fatty acids:

The fatty acids are the building block of lipids.

The fatty acids are of two types.

(i) **Saturated fatty acids:** These are the fatty acids in which adjacent carbon atoms are connected by single bond. They have higher melting point. E.g. Lauric, Myristic, Palmitic, Stearic, Arachidic and Lignoceric.

(ii) **Unsaturated fatty acids:** These are the fatty acids in which adjacent carbon atoms are connected by double bonds, e.g., Palmitic, Oleic, Linoleic, Linolenic and Arachidonic The linoleic, linolenic and archidonic fatty acids are referred as essential fatty acids acids for animals.

Funcitons/Importance of Lipid:

- It is a rich source of energy and supplies about 225 times more energy carbohydrate and proteins.
- It supplies essential fatty acids.
- **It carries fat soluble vitamins A,D, E, & K**.
- It provides insulation for the vital organs.
- It lubricates the gastro – intestinal tract.
- It delays sensation of hunger.
- It improves palatability/taste of feed.
- It is poor conductor of heat, therefore helps in heat regulation.
- Phospholipids are essential components of cell membrane.
- Ch**olesterol is interme diary precursor of steroids and bile.**

CHAPTER – 3

Nutrients are classified into 2 parts :-

1) Organic

2) Inorganic

Organic –

1. Carbohydrates
2. Proteins
3. Lipids
4. **Vitamins – fat soluble (A,D,E and K) water soluble (B complex and C)**

Inorganic

1. Water
2. Minerals

Now minerals are classified into – macro and micro minerals.

Macro – minerals – (present in high concentration > 70mg/kg live weight)

1. Calcium (Ca),
2. Magnesium (Mg),
3. Sodium (Na),
4. Phosphorus (P),
5. Chlorine (Cl),
6. Sulphur (S),
7. Potassium (K)

Micro – minerals – (present in high concentration <70mg /kg live weight)

1. Iron (Fe),
2. Nickel (Ni),
3. Copper (Cu),
4. Zinc (Zn)
5. Manganese (Mn)
6. Iodine (I)
7. Selenium (Se)
8. Molybdenum (Mo)
9. Chromium (Cr)
10. Fluorine (F)

11. Tin (Su)
12. Vanadium (v)
13. Silicon (Si)
14. Nickel (Ni)
15. Arsenic (Ar)

CALCIUM –

Function of calcium

- Structural component of body (Skeleton and teeth): **99% of the calcium in the body is present in the bones and teeth**.
- Calcium controls the excitability of nerves and muscles
- Calcium is required for **normal clotting** of blood

Regulation of ca metabolism –

- Whenever blood calcium level decreases below the normal, parathyroid gland is stimulated to secrete **parathormone.** This hormone mobilizes calcium from the bone and also facilitates reabsorption of calcium in the kidney.
- It also increases calcium absorption in the small intestine by increasing the synthesis of **1,25 dihydroxy Cholecalciferol (active form of vitamin D**) from 25 hydroxy Cholecalciferol in the kidneys, which in turn increases the synthesis of calcium binding protein resulting in increases calcium absorption.
- High level of blood calcium stimulates the secretion of **calcitonin**, which has antagonistic action to that of parathormone.

Deficiency symptoms –

The **deficiency of Ca** leads to **rickets/Osteomalacia and milk fever.**

- The symptoms of rickets are misshapen bones, enlargement of the joints, lameness and stiffness.
- In osteomalacia the bones become weak, fragile and are easily broken.
- **Milk fever (parturient paresis)** is a condition, which most commonly occurs in dairy cows shortly after calving.
- It is characterized by a lowering of the serum calcium level, muscular spasms and in extreme case paralysis and unconsciousness.
- In hens, deficiency symptoms are soft beak and bones,
- Retarded growth and bowed legs,
- **The eggs have thin shells or there is production of leathery eggs**.

Source -

- Animal byproducts containing bone are excellent sources such as fishmeal, Meat and bone meal
- Milk and green leafy crops, especially legumes are good sources of calcium.
- Other sources include ground limestone, dicalcium phosphate.

PHOSPHORUS –

functions

- Phosphorus occurs in close association with calcium in bone.
- Phosphorus plays a vital role in energy metabolism in the formation of sugar – phosphates and adenosine di – and triphosphates.
- Phosphorus plays a key role in metabolic reaction of carbohydrate, protein and lipids which occurs through phsophorylated intermediate compounds.
- Phosphorus is the component of phospholipids, which are important in lipid transport and metabolism as constituent of cell membranes.
- Phosphorus is constituent of RNA and DNA.
- Phosphorus is a component of many enzyme systems.

Deficiency symptoms -

- **Rickets / Osteomalacia:** Like calcium, phosphorus is also required for bone formation and a deficiency can also cause rickets or osetomalacia.
- '**Pica' or depraved appetite** has been noted in cattle when there is deficiency of phosphorus in their diet; the affected animals have abnormal appetites and chew wood, bones, rags and other foreign materials.
- In **chronic phosphorus** deficiency animals may have stiff joints and muscular weakness.
- Low dietary intakes of phosphorus have also been associated with **Poor fertility,** apparent dysfunction of the ovaries causing inhibition or depression **and irregularity of oestrus**.
- There are many examples where phosphorus supplementation increases fertility in grazing cattle.
- In cows a deficiency of this element may also reduce milk yield.
- Subnormal body growth in young animals.

NUTRITIONAL SECONDARY HYPERPARATHYROIDISM

- **The optimum calcium phosphorus ratio is between 1:1 and 2:1**.

- An excess of dietary phosphorus in relation to calcium may result in a bone disorder called **nutritional secondary hyperparathyroidism (NSH).**
- Nutritional secondary hyperparathyroidism occurs in horses that are fed large amount of grains or their byproducts without calcium supplementation. The condition is also referred to as **miller's disease or bran disease or big head disease.**

Supplementation -

- Cereal grains, fish meal and meat products are good sources of phosphorus.
- Much of the phosphorus present in cereal grains is in the form of phytates, which are not digested and utilized in monogastrics.
- In ruminants, hydrolysis of phytates by bacterial phytates occurs in the rumen and therefore well utilised.

MAGNESIUM –

Functions -

- Magnesium is closely associated with calcium and phosphorus.
- Essential constituent of bone and teeth
- Magnesium is the commonest enzyme activator
- **Magnesium plays a role in oxidative phosphorylation leading to ATP formation** s

Deficiency symptoms -

- In adult ruminants a condition known as **hypomagnesaemic tetany** associated with low blood levels of magnesium (hypomagnesaemia) has been known under a variety of names including **Magnesium tetany, lactation tetany and grass staggers,**
- Typical symptoms of tetany are Nervousness, Tremors, Twitching of the facial muscles, Staggering gait, Convulsions.
- In poultry decreased egg production.
- Reduced growth rate, egg production and eggshell thicknes.

SODIUM, POTASSIUM AND CHLORIDE – FUNCTIONS

- Nutritionally sodium, potassium and chloride are considered together because or the similarity of their functions and distribution in the body.
- Sodium, potassium and chloride are stored largely in body fluids and soft tissues.
- They maintain **osmotic pressure.**
- **They regulate acid base equilibrium**
- They control water metabolism in the tissue

- They are essential for the operation of enzyme systems
- They are essential for neural and muscular conduction and transmission
- Nutritionally sodium, potassium and chloride are considered to be of minor importance because they are present in sufficient quantity in the diet.
- **Sodium is the main cation of extracellular fluids, while potassium is the main cation of intracellular fluid.**
- Chlorine (anion) plays an important part in the gastric secretion, where it occurs as hydrochloric acid as well as chloride salts.

Deficiency symptoms – potassium

- Experimental diets low in potassium induces retarded growth, weakness and tetany, followed by death.

Deficiency - sodium

- A deficiency of sodium in the diet leads to a lowering of the osmotic pressure which results in dehydration of the body.
- Symptoms of sodium deficiency include poor growth and reduced utilization of digested proteins and energy. In hens, egg production and growth are adversely affected.

Deficiency - chloride

- A dietary deficiency of chlorine is rare.
- Alkalosis of blood caused by excess of bicarbonate ion.

Excess of sodium chloride

Excess of sodium chloride in the diet leads to slat toxicity

- Symptoms are **excessive thirst**, muscular weakness and **oedema.**
- Salt poisoning is quite common in pigs and poultry, especially where fresh drinking water is limited.

SULPHAR -

- Sulphur is a component of (Thiamine, Biotin, Glutathione**, Insulin,** Coenzyme A, Chondroitin sulphate)
- Rumen microbes require sulphur for synthesis of sulphur containing amino acids.
- **Three sulphur containing amino acid are _____, _____ _____**

Supplementation – Sulphur requirement may be met by inorganic sulphates in ruminants which is not possible in Monogastrics.

IMPORTANCE OF MICRO – MINERALS

IRON

Functions -

- More than 90 per cent of the iron in the body is combined with proteins, the most important being **haemoglobin and myoglobin.**
- Iron also occurs in blood serum in a protein called **transferrin,** which is concerned with the transport of iron from one part of the body to another.
- **Ferritin** is a protein containing iron. It is present in the spleen, liver, kidney and bone marrow and provides a form of storage for iron.
- **Haemosiderin** is in another storage form of iron.
- Iron has a major role in many of biochemical reactions, particularly in connection with enzymes of the electron transport chain (**Cytochromes**).
- Enzymes containing or activated by iron are **Catalase, peroxidases, phenylalanine hydroxylase** etc.,

DEFICIENCY – ANAEMIA(piglet anemia)

- **Anaemia** due to iron deficiency occurs most commonly **in rapidly growing suckling piglets , since the iron content of milk is usually very lo**w.
- This can occur in **piglets** housed in pens without access to soil. The piglet is born with very limited iron reserves and sow's milk provides only **about 1mg per day**.
- Providing the sow with supplementary iron in gestation does not increase the foetal piglets liver iron or the amount of iron in the milk.
- Anemia in piglets is characterized by poor appetite and growth. Breathing becomes labored and spasmodic – hence the descriptive term **'thumps'** for the condition.
- Iron deficiency anemia is not common in lambs and calves.

REQUIREMENT AND SUPPLEMENTATION

- Because of efficient recycling, requirement of iron for most of the farm animals is very low @ 25 – 100 mg kg^{-1} dietary dry matter.
- In laying hens the iron requirement is more, since egg production represents a considerable drain on the body reserves.
- Increased during pregnancy, haemorrhages, young one when they are maintained on milk diet. Higher growth rate demands 125 ppm in piglet diet and 40 ppm to calves.

Supplementation

- Feeds of animal origin, such as meat, blood and fish meals, are excellent sources of iron.
- Legume and oil seed meal are rich in iron.
- Cereals straw and bran are rich in iron.
- Ferrous sulphate salts and iron dextran.

MUCOSAL BLOCK THEORY

- The efficiency of absorption is increased during periods of iron need and decreased during periods of iron overload.
- According to Mucosal block theory the mucosal cells of the gastrointestinal tract absorb iron and convert it into ferritin, and when the cells become physiologically saturated with ferritin, further absorption is impeded until the iron is released and transferred to plasma.
- The adult's need for iron is normally low, as the iron produced from the destruction of haemoglobin is made available for haemoglobin regeneration, only about 10 per cent of the element escaping from this cycle.

- **COPPER**

Functions

- Copper is the integral component of following enzyme.
- **Ceruloplasmin (ferrooxidase) –** conversion of iron into transferrin.
- **Erythrocuprein –** occurs in erythrocytes where it plays a role in oxygen metabolism.
- **Cytochrome oxidase,** which is important in oxidative phosphorylation and myelin synthesis.
- **Lysyl oxidase** is needed for the conversion of lysine to desmosine which forms crosslinks inelastin and collagen fibres.
- **Tyrosinase** is necessary for the conversion of the amino acid tyrosine to melanin which is necessary for the normal pigmentation of hair, fur and wool.
- Copper is the integral component of **Turacin, a pigment of feathers.**
- Copper is required for maintenance of crimp of wool.

DEFICIENCY

- **A deficiency of copper impairs the animal's ability to absorb iron leading to anemia**,
- Deficiency of copper causes
- Poor growth
- Bone disorders.
- Scouring, gastro – intestinal disturbances
- Infertility.

- Depigmentation of hair and wool,
- Lesions in the brain stem and spinal cord. The lesions are associated with muscular incoordination, and occur especially in young lambs – **Swayback** condition also known as **'enzootic ataxia'** or **neonatal ataxia.** the signs range from complete paralysis of the newborn lamb to a swaying staggering gait, which affects, in particular, the hind limbs.
- Loss **of 'crimp' in wool – 'stringy' or 'steely' wool**
- **'falling disease' –** sudden death due to rupture of major blood vessels.
- Copper deficiency also leads to reproductive problems in cattle.

COPPER POISOING –

- Continous ingestion of copper in excess of nutritional requirements leads to an accumulation of the element in the body tissues, especially in the liver. Hence copper can be regarded as a cumulative poison.
- The tolerance to copper varies considerably between species. **Pigs are highly tolerant** and cattle relatively so. On the other hand, sheep are particularly susceptible and chronic copper poisoning has been encountered in housed sheep on concentrate diets containing 40 mg/kg of copper.
- Chronic copper poisoning results in necrosis of the liver cells, jaundice, loss of appetite and death from hepatic diseases.

COPPER – MOLYBDENUM – SULPHUR INTERRELATIONSHIP

- Sulphide is formed by ruminal microorganisms from dietary sulphate or organic sulphur compounds.
- The sulphide then reacts with molybdate to form thiomolybdate which in turn combines with copper to form an insoluble copper thiomolybdate ($CuMoS_4$) thereby limiting the absorption of dietary copper.
- In addition it is considered likely that if thiomolybdate is formed in excess; it may be absorbed from the digestive tract and exert a systemic effect on copper metabolism in the animals.
- **Molybdenum toxicity-TEART-cattle start scouring and develops stary ,harsh coats.**

ZINC

FUNCITONS

- High concentrations of zinc are present in the skin, hair and wool of animals.
- Several enzymes in the animal body are known to contain zinc; these include carbonic anhydrase, pancreatic carboxypeptidse, lactate dehydrogenase, alcohol dehydrogenase, alkaline phosphatase .

DEFICIENCY GENERAL SYMPTOMS

- Gross signs of zinc deficiency in chicks are
- Retarded growth,
- Foot abnormalities,
- **'frizzled' feathers,**
- Bone abnormality referred to as the **'swollen hock syndrome' in poultry.**
- Symptoms of zinc deficiency in calves include inflammation of the nose and mouth, stiffness of the joints, swollen feet and **Parakeratosis**.

DEFICIENCY – PARAKERATOSIS

- Zinc deficiency in pigs causes Parakeratosis, a skin disorders.
- Reddening of the skin followed by eruptions, which develop, into scabs.
- **Parakeratosis is aggravated by high calcium levels in the diet and reduced by decreased calcium and increased phosphorus levels.**
- Pigs given diets supplemented with high levels of copper, for growth promotion have an increased requirement for zn.

MANGANESE

FUNCTIONS

- An activator of many enzymes such as hydrolases and kinases
- As a constituent of enzymes such as arginase, pyruvate carboxylase .
- Managanese through its activation of glycosyl trasferases is required for the formation of the mucopolysaccharide which forms the organic matrix of bone.
- Manganese containing superoxide dismutase catalyses the reactions that promote immunity in animals.

Deficiency – perosis or 'slipped tendon'

- Manganese is an important element in the diet of young chicks, a deficiency leading to **perosis or 'slipped tendon',** a malformation of the leg bones.
- There is enlargement of the hock joint, thickening and shortening of the tibia which causes Achilles tendon to slip from its condyle causing the leg of the bird to be pulled sideward and backward.

Deficiency – nutritional chondrodystrophy

- Manganese deficiency in breeding birds reduces hatchability and shell thickness, and causes head retraction in chicks, causes a condition called as **Nutritional**

chondrodystrophy which is characterized by the shortening of the bones of the wings and legs, shortening of the lower mandible leads to **parrot beak condition.**

COBALT

Functions

- **Cobalt is required by microorganisms in the rumen for the synthesis of vitamin B12.**

Deficiency

Deficiency – wasting disease or coast disease or Pining or Enzootic marasmus

- **Cobalt deficiency causes vitamin B 12 deficiency in ruminants**
- Decreased feed intake
- Emaciation – Loss of body weight due to wasting of skeletal muscles
- Decreased growth rate
- Fatty degeneration of liver

Selenium toxicity – alkali disease and blind staggers..

- **Alkali disease and blind staggers** are localized names for chronic diseases of animals grazing certain seleniferous areas in the USA.
- Symptoms include dullness, stiffness of the joints, loss of hair from mane or tail and hoof deformities.
- Acute poisoning, which results in death from respiratory failure, can arise from sudden exposure to high selenium intakes.

Supplementation

- Fish meal is a good source of selenium.
- Seleno – methionine, seleno – cysteine and sodium selenite are supplemental sources for selenium.

IODINE

Functions

- Iodine plays an important role in the synthesis of the two hormones, triiodothyronine and tetraiodothyronine (thyroxine) produced in the thyroid gland.
- The thyroid hormones accelerate reactions in most organs and tissues in the body, thus increasing the basal metabolic rate, accelerating growth, and increasing the oxygen consumption of the whole organism.

DEFICIENCY - GOITRE

- When the diet contains insufficient iodine the production of thyroxine is decreased.
- The main indication of such a deficiency is an enlargement of the thyroid gland, termed **endemic goitre,** and is caused by compensatory hypertrophy of the gland.
- The thyroid being situated in the neck, the deficiency condition in farm animals manifests itself as a **swelling of the neck.**
- Reproductive abnormalities are one of the most outstanding consequences of reduced thyroid function; breeding animals deficient in iodine give birth to hairless, weak or dead young.

Supplementation.

- In areas where goiter is endemic, precautions are generally taken by supplementing the diet with the element, usually in the form of iodized salt.

MOLYBDENUM

Functions

- The biological function of Molybdenum, apart from its reactions with copper, are concerned with the formation and activities of the following enzymes.
- Xanthine oxidase,
- Cytochrome C oxidase
- Aldehyde oxidase.

Deficiency

- Molybdenum deficiency has not been observed under natural conditions in any species.

Toxicity

- The prominent manifestations of molybdenum toxicity in cattle are diarrhea, scouring, harsh, staring coats and weight loss. This condition is termed as **'Treat' or 'peat scours'.**

Requirement

- Since the requirement is very low, it is met from the usual diet

FLUORINE

- Fluorine is a very toxic element, with ruminants being more susceptible than non – ruminants**. It causes a condition called as fluorosis**.

- There is dental pitting and wear, leading to exposed pulp cavities. Further increases in fluorine cause depression of appetite, lameness and reduced production.
- The commonest sources of danger from this element are fluoride – containing water..

ARSENIC

- Animals given an arsenic – deficient diet had rough coats and slower growth rates than control animals given a supplement of arsenic.
- A long term study with goats showed interference with reproduction (abortion, low birth weights) and milk production and sudden death.
- The toxicity of the element is well known; symptoms include nausea, vomiting, diarrhea and severe abdominal pain.

CHROMIUM

- **Chromium was first shown to be essential for normal glucose utilization in rats**.
- Chromium appears to have a role in glucose tolerance, possibly forming a complex between insulin and its receptors. Chromium is component of glucose tolerance factor (**GTF**)
- Chromium may also play a role in lipid synthesis.

CHAPTER – 4

VITAMINS

Vitamins are organic substances necessary in small quantities for maintenance growth and production. Absence or deficiency causes deficiency disorders.

- Vitamins may be classified based on their solubility as fat soluble vitamins and water soluble vitamins.
- **Fat – soluble vitamins** include vitamin A, D, E and K.
- **Water – soluble vitamins** include vitamin B complex group and vitamin C.
- **The B complex group** of vitamins includes the following:

1. Vitamin B1 (**Thiamin**)
2. Vitamin B2 (**Riboflavin**)
3. Vitamin B3 (**Niacin/Nicotinamide/Nicotinic acid**)
4. Vitamin B6 (**Pyridoxine**)
5. Pantothenic acid
6. Folic acid
7. Vitamin B12 (**Cyanocobalamine**)
8. Biotin
9. Choline

B. Vitamin C (ascorbic acid)

Differences	Fat soluble	Water soluble vitamins
Names	A, D, E, K	Vitamin C B Vitamins
Solubility	Soluble in fats and organic solvents	Water soluble
Digestion and absorption	Requires fat and bile	Easily absorbed in intestine
Excretion	Via faeces	Via Urine
Storage	Stored in the body in fat depots and in liver	Not stored in body except vitamin B12
Toxicity	An over dosage can lead to toxicity	Usually not toxic as it is readily excreted when given in excess

C. Vitamin A (Anti Infective Vitamin)

Chemical name : Retional ($C_{20}H_{29}OH$)

Vitamin A2 – Dehydro Retional

Properties – Destroyed by oxidation on exposure to light. It is a **pale yellow crystalline solid.**

Source:

- Animal source: Oils from livers of certain fish (Cod and Halibut), egg yolk, milk fat.
- **Plant source : All green leaves are rich in Provitamin A, beta – carotene**.
- Conversion of carotene to vitamin A takes place in the intestinal mucosa.
- One molecule of beta – carotene is converted into two molecules of retinol.

Function of vitamin A and vision –

Rhodopsin synthesis – Visual cycle

- The retina is located at the back of the eye. When light passes through the lens, it is sensed by the retina and converted to a nerve impulse for interpretation by the brain.
- Retinol is transported to the retina via the circulation, where it moves into retinal pigment epithelial cells.
- There, retinol is esterified to form a retinyl ester, which can be stored. When needed, retinyl esters are broken apart to form 11 – cis retional, which can be oxidized to form 11 – cis retinal.
- 11 – cis retinal cn be shuttled to the rod cell, where it binds to a protein called opsin to form the visual pigment, rhodopsin (visual purple).
- Rod cells with rhodopsin can detect very small amounts of light, making them important for night vision.
- Absorption of a photon of light catalyzes the isomerization of 11 – cis retinal to all trans retinal and results in its release.
- This isomerization triggers the generation of an electrical signal to the optic nerve.
- The nerve impulse generated by the optic nerve is conveyed to the brain where can be interpreted as vision.
- Once released all – trans retinal is converted to all – trans retinol, which can be transported to the retinal epithelial cell to complete the visual cycle.
- Inadequate retinol available to the retina results in impaired dark adaptation, known as **"night blindness."**

Vitamin A deficiency:

- **Night blindness:** inability to see in dim light
- **Xerophthalmia –** Severe or prolonged vitamin A deficiency causes a condition called **Xerophthalmia (dry eye)**

- Xerophthalmia is characterized by changes in the cells of the cornea that ultimately result in **corneal opacity, keratinisation of the cornea,** corneal ulcers, scarring, and blindness.
- Sometimes vitamin A deficiency can lead to obstruction of lacrimal ducts due to degenerated epithelial cells leading to **decreased output of tears**.
- Mild vitamin A deficiency may result in changes in the conjunctiva (corner of the eye) called **Bitot's spots.**
- Deficiency of vitamin A can lead to **developmental bone deformities.**
- **Nutritional roup**
- In poultry Vitamin A deficiency leads to high mortality rate.
- Early symptoms include retarded growth, weakness, ruffled plumage and a staggering gait.
- Egg production and hatchability are reduced. Nasal and ocular discharge, drowsiness, pale comb and wattles, eyelids stuck shut with thick exudates.

Congenital blindness

- Vitamin A is needed for bone formation.
- If vitamin A is deficient optic foramen is not formed properly.
- Small size optic foramen leads to the constriction of optic nerve.
- Permanent damage to the nerve can lead to permanent blindness.

Effect on reproduction

- Deficiency of vitamin A can lead to infertility or sterility in male
- Deficiency of vitamin A can lead to vaginitis, abnormal oestrous cycle, early embryonic mortality, abortion and defective formation of foetus in females.

Vitamin A Toxicity:

- The condition caused by vitamin A toxicity is called hypervitaminosis A. it is caused by over consumption of vitamin A.
- Symptoms include nausea, headache, and fatigue, loss of appetite, dizziness, and dry skin. Swelling over long bones, Liver enlarged (Eskimos consuming polar bear livers).

Vitamin D (Anti Rachitic Vitamin)

Chemical structure:

Vitamin D2 – Ergo calciferol – plant origin

Vitamin D3 – Cholecalciferol – Animal origins

Properties:

Soluble in fat and fat solvents more stable than Vitamin A with regard to oxidation

Sources :

- Cod liver oils (rich source),
- Egg yolk and sun dried roughage's / grains.
- Colostrum contains 6 to 10 times the amount present in ordinary milk.
- **Provitamin D :** Ergosterol – plant and 7 – dehydrocholestrol – skin of animals. Cod liver oils – Rich source Egg – yolk, Sundried vegetables / grains.

Provitamin / precursor of vitamin D:

Ergosterol in plants and 7 – dehydrocholesterol present in the skin.

Ergosterol is converted to Ergocalciferol and 7 dehydrocholesterol on exposure to UV rays is converted to Cholecalciferol

Deficiency:

In young children deficiency of vitamin D causes rickets and in adults it causes Osteomalacia.

Osteomalacia:

- Resorption of calcium and phosphorus from the bone.
- Bones become weak, more prone to fractures and deformities.
- It can occur in pregnant and lactating animals, which require increased amount of calcium and phosphorus.

Rickets:

- Calcium and Phosphorus deposition in bones is affected and the bones are weak, more prone to fractures and deformities.
- The conditions commonly seen are bowing of legs, swollen knees and hock and arching of back.
- Occasionally there is paralysis.
- Rickety Rosary – enlargement of Osteochondral junction in ribs are also noticed

Rubbery legs in poultry

- **In poultry** bones and beak become soft and rubbery; legs become weak.
- Egg production is reduced and eggshell quality deteriorates.

Toxicity –

Vitamin D toxicity (hypervitaminosis D) induces abnormally high serum calcium levels (hypercalcemia), which could result in

- Bone loss,
- Kidney stones, and
- Calcification of organs like the heart and kidneys if untreated over a long period of time.

Vitamin E (Anti Sterility Vitamin)

Chemical name – Alpha Tocopherol

Sources: - Green fodders, cereal grain, vegetable oils, fats, and nuts, oil seeds and legumes.

Functions:

- Vitamin E function in the animal mainly as biological antioxidant.
- The animal has two main methods of protecting itself against oxidative damage. Firstly, radicals are scavenged by Vitamin E as a first line of defence and secondly, glutathione peroxidase destroys any peroxide formed before they can damage the cell.
- These two defence mechanisms complement one another.
- Vitamin E also plays an important role in the development and function of the immune system.
  1) Vitamin E prevents per oxidation of PUFA in tissues and membranes. Vitamin E deficiency: PUFA undergo per oxidation and yellow and brown pigments are formed in fatty tissues.
  2) Protects RBC from haemolysis by oxidizing agents.
  3) Protects liver from carbon tetrachloride poisoning.

Deficiency –

Nutritional myopathy / white muscle disease / stiff lamb disease / mulberry heart disease / exudative diathesis / crazy chick disese

- The most frequent and thye most important manifestation of selenium deficiency in farm animals is muscle degeneration (myopathy).
- **Nutritional myopathy,** also known as muscular dystrophy, frequently occurs in cattle, particularly calves.
- The myopathy primarily affects the skeletal muscles and the affected animals have weak leg muscles, a condition manifested by difficulty in standing and, after standing, a trembling and staggering gait.

- Eventually, the animals are unable to rise and weakness of the neck muscles prevents them from raising their heads.
- A popular descriptive name for this condition is **white muscle disease.**
- The heart muscle may also be affect and death may result.
- Nutritional myopthy also occurs in lambs, with similar symptoms to those of calves. The condition is frequently referred to as **stiff lamb disease.**
- In pigs, the two main diseses associated with vitamin E and selenium deficiency are myopathy and cardiac disease.
- The pigs demonstrate an uncoordinated staggering gait, or are unable to rise.
- The pigs demonstrate an uncoordinated staggering gait, or are unable to rise.
- The pigs heart muscle is more commonly affected.
- Sudden cardiafailure occurs and on post – mortem examination the lesions of the cardiac muscles are seen as pale patches or white streaks. This condition is commonly known as **mulberry heart disease.**
- Vitamin E deficiency in chicks may lead to a number of distinct diseases: **Nutritional myopathy, encephalomalacia and exudative diathesis. In nutritional myopathy** the main muscles affected are the pectorals although the leg muscles also may be involved.
- **Nutritional encephalomalacia** or **crazy chick disease** is a condition in which the chick is unable to wal or stand, and is accompanied by haemorrhages and necrosis of brain cells.
- **Exudative diathesis** is a vascular disease of chicks characterized by a generalized oedema of the subcutaneous fatty tissues, associated with an abnormal permeability of the capillary walls.
- Both selenium and vitamin E appear to be involved in nutrition myopathy and in exudative diatheisis but selenium does not seem to be important in nutritional encephalomacia.

Supplementation

- Green fodders, cereal grain, vegetable oils, fats, and nuts, oil seeds and legumes.

VITAMIN K

Chemical name

Phylloquinone K1 - Present in plants

Menaquinone K2 - Bacterial synthesis

Both are derived from menadione

Source: Green leafy vegetables, Egg yolk, Liver, Fish and synthesized by bacteria in large intestines.

- **Functions:** Vitamin K is required for synthesis of prothrombin in the liver and also for the synthesis of factors palasma thrombin to thrombin.
- The inactive vitamin K dependent zymogens are converted into calcium binding proteins which activate them.

Deficiency:

- Low prothrombin level in blood leads to haemorrhagic conditions.
- In cattle **sweet clover disease** is associated with Vitamin K.
- Sweet clover when it gets mould infested contains a compound **dicoumarol,** which lowers prothrombin content of blood leading to haemorrhagic disease and hence vitamin K is also called as anti haemorrhagic vitamin.
- In chicks Vitamin K is also called as anti haemorrhagic vitamin.
- In chicks Vitamin K deficiency causes anaemia and delayed clotting time of blood.

Supplementation

- Green leafy vegetables, egg yolk, liver, fish and synthesized by bacteria in gastro intestinal tract.

Detect Deficiency Coagulation time of blood.

Toxicity : When vitamin K administered to premature infants leads to toxicity it causes hyper – bilirubinaeamia or kern icterus.

H2O SOLUBLE VITAMINS:

Vitamin C (Ascorbic acid)

Colour Crystalline H2O soluble.

Functions:

- Formation of collagen and intercellular cement substance (capillaries, teeth, bone)
- Metabolism of tyrosine
- Absorption of Fe
- Hydroxylation of deoxycorticosterone, tryptophan, phenyl alanine
- Bone formation
- Adrenal cortex function
- Electron transport

Deficiency –

a. **Scurvy in Adults :** Weakness, bleeding, loose teeth, Swollen joints, haemorrhages.

b. **Infantile scurvy:** Anaemia, Leg drawn up to abdomen swelling at ends of long bone. Gums have swollen dyspnoea, cyanosis, convulsions, and death if not treated.
c. **Delayed wound healing.**

Requirement

- Vitamin C is dietary essential **only in man, guinea pig and other primates, red vented bulbul and fruit eating bat** as these species lack the enzyme L – gulonolactone oxidase.
- Stress increases the requirement of this vitamin.
- Other species synthesise vitamin C from glucose.

Supplementation

- Citrus fruits and green leafy vegetables are rich sources

VITAMIN B COMPLEX

All vitamins of the group are H_2O soluble. Most of them are co – enzymes.

Thiamine (Vitamin B1)

Functions:

Thiamine diphosphate is a coenzyme involved in oxidative decarboxylation of pyruvate to acetyl coenzyme A. & of alpha ketoglutarate to succinyl COA in TCA cycle.

Deficiency:

- Anorexia,
- Emaciation,
- Muscular weakness and progressive dysfunction of the nervous system

Star grazing

In chicks deficiency of thamine leads to anorexia, emaciation, polyneuritis characterized by head retraction, nerve degeneration and paralysis which otherwise called as **star gazing posture.**

- Thiamine deficiency in foxes causes **Chastek paralysis**

Supplementation

- Yeast, germ and bran of cereal grain
- Port is rich in thiamine.

Riboflavin (vitamin B2)

It consists of a dimethyl isoalloxazine nucleus combined with ribitol. It is a yellow, crystalline compound that has yellowish green fluorescence in aqueous solution. It is only sparingly soluble in water, stable in acid or neutral solution but destroyed in alkaline solution. It is unstable in light.

Sources:

It is synthesized by yeast, bacteria and fungi. Rich sources are liver, yeast, milk and green leafy vetables.

Functions:

- It is a constituent of **Flavoproteins, Flavin mononucleotide and Flavin adenine dinucleotide.**
- They are involved in amino acid and carbohydrate metabolism.
- In sows riboflavin is necessary to maintain normal oestrous activity and prevent premature parturition.

Deficiency:

- Poor appetite, retarded growth, vomiting, skin eruptions and eye abnormalities.
- In chick's riboflavin deficiency causes **Curled toe paralysis** caused due to peripheral nerve degeneration, in which the chicks walk on their hocks with the toes curled inwards.
- In breeding hen's deficiency causes decreased hatchability. Embryonic abnormalities occur including the **clubbed down condition** in which the down feather continues to grow within the follicle leading to curled feather.

Niacin (Nicotinamide)

It is the amide of nicotinic acid. It is a stable vitamin not reatily destroyed by heat, acids or alkali.

- **Functions:** nicotinamide function in the animal body as the active group of two important coenzymes, nicotinamide adenine dinucleotide (NAD) and incotinamide adnine dinucleotide phosphate (NADP).
- These coenzymes are involved in the mechanism of hydrogen transfer in living cells.

Deficiency symptoms:

- In pigs, deficiency symptoms include poor growth, anorexia, enteritis, vomiting and dermatitis.
- In fowls a deficiency of the vitamin causes bone disorders, feathering abnormalities and inflammation of the mouth and upper part of the oesophagus.

- Deficiency b symptoms are particularly likely in pigs and poultry if diets with a high maize content are used, since maize contains very little of the vitamin or of tryptophan
- Pellagra is commonly observed in human population where is predominant part of diet.

Supplementation

- It can be synthesized from amino acid tryptophan in the body tissues.
- If the diet is rich in protein containing tryptophan than dietary requirement of the vitamin is low.
- Rich sources of the vitamin are liver, yeast, groundnuts and sunflower meals.
- In cereals the vitamin is present in the bound form.

Vitamin B6 (pyridoxine)

Functions:

- Of the three related compounds (pyridoxine, the corresponding aldehyde derivate as pyridoxal and the amine as pyridoxamine.) the most actively functioning one is pyridoxal in the form of the phosphate.
- Pyridoxal phosphate plays a central role as a coenzyme in the reactions by which a cell transforms nutrient amino acids into mixtures of amino acids and other nitrogenous activities of transminases and decarboxylases, and over 50 pyridoxal phosphate – dependent enzymes have been identified.
- The vitamin is believed to play a role in the absorption of amino acids from the intestine.

Deficiency symptoms:

- Affects the animal's growth rate.
- In addition, pigs exhibit a reduced appetite and may develop **anemia.**
- Chicks on a deficient diet show jerky movements, while in adult birds hatchability and egg production are adversely affect

Supplementation

- The vitamin is present in plants as pyridoxine whereas animal products may also contain pyridoxal and pyridoxamine.
- Pyridoxine and its derivatives are widely distributed in yeast, pulses, cereal grains, liver and milk.

Panthothenic acid

Functions:

- **Pantothenic acid is a constituent of coenzyme A,** which is the important coenzyme of acyl transfer.
- It is also a structural component of acyl carrier protein, which is involved, in the cytoplasmic synthesis of fatty acids.

Deficiency symptoms :

- Deficiency of pantothenic acid in pigs causes slow growth, diarrhea, loss of hair, scaliness of the skin and a characteristic '**goose – stepping' gait.**
- In severe cases animals are unable to stand.
- In the chick, growth is retarded and dermatitis occurs.
- In mature birds, hatchability is reduced

Supplementation

- Rich sources are liver, egg yolk, groundnuts, peas, yeast and molasses.
- Cereal grain and potatoes are also good sources of the vitamin.

FOLIC ACID

Functions:

Folic acid is converted into **tetrahydro folic acid which function as a coenzyme in the mobilization and utilization of single – carbon groups (e.g) formyl, methyl** that are added to, or removed form, such metabolites as histidine, serine, glycine, methionine and purines.

Deficiency symptoms:

- A variety of deficiency symptoms in chicks and young turkeys have been reported, including.
- Poor growth,
- Anaemia,
- Poor bone development and
- Poor egg hatchability.

Supplementation

- Folic acid is widely distributed in nature; green leafy materials, cereals and extracted oilseed meals are good sources of the vitamin.
- Folic acid is reasonably stable in food stored under dry conditions but it is readily degraded by moisture, particularly at high temperatures.
- It is also destroyed by ultraviolet light.

BIOTIN

- Biotin serves as the prosthetic group of several enzymes which catalyse the transfer of carbon dioxide from one substrate to another.
- In animals there are three biotin – dependent enzymes of particular important:
- Pyruvate carboxylase,
- Accetyl coenzyme A carboxylase,
- Propionyl coenzyme A carboxylase.

Deficiency -

- In pigs, biotin deficiency causes foot lesions, alopecia (hair loss) and a dry scaly skin.
- In poultry, biotin deficiency causes reduced growth, dermatitis, leg bone abnormalities, cracked feet, poor feathering and **Fatty liver and kidney syndrome (FLKS).**
- **Fatty liver and kidney syndrome,** which mainly affects two – to five – week – old chicks, is characterized by a lethargic state with death frequently following within a few hours.
- On autopsy, the liver and kidneys, which are pale and swollen, contain abnormal depositions of lipid.
- Avidin, a protein present in the raw white of eggs can induce biotin deficiency which combines with the vitamin and prevents its absorption from the intestine.

Supplementation

- Biotin is widely distributed in foods; liver, milk, yeast, oilseeds and vegetable are rich sources.

CHOLINE -

- Choline is an essential structural component of body tissues.
- It is a component of lecithin's which play a vital role in cellular structure and activity.
- It also plays an important part in lipid metabolism in the liver by preventing the accumulation of fat in this organ.
- It serves as a donor of methyl groups in trans methylation reactions and is a component of acetylcholine which is responsible for the transmission of nerve impulses.
- Choline can be synthesized in the liver from methionine and the level of methionine in the diet therefore influences the exogenous requirement for this vitamin.

Deficiency symptoms

- Deficiency symptoms, including slow growth and fatty infiltration of the liver, have been produced in chicks and pigs.

- Chorine is also concerned with the prevention of **Perosis or slipped tendon in chicks.**
- The choline requirement of animals is unusually large for the vitamin, but in spite of this, deficiency symptoms are not common in farm animals because of its wide distribution, its wide distribution, its high concentrations in foods and because it can be readily derived from methionine.

Supplementation

- Green leafy materials, yeast, egg yolk and cereals are rich sources of choline.

VITAMIN B_{12}

- The coenzymic forms of vitamin B_{12} function in several important enzyme systems.
- These include isomerases, dehydrases and enzymes involved in the biosynthesis of methionine from homocysteine.
- Poor growth,
- Poor feathering,
- Deceased hatchability,
- Dermatitis and rough coat.s
- In poultry housed with access to litter, majority of the vitamin requirements can be obtained from the litter.
- **Microorganisms in the rumen synthesize B_{12}., if cobalt is present in the diet.**

Supplementation

- Vitamin B_{12} is considered to be synthesized exclusively by microorganisms and its presence in foods is thought to be ultimately of microbial origin.
- The main natural sources of the vitamin are foods of animal origin, liver being a particularly rich source.

CHAPTER – 5

FORMULATION OF LEAST COST RATION –

Definition

- A least cost ration incorporates all the available feedstuffs having good nutritive value and being available at a reasonable low cost.
- It can also be defined as an economic ration for animal production (dairy, beef, sheep, goats, poultry etc.) that provides nutrients in balanced proportion with lowest possible cost per kg or 100kg.
- It is the ration containing all essential nutrients that are needed to meet the requirements of the animal (growth, maintenance, production, reproduction work etc.) without affecting quality and with least cost.

Aim

- To minimize the cost of ration while meeting the nutrient requirements of animals without affecting their productivity.

Advantages

- Incorporation of non – conventional feedstuffs is easy.
- The speed and accuracy of the linear programming by computer saves time and labour.
- As the programme is flexible, inclusion of feed ingredients as per availability and quality can be made quickly.
- Gives more productive of the livestock farm.
- Farmer can also afford to make use of it more effectively because it is cheaper in nature.

Procedure

- List all the available feeds, fodders and other available ingredients.
- Enlist the components of each ingredient i.e proximate value of dry matter(dm)DCP,TDN.
- Feed the computer with the cost of all available feed ingredients.
- Give instructions to the computer for the type of ration desired depending upon the requirements of animal (growth, maintenance, production, reproduction, work, or starter, grower, layer etc; high energy, high protein, low energy, low protein etc.)
- Give instructions to the computer regarding the amount of feed ingredients (for example say DM of 20 kg of DCP of 0.75 kg). similarly, amount of certain feed ingredients in the ration can be fixed like fish meal (say 10%) and mineral mixture (say 2%).
- Now, the computer will take the least cost feed ingredients for formulating least cost ration.

- It is a linear programme based model that includes the following stepwise approach: i.e. proximate values (DM and nutritive value i.e. CP/DCP and TDN / ME).

Limitations of computer based model.

- Certain constraints need to be imposed on ingredients (maximum and minimum levels) or otherwise, it may take all low cost ingredients with poor nutritive value. Such a ration would not result in high milk production at least cost and hence, milk production may get adversely affected.
- Computer cannot encounter the toxic material in the ingredients.
- Computer will not count the additive effect of feeds.
- Computer cannot judge the digestibility and palatability of ingredients. It may be a least cost ration, but with poor palatability.
- Needs skill and good programming.

Other systems of feeding

1. **Liquid urea – molasses feeding**

- Liquid molasses containing 2 to 3 % uniformly mixed urea and fortified with minerals and vitamins is referred to as liquid feed. The principle of urea – molasses liquid feed preparation lies in the homogenous mixing of urea in liquid molasses.

The most practical and least toxic urea – molasses liquid feed contains

- Sugarcane molasses – 92.0
- Urea – 2.5
- Fresh water – 2.5
- Mineral mixture – 2.0
- Common salt – 1.0

The mixture is fortified with vitablend (vitamins A & D)

- Urea is completely dissolved in water and poured gradually into the tank containing molasses with simultaneous mixing using a wooden stirrer.
- Powdered salt and mineral mixture are sprinkled over the molasses while stirring to ensure uniform distribution of all the additives in the liquid molasses.
- Special attention is required for the uniform mixing of urea solution.
- During winter season, the viscosity of molasses increases and hence, heating of the urea – molasses mixture is essential for thorough mixing.
- This undiluted urea – molasses liquid feed containing 65% and more dry matter can be safely stored for long periods.

3) @ 25G/100kg.66 Procedure for preparing urea – Molasses Liquid Feed:

b. **Another combination of urea – molasses liquid feed**

- Molasses – 83%
- Urea – 2%
- Phosphoric acid – 2%
- Salt – 2%
- Mineral mixture – 1%
- By pass protein – 10%
- (cotton seed cake or Fish meal)

Precautions to be followed while feeding liquid urea – molasses diets

- It is desired to supplement the liquid molasses diet to certain minimum quantity of roughages to maintain bulk.
- It is advisable to introduce liquid feed gradually in the ration in about 10 to 15 days.
- Fresh drinking water should be made available at all times for the animals on liquid diet.
- It is good to provide mineral mixture or mineral licks free of choice in a separate container.

2. Uro – mol Brick feeding

- The National Diary Development Board (NDDB) has started manufacturing urea – molasses blocks.
- The production and utilization of urea molasses blocks assumes an increasingly important role in drought prone areas.
- When licked by the ruminant animals, the urea – molasses blocks provide nitrogen to micro – organisms in the rumen and in turn improve digestion of the straw, which is fed during disastrous conditions.
- These blocks are available commercially in packed condition so that they can be transported to the areas of necessity easily.

Composition of urea – molasses mineral block

- Molasses – 45%
- Urea – 15%
- Mineral mixture – 15%
- Salt – 8%
- Calcite powder – 4%
- Bentonite/Guar gum – 3%

- Any vegetable oil cake – 10%

Procedure for preparing urea – Molasses mineral block

- Binder is added to the cake and the mixture is produced into the block molds and allowed to cool.
- Apart from cake, bran or some roughage source can also be incorporated to prepare complete feed blocks for feeding of ruminant livestock in drought prone areas.
- At present, de-wormer included medicated blocks are commercially available for feeding to small ruminants.

3. Uromin lick

This "Uromin" lick also called "Pashu Chaat" contains besides urea, molasses and minerals, certain fillers like de-oiled rice bran, maida (sieved flour), mustard cake, common salt and feed binder (Bentonite or guar gum).

- Molasses – 30
- Urea – 10
- Deoiled mustard cake – 10
- Deoiled rice bran – 10
- Common salt – 10
- Mineral mixture – 15
- Maida (sieved flour) – 15
- Bentonite / guar gum - 03

Procedure for preparing Uromin lick

First, molasses and urea are heated together in a round iron utensil for about half an hour.

- By doing so, Urea and molasses are converted into uromol, where urea – N bound with sugars of molasses is used efficiently by the rumen system.
- Now, all the other ingredients (premix) are mixed with uromol while it is hot to prevent lump formation.
- The whole mixture is then pressed in the dye of a Uromon lick making machine, preferably with the help of a hydraulic jack at a pressure of 10 tons psi.
- A hard Uromin lick is ready in 20 -30 minutes depending upon the atomospheric temperature.
- This brick shaped Uromin lick will weigh around 3 kg and can be sealed in a polythene envelope for future use.

Exercise

- Identify the feedstuffs that are available in your area that can be best utilized for feeding livestock during scarcity and disastrous conditions and give their nutritive value?
- Give details of some commercially available urea – molasses blocks for feeding of livestock?

Composition of Uromin Lick

- Molasses, urea, mineral mixture, salt and calcite powder are mixed with thorough stirring and boiling.

Pearson square method

- Draw a Pearson's square for determining the proportions (or) ratio of feeds to be mixed.
- Partition the feeds as high protein and low protein feeds.
- Place the percentage of crude / digestible crude protein desired in the center of the pearson's square.
- Place the average percentage of crude / digestible crude protein present in high protein feeds on the left side upper corner of this square.
- Place average percentage of crude / digestible crude protein present in low protein feeds on the left side lower corner of this square.
- Take about the diagonal lines in the square.
- Draw the difference between the figures on the left hand sides and the center figure and place these on the right hand corners of the square, in the direction of diagonal lines.
- The figures obtained on the right hand side corners are the parts or proportions in which ration the given feeds should be mixed to obtain the mixture of desired CP/DCP percentage.
- Pass the feeds to be mixed through grinder and then mix the ground feeds in horizontal/vertical mixer.
- Fill the gunny bags using the shovel (or) directly fill it from the mixer.
- Label the feed mixture along with the weight neatly, clearly and legibly.

CHAPTER – 6

1. Feeding of claves

Feeding of Colostrum

Calf feeding starts with colostrums, which is first milk drawn cow after parturition and rich in nutrient and immunoglobulin and **provides passive immunity** to the calf, gives immediately within 30 minutes of birth.

The calf should fed 2 – 3 liters of colostrums for first three days following its birth, however according to one recommendation the colostrums must be fed as per the percent of their body weight:

COLOSTRUM AS PERCENT OF BODY WEIGHT	
15 – 30 minutes	5 – 8%
10 – 12 hours	5 – 8%
2nd day	10%
3rd day	10%

Importance of colostrums feeding

1. Colostrum provides the Immunoglobulins which are presumed to be the source of antibodies which protect the calf from many infections.
2. **The protein content of colostrum is 3 – 5 times as that of normal milk**. Some minerals (Cu, Fe, Mg & Mn) and vitamins (Vit. A, B_1, B_2, B_5 & Choline).
3. Colostrum acts as a **laxative;** and helps in expulsion of **meconium (1st faeces).**
4. **Colostrum contains 5 – 15 times more vitamin A than normal milk but it depends upon the type of ration given to the dam during dry period.**

Artificial colostrum – In case of non availability of colostrums due to accidental death of mother of artificial colostrum substitute can be used.

In can be prepared by mixing 2 whole eggs in one litre of milk and 30 ml of castor oil.

It should be fed three times in a day.

COMPARATIVE CHARACTERSTICS OF COLOSTRUM AND MILK

S. No.	Physical Characteristics	Colostrums	Milk
1	Taste	Slightly bitter	Sweet
2	Odour	Abnormal	Normal
3	Acidity	0.2 – 0.4	0.12 – 0.14

4	Freezing point	- 0.606	- 0.52 – 0.56
5	Chloride %	0.148 – 0.156	0.14
6	Specific gravity	1.05-1.08	1.029 – 1.032

Composition

1	Total solids	22.5	12.5
2	Fat %	3.5	4.0
3	Protein %	14.3	3.3
4	Lactose	3.0	4.6
5	Ash	1.8	0.8

The farms, where weaning, is not practiced calf automatically learns and leads to the udder to its mother within half an hour but in case where weaning is followed the calves need to train for taking milk either from pail or milking bottles with rubber nipples.

Pail feeding – A method of rearing calves by weaning them of the dam and feeding them on her or another cow's milk or milk replacer in bucket without use of a nipple.

Feeding whole milk.

A calf must get 2 – 3 liters milk daily i.e. 1/10th of its body weight.

Milk replacer – It is the substance that replace the milk which is fed to the calf. In the following condition;

1. If the dam/mother die.
2. If there is cessation of milk production by the dam.
3. If milk is insufficiently produced by the dam.

Good quality milk replacer –

Spray dried skim milk powder – 50 parts, dried whey 10 parts and non – milk source (antibiotics, vitamin, vegetable protein, fats) of 40 parts

(Note: this milk replacer will be mixed with lukewarm water in preparation of 1:8)

Partial milk replacer –

Component	Parts
Wheat	10
Linseed meal	40
Milk	23
Coconut oil	10

Butyric acid	0.3
Citric acid	1.5
Mineral mixture	3.0
Antibiotic	0.2
Total	**100**

Feeding calf starters

Calf starter is a mixture consisting of ground farm grains, protein feeds and minerals, vitamins and antibiotics. At **2 weeks of age** calf starter may be started to given and whole milk may be cut down. **Calf starter should have 75% TDN, 14-16% DCP and 20 – 22% CP**.

Sr. No.	Ingredients	Parts
1	Maize	42
2	Ground nut (ewaxQyh) cake	35
3	Wheat/rice bran (pksdj)	10
4	Fish meal	10
5	Mineral Mixture	2
6	Salt	1

Feeding grain mixture

A grain mixture consists of ground maize – 2 parts, wheat bran – 2 parts is good for feeding claves. Grains should be given from 4 months of age.

Silage feeding – if good quality silage is available then 1 – 2 kg silage daily can be fed to the claves up to 3 – 4 months of age. Increase the amount about 500g per day for each months of calf's age.

Antibiotic supplementation – Though it is a controversial issue to use antibiotic as growth promoter or not owing to the problem of antibiotic resistance but the experiment has indicated that feeding aureomycin and terramycin at the rate 80 mg per day per calf 4 – 116 days of age increase growth rate from 10 - 30%, improve appetite, reduce calf scour and thus, calf mortality rate also .

Providing minerals:- Minerals such as calcium, phosphorus etc should be fed to the calf @ of at least 2% of the concentrate.

Deworming – Deworming of calves is necessary because 90% of calves die within 6 months due to Ascariasis.

Acaricidal Treatment – in cross breed cattle, calf Theleriasis and other protozoan Parasites are found commonly. Hence medicines against ticks should be sprayed regularly.

Disbudding – it should be done at the **age of 10 -20 days.**

Weaning of calf – Separation of calf from the mother after parturition is called ad weaning.

A calf can be weaned immediately after birth or after colostral period of 3 – 5 days. In normal condition where suckling is practiced calves are weaned naturally after 6 to 12 months of age.

Advantages of weaning system :-

1. If the calf is dead then there is no difficulty in regular milking of its mother.
2. In this system the scientifically right amount of milk is feed to the calf. Os it is economical and good for the health of calves.
3. Control of some diseases such as diarrhea, white scour etc can be done by this system.
4. Actual milk yield can be measured in this system.
5. Total increase in milk can be calculated in this system.
6. The calf can be culled out at any early stage.
7. Without calf milking is more hygienic and sanitary.

Disadvantages of weaning system –

1. **Weaning is a problemeatic in Bos indicus and buffaloes due to strong maternal instinct.**
2. 0 day weaning can cause reduced milk yield in such animals, and also cause early temperamental problem.

FEEDING SCHEDULE FOR CALVES UP TO 6 MONTHS

Age of calf	Approx. Body weight (kg)	Quantity of milk (kg)	Quantity of calf starter (g)	Green grass/Ha (kg)
Upto 3 days	25	2 – 2.5 litres colostrum should be fed daily		
4 days – 4 weeks	25	2.5	Small qty.	Small qty
4 – 6 weeks	30	3.0	50-100	Small qty
6 – 8 weeks	35	2.5	100 – 250	Small qty
8-10 weeks	40	2.0	250 – 350	Small qty
10 – 12 weeks	45	1.5	350 – 500	1 – 0
12 – 16 weeks	55	-	500 – 750	1 – 2
16 – 20 weeks	65	-	750 – 1000	2 – 3
20 – 24 weeks	75	-	1000 – 1500	3 – 5

FEEDING SCHEDULE OF GROWING ANIMALS

(FROM 6 MONTHWS ONWARDS)

Age (Months)	Approximate body weight (kg)	Concentrate mixture (kg)	Grass (kg)
6 – 9	70 – 100	1.5 – 1.75	5 – 10
9 – 15	100 – 150	1.75 – 2.25	10 – 15
15 – 20	150 – 200	2.25 – 2.50	15 – 20
Above 20	200 – 300	2.50 – 2.75	15 – 20

Feeding of cattle –

Early lactation -

- The recently claved high producing cow is unable to eat enough feed to support her milk production.
- This means that the cow should have enough reserve to store nutrient to be drawn to tide over the period of heavy demand in early lactation, during which period the cow loses weight.

Challenge feeding – Last two week before the calving challenge feeding is done for the (high elder animals) and we are challenging against negative N_2 energy which is suspected few days after calving.

- Challenge feed will be followed 2 weeks prior to calving.
- First day start 300 – 400 gm concentrate extra, next we have to add 500gm concentrate daily till the animal will consume 1 – 1.5 kg/100 kg body weight.
- 2 days before parturition stop concentration 4 – 5 days after calving give concentrate 500 gm add 400 gm concentrate daily till the animal consume adlibitum up to the peak milk yield. After peak milk yield provide concentrate according to milk yield/day. For cattle 1 kg concentrate for every 2.5 – 3 kg of milk and in buffalo 1 kg concentrate for every 2 – 2.5 kg milk.

CHALLENGE FEEDING SCHEDULE

Period	Concentrate allowance
Last 2 weeks before calving	Starting from 500g , increase 300 – 400g daily unt the cow is eating 500 – 1000g per 100kg body weight.
First 2 weeks of lactation	Increase 500g day to free choice level.
Second week to peak yield (test day)	Free choice
From test day onwards	According to production as per thumb rules. E.g. 1Kg for every 2.5 kg milk produced

Remaining lactation	Concentrate adjusted to monthly test of milk production
All periods	Green fodder and dry fodder given adequately

Feeding during mid and late lactation:

- During this period the cow may be fed a well balanced ration of god quality fodder an concentrate according to the milk yield and at percentage of milk.
- During the late lactation, intake ability of the cow exceeds nutrient needs. This is the time when the cow starts needing extra allowance for the growing foetus.
- This is also the period when the cow can readily replenish the already depleted body reserve and gain weight very fast.
- From $7\frac{1}{2}$ months to 10 months of lactation, cow may be fed 1 – 2 kg concentrate feed in addition to their nutrient requirement for maintenance and milk production to replenish the condition lost in early lactation.

Pregnancy allowance – From 6 months onwards, 1 – 1.5 kg concentrate/day extra feed the pregnant animals.

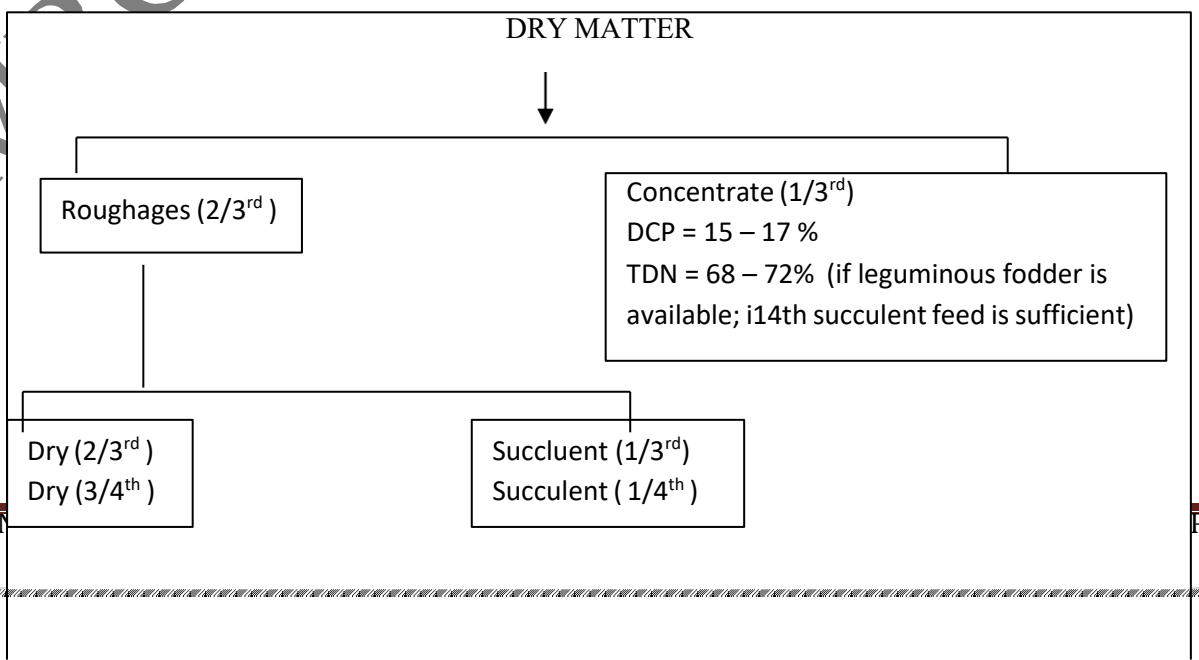
Feeding high producing dairy cows –

- High producing dairy cow should eat a large volume of nutrient daily to sustain the milk production at that level.
- Ruminant ration should contain a minimum of 20 – 25 per cent crude fibre.
- Cows need acetic acid for maintaining normal milk fat percentage as well as total milk production.

FEEDING SCHEDULE FOR DIFFERENT CLASSES OF ADULT COWS

Dry matter requirement: 2 -2.5kg DM/ 100 kg b.wt. of zebu cattle

2.5 – 3 kg DM/ 100 kg b.wt. of CB cattle/buffalo



Straw requirement: Zebu = 4 kg, Buaffalo and Cross breed cow = 4 – 6 kg

Concentrate for maintenance: Cow = 1 – 1.25 kg, Buffalo = 2 kg

Conc. For production: Cow = 1 kg /3 kg milk, Buffalo = 1kg/2kg milk

Conc. For pregnancy: Production + 1 – 1.5 kg from 6th month of pregnancy

Mineral mixture and salt add @ of 1% of concentrate.

FEEDING OF BULL

Feeding of bull calves

- Animals which are earmarked to be raised as future breeding sires, should generally be kept on a liberal amount of milk for the first six months or more of their life. milk is also supplemented with calf starter from two weeks of age onwards along with good quality hay.

S.N.	Age of bull calves	Quality to be given (kg)		
		Concentrate	Green fodder	Dry Fodder
1	6 to 12 months	2.5	5 – 7	Adlibitum
2	1 to 2 years	3.0	7 – 10	Adilibitum

- Young males to be used for draft purpose should only be castrated at 12 to 15 months of age and their feeding schedules should be identical to that of heifers. To economize the coast of feeding more green fodde4r and hay can be fed (upto 15 – 20 kg /day).

Nutrient requirement of breeding bulls

Live weight (kg)	**DCP g**	**TDN kg**	**ME Mcal**	**Ca g**	**P g**	**Carotene mg**	**Vitamin a 1000 IU**
400	380	3.6	13.0	18	13	40	16
500	450	4.5	16.2	20	15	53	21
600	530	5.4	19.4	22	17	64	26

- When berseem/Lucerne/cowpea are available they can be fed along with the straw or other good quality roughages like oats without any concentrate are to be fed.
- When non – leguminous green fodders, like oat, maize, sorghum, good grazing etc, from the basal roughage there is no need to feed concentrate mixture.

Feeding for working bullock

- When wheat/ paddy straw from the basal ration, then a concentrate mixture containing 12% DCP and 75% TDN should be fed at the rate of 1, 1.5, 2 and 2.5 kg respectively to 200, 300, 400 and 500 kg animal along with ad libitum bhusa. For heavy work 2, 3, 4 and 5 kg of concentrate mixture should be fed along with wheat straw. 2.5 kg green fodder may be fed to satisfy the vitamin A requreiment.
- When the animals are not working, they should be fed as per the maintenance requirement. For light work, the animal should be fed with 30 kg green maize and 10 kg cowpea. For heavy work, 10kg extra cowpea may be fed to take care of extra protein requirement. When cultivated fodders are available 20 kg berseem/Lucerne with 20 kg oats may be fed.

Alternative Feeding Schedule for Working bullock

Light work

- Roughage: Ad libitum straw (6 – 10kg)
- Concentrate (12% DCP, 60% TDN) : 1 – 2.5 kg/day
- Roughage: ad libitum straw (6 – 10 kg)
- Concentrate (12% DCP, 60% TDN): 1.5 – 4 kg/day

Heavy work

- Roughage: Ad libitum straw (6 – 10 kg)
- Concentrate (12% DCP, 60% TDN): 2 – 5 kg/day

Nutrient requirement of sheep

	DM	DCP	TDN
Maintenance of adult animals	60.6 g per kg metabolic body size or 2.5% of body weight	3.0 g per kg metabolic body size	27.3 g per kg metabolic body size
Pregnant animal	1.5 times maintenance the last six weeks of pregnancy	2.5 times maintenance during the last size weeks of pregnancy	2.0 times maintenance during the last six weeks of pregnancy

Lactating animals	2 times the maintenance DM during 1st two months of lactation & 1.5 times maintenance due the remaining period of lactation	2.5 times maintenance during 1st two months of lactation & 1.5 times maintenance during the remaining period of lactation	Twice the maintenance during 1st two months of lactation & 1.5 times maintenance during the remaining period lactation

Wool production -

- The weight of wool produced by sheep varies considerably from one breed to another, and an average value is useful only for guidance.
- For eg: a Merino weighing 50 kg produces annually 4 kg fleece. Such a fleece would contain about 3 kg of actual wool fibre, the remaining 1kg being wool wax, suint, dirt and water.
- Wool was is produced by the sebaceous glands, and consists mainly of esters of cholesterol and other alcohols.
- The wool fibre consists almost entirely protein and wool keratin. To grow in one year, a fleece containing 3 kg protein the sheep would need to deposit a daily average of about 8g protein or 1.3g nitrogen.

Feeding of growing fattening and breeding ram

- When good quality fodders are available, the following concentrate mixture can be used.

COMPOSITION OF IDEAL CREEP FEED

- Maize – 40%
- Ground nut cake – 30%
- Wheat bran – 105
- Deoiled rice bran – 13%
- Molasses – 5%
- Mineral mixture – 25
- Salt – 1% fortified with vitamins A, B2 and D3 and antibiotic feed supplements sheep are allowed for grazing for 6 to 8 hours per day and fed with dired groundnut haulms as a supplementary feed

Body weight	Concentrate Mixture / day
10 – 15 kg	50 gm
16 – 25 kg	100 gm
26 – 35 kg	150 gm

Feeding of fattening lambs

This concentrate ration should be fed at the rate of 110 – 450 gm/day/depending on the weight of ram to be fattened.

- Cereal grains – 2 parts
- Bran – 1 parts
- Oil cakes 1 part

Feeding of breeding rams

- Rams used for breeding purpose should not be too fatty, which may influence rate of fertility and mating behavior.
- This procedure should be followed for 8 weeks before ram is allowed to mare with ewes.
- Before 2 weeks of mating again normal feeding schedule is followed.
- During summer months concentrate mixture consisting of
- Crushed grams – 2 parts
- Wheat bran – 2 parts
- Sodium chloride – 1 part, can be given.
- During winter months crushed grams should be replaced by available crushed oil seeds cakes.

Feeding of goat

- Goats are considered to be the best converter of fibrous feed into good quality meat called as ‘ Chevon’.
- Goats have upper mobile lip and very prehensile tongue, which helps them to graze on very short i.e. near to earth grasses and browsing on plant leaves which are not usually eaten by other speices of animals.

Dry matter requirement of goats

- The dry mater requirement depends on the type of breed.
- In meat type goat breeds the dry matter intake is on an average 3 – 4% of their live body weight.
- While in milch type goats it is 5 – 7% of their live body weight.

Water requirement of goats

- Goats should be provided with ad – libitum clean water.
- On an average a adult goat drinks about 400 – 700 ml, water / day.

Energy requirement

- An average energy requirement for maintenance is 101 kcal ME/kg $W^{o.75}$/day.
- While for pregnancy it is 180 kcal ME/kg $W^{o.75}$/day.
- The daily energy reqirement for milk production is found to be 1220 kcal ME/kg for 4% fat corrected milk (FCM).

Protein require ment

- The daily average requirement of dietary proteins for maintenance is 20 – 30 g DCP/50 kg body weight and for milk production it is 60 – 70 g DCP.kg of milk produced.
- A minimum of 6% total proteins have to be provided other wise fed intake gets reduced which may result in reduced semen activity and lowered feed effeiciency.

Formulation of ration and feeding of poultry for egg production

Broilers –

The BIS recognizes only two phases in the broilers from day old to marketable age of 8weeks, that is broiler starter phase (0 to 5 weeks) and broiler finisher phase (5 to 9 weeks) while NRC divide the period into 0 – 3 weeks, 3 to 6 weeks 6 to 8 weeks since the requirements for nutrients of growing chicken depend upon their rate of growth.

Layers –

The BIs recognizes only two phases during the growing period of the chickens, 1. Chick phase (0 – 8 weeks), 2. Grower phase (8-20 weeks). On the basis of their growth rate and the accompanying nutrient requirements, the growing period of chickens to 18 weeks (pllet developer phase) and 18 weeks to first egg (NRC, 1994)

Types of chicken feeds according to BIS (2007) are as follows.

1. Broiler pre – starter feed 1 – 7 days
2. Broiler starter feed: 8 – 21 days (earlier 0 to 5 weeks; 0 to 6 weeks)
3. Broiler finisher feed: 22 finish (42 days) (earlier after 5 weeks; 6 to 8 weeks)
4. Broiler breeder chick feed
5. Broiler breeder grower feed
6. Broiler breeder layer feed
7. Broiler breeder male feed
8. Layer chick feed
9. Layer grower feed
10. Layer phase – I feed
11. Layer phse – II feed

12. Layer breeder chick feed
13. Layer breeder grower feed
14. Layer breeder layer feed
15. Layer breeder male feed

Composition of grower ration

Ingredients	Precentage
Yellow maize	43
Groundnut cake (expeller)	8
Gingelly oil cake	5
Fish meal/dried unsalted fish	6
Rice polish	16
Wheat bran	20
Salt	0.25

Average feed consumption of egg type birds during growing period

Age in weeks	Feed consumed (g/bird/day)
10	53.0
11	58.0
12	60.0
13	60.0
14	60.0
15	62.0
16	62.0

CHAPTER – 7

VARIOUS PHYSICAL, CHEMICAL & BILOGICAL METHODS OF FEED PROCESSING

PHYSICAL	CHEMICAL	BIOLOGICAL	COMBINATION
Soaking	Acid treatment	SCP production	Physicochemical
Grinding	Alkali treatment	Use of celluolytic organisms.	Karnal process
Steam pressure	Use of other chemical – ozone H_2O_2	Mushroom growth	
Explosion			
Irradiation			
Pelletting			
Supplementation			
Chaffing			

Soaking:

- Chopped straw is soaked in water overnight. Softens the straw leading to increased intake.
- Disadvantage is mould growth.

Chaffing:

- Decreasing particle size. Increases surface area for action of rumen microbes and hence increase digestibility.

Grinding:

- Particle size is reduced still further. (0.1 to 0.3cm)
- Disadvantage is that it increases rumen flow rate, decreases relention time in the rumen leading to decreased production of acetate causing a condition of low milk fat syndrome.
- Steam pressure – Straw treated with Steam at pressure 21.1 kg/cm^2 for 10 to 30 seconds. Causes rupture of lingo cellulosic bonds to a certain extent and make cellulose available for microbial action.

Explosion:

- Chopped or ground straw is treated with steam at pressure of 22.5 kg/cm^2 for two minutes and pressure is suddenly releases.
- Caused rupture of lingo cellulosic bonds to a certain extent and makes cellulose available for microbial action.

Irradiation:

- Straw is treated with Y irradiation.
- Causes rupture of lingo cellulosic bonds and makes cellulose available for microbial action.

Pelleting:

- Particle size is reduced to 0.1 to 0.3cm and Pelleted through 1-2 cm die.
- Retention time in the rumen increases and the disadvantage of only grinding is overcome.

CHEMICAL TREATMENT

Acid treatment:

- Straw is soaked in dilute acids for a specified period of time, washed with water drained and fed to the animals.

Alkali treatment:

- Straw is treated with NaOH, NH_4OH, CaOH, KOH and urea.
- When straw is exposed to the alkali the ester linkages between lignin and cellulose/hemicelluloses are hydrolysed causing the cellulose/hemicellulose to be available for digestion by microbes.

BIOLOGICAL TREATMENT

Growing mushrooms:

- Straw is steam treated, packed in polythene bags, inoculated with seed material of mushroom, bag when filled with mycelia slit open to allow fruiting, after harvesting of mushrooms the spent straw is used as feed.

Single cell protein production:

- Straw is hydrolysed, steam treated, treated with ammonia, inoculated with Candiada utilis and incubated, after harvesting of SCP the spent straw is used as feed.

Enzyme treatment:

- Pre – treatment of straw with lignase

Preparation of silage

- Straw sprayed with water, additives such as molasses added and ensiled in a silo.
- Nitrogen content is increased by adding urea or poultry manure.

- The above treatments cause biodegradation of lignin and increase the digestibility of cellulose. They also increase the protein content of the straw.

Karnal process -

- Technology developed at NDRI, Karnal. Straw treated with 4% urea at moisture level of 60%.
- Stacked in a silo pit under cover for 30 days. A temporary loose brick structure constructed.
- Thin layer of urea treated straw spread evenly in this structure.
- A solution of the following composition is prepared. 60g superphosphate, 60g calcium oxide dissolved in 8 litre water. Sprinkled over the urea treated straw.
- Inoculated with 3% Coprinus fimeratius culture.
- Allowed to reman for 5 days then used for feeding.
- Main advantage of this process is that free ammonia is converted into microbial protein and lingo cellulose bond is degrabed.

Effect of various treatment.

Advantage:

- Increases palatability.
- Increases digestibility.
- Certain treatments increase nitrogen or protein content.
- Improves animal performance.

Disadvantage:

- Increase feed cost.
- Technology or methodology involved.

CHAPTER – 8

Conservation of forage crops -

- There are two methods of conserving forages; the simple method is to drive off moisture in forages, while in the other method, natural fermentation is facilitated to retain succulence in the preserved forage.
- The driving of moisture from forage forms the basis in hay making while retaing forage's succulence forms the basis for silage making.

Crop residues –

Hay making :

- Reducing the moisture content of the green crop to a level low enough (12% - 14%) to inhibit the action of plant and microbial enzymes is the aim of hay making.
- The harvested crop can be dired either by natural drying or through artificial drying, but natural drying is preferred as there it can be done without incurring expenditure towards electricity.
- Hay can be stored satisfactorily in a stack or bale.

Requisites for good hay:

- **Selection of crop –** The crop to be made as hay should have soft pliable stem.
- **Harvesting of crop –** The crop should be harvested at 2/3rd flowering stage as it is at that time the plant will have the maximum nutrient in it. Delaying the harvesting further would divert the nutrients from the plant to seed production resulting in low nutritive value of the harvested crop.
- hay should be free from moulds and weeds.
- Hay should have the characteristic aroma of the crop.

SCHEDULE FOR HARVESTING AND CURING OF HAY

- Good quality hay can be produced by harvesting the crop early in the morning and left in the field as such for curring.
- The harvested crop should be allowed to dry in the field until the moisture content is reduced to about 40%.
- Frequent turning is necessary to facilitate uniform drying.
- On sunny days field drying of harvested crop for two days is sufficient to make hay.
- The air dried crop may be turned with the rake and made into small feathery windrows at the end of first day.

- The windrows may be blaed (at the end of second day and if further drying is required inspite of two days of sun drying, they may be placed over tripods or tetrapods or over the fence to facilitate aeration during drying.
- Hay should always be stored in well ventilated place as they catch fire easily.
- Average quality hay will have 25-30 per cent crude fibre and 45-60 per cent TDN.

Kinds of hay

1. Leguminous hay
2. Non – leguminous hay
3. Mixed hay

1) **Legume hay –** good legume hay has many characterstics that make it of special value in feeding animals. It has got a higher percentage of digestible nutrients.
   It has got more of digestible protein because of high protein content.
   Crops – Berseem, Lucerne, Cowpea
2) **Non – legume hay –** It is less palatable and less amount of protein, vitamin and nutrients. It is rich in carbohydrates.
   Crop – Oat, barley, Bajra, sorghum and many grasses.
3) **Mixed hay –** The nutritive value of mixed hay depends upon the type of legume and non – legume crops used in mixed hay.

Chemical changes –

Plant & microbial enzymes

- **Oxidation:** During drying, oxidation occurs leading to **reduction in the carotene** concentration and that is why sun drying should be stopped when greenery starts fading.
- But sun drying **enhances the vitamin D** content in the hay due to irradiation of ergosterol present in green plant.

Leaching:

- Loss of minerals, sugar & Nitrogen.
- Mould growth.

Microbial action :

- Microbes flourish during drying for prolonged period under bad weather leading to moldy hay that is unpalatable & harmful to farm animals & man.
- Such hay may cause allergic diseases affecting man known as **hay fever or farmer's lung.**

Plant Species:

- Legume hays are rich in protein & minerals than grass hay.
- Non – legume hay has more carbohydrate but less palatable.

Stage of growth/cutting:

- The nutritive value of hay depends on the stage of growth of the crop at the time of cutting.
  Harvest at 2/3rd flowering to make good quality hay.

Mechanical damage:

Handling hay during early morning minimized loss of leaves.

Changes during storage –

Dark brown colour observed in over heated hay stored at higher moisture level during stacking is due to oxidative degradation of sugars combining with amino acids or proteins.

Losses in nutritive value of hay are due to:

- Losses due to late cutting.
- Losses of leaves by shattering.
- Losses due fermentation.
- Losses due to leaching.

Biochemical changes during and storage of hay-

Carbohydrate -

- Plant continues to respire even after harves and during respiration, the sugars are like cellulose and lignin.
- Organic acids concentration decreases during wilting.

Nitrogenous constituents:

- Plants enzymes proteolyse the protein resulting in formation of free amino acids.
- Cynogenic glycosides in forages lose their toxicity during drying due to denaturation of enzymes.

Vitamins

- During sun drying oxidation occurs leading to reduction in the carotene concentration and that is why sun drying should be stopped when greenery starts fading.

- But sun drying enhances the vitamin D content in the hay due to irradiation of Ergosterol present in green plant.

Artificial drying –

Expensive method -

- Hot gas (150°C) for 20-50 minutes.
- Hot gas (500-1000°C) for 0.5-2 minutes.

Silage –

Silage – Silage is a fermented feed resulting from the storage of high moisture crop, usually green forages under anaerobic conditions in a structure, called silo.

Ensiling – It is also referred to as ensilage. There is a physical and chemical changes that take place when forages or feed with sufficient moisture are stored in a silo in the absence of air. The entire silage process required three weeks for converting forages into silage.

Silo – Silo is an air tight or semi – air tight structure designed for storage and preservation at high moisture feed as silage.

Ensilage

- Ensilage is the name given to the silage making process.
- The main purpose of silage making is to preserve succulent fodders for usage at the time of scarcity.

Advantages of Silage Making:

- Silage can be made even on weather that does not permit hay making More number of animals can be reared per unit of land.
- Year round supply of high quality succulent fodder is possible.
- Satisfactory silage can be produced in spite of weeds, as ensiling process kills many kinds of weed seeds.
- Silage making converts stemmy forage crops to soft that are better utilized by the livestock.

Factor of silage making –

Selection of crop -

- Crop with soft and pliable stem is most suitable for silage making.

Time of harvest -

- Crop should be harvested when 50% of the crop are in ear emergence stage as at this stage crop will be nutritious as well as with high biomass yield.

Wilting of the crop -

- To reduce effluent loss, crops with high moisture content are wilted for few hours, until moisture level is reduced to 60%.

Chaffing of the crop -

- The success of silage depends on the ability to provide anaerobic condition in silo.
- Anaerobic condition prevents oxidation of nutrients in crop and promotes conducive environment for desirable organisms to survive and produce lactic acid.
- Thus, in order to prevent the development of air pockets in silo, compression of ensiling materials is important.
- Compression can be achieved better by chaffing the crop.

Preparation of the silo -

- Several types of containers are used as silo.
- The silo should be cleaned and re plastered to make the silo walls smooth and strong.

Additives –

- Molasses at the rate of 2% (Weight of forage), Further Molasses increases palatability and nutritive value of silage.
- Salt at the rate of 1% (Weight of forage) is also added to improve palatability of silage.

Filing up of the silo:

- Rapid filling of silo is desired for anaerobic condition.
- Silage making should not be undertaken during rainy days.

Compaction -

- Compaction of chaffed material can be brought about by manual trampling or by engaging tractor.
- Compaction is the key step in silage as it removes the air pockets to promote anaerobic fermentation.

Sealing of the silo to prevent the entry of air or water:

- To sustain anaerobic condition and to prevent entry of atmospheric air/rain into silo, the silo should be sealed as soon as the silo is filled.

Principles of fermentation in silo –

In well preserved silage ph should be 3.8-4.2.

At this ph silage can be stored for 3-4 years.

Factor affecting nutritive value of silage –

Chemical changes

Plant enzymes -

- Plant continues to respire as long as oxygen present or until the plant sugars are used up.
- Sugars are oxidized to carbon dioxide and water, with the production of heat causing rise in temperature of the mass.
- In addition, proteolysis also occurs immediately after the herbage is cut.
- Protein is rapidly broken down to simpler substances mainly amino acids.
- Packing the silo compactly eliminates air pockets and prevents this activity.
- However, if the herbage is not well consolidated, then air may penetrate into the mass and the temperature will continue to rise.
- Thus over heated product will be dark brown or black in colour with low feeding value due to excessive loss of soluble carbohydrate and a lowering of the protein digestibility.

Microorganisms:

- Production of lactic acid lowers pH to 4.0.
- 60% protein broken down to amino acids.
- No other organism can survive at this pH.
- In badly preserved silage amino acids are further broken down to toxic amines.

Nature of crop -

- Legumes have low soluble carbohydrate content with high buffering capacity make thenm difficult to ensile .
- Spray molasses to legumes to provide readily soluble carbohydrate.
- Chopping exposes cell sap for microbial fermentation.

Types of Silos –

Pit silo :

Trench silo

Tower silo

Tube silo

Composition on the characteristics of silage –

	Very Good	**Good**	**Fair**	**Poor**
Butyric acid	Absence	Traces	Little	High
Ph	3.8-4.2	4.2-4.5	4.5-4.8	>4.8
Ammonical Nitrogen	<10%	10-15%	15-20%	>20%
Colour	Greenish brown	Brownish	Tobacco brown	Blackish

Haylage -

- Haylage are low moisture silage with characteristics between those of hay and silage.
- It is made from grass and / or legume to a moisture level of about 45-55%.
- This condition will prevent the forage from spoiling by moulding, oxidising, heating etc.

Advantages :

- Haylage has a pleasant aroma, palatable & high quality feed.
- Partially dried forage can be made into haylage.

Disadvantages:

- Fine chopping, good packing and complete sealing against air entrance inside the silo is more critical than with silage.
- The danger of excessive heating that lowers protein digestibility is more.

Non – Legume fodder crops.

- Bajra (Pennisetum americanum)
- Maize (Zea mays)
- Guinea grass (Panicum maximum)
- Napier grass or Elephant grass (Pennisetum purpureum)
- Hybrid Napier
- Jonna or Jowar (Sorghum bicolor)

Legume fodder crops -

- Berseem (Trifolium alexandrium)

- Lucerne(Medicago sativa)
- Cowpea (Vigna anguculata)

CHAPTER – 9

Requirement for maintenance

The physiological phases

- Maintenance
- Growth
- Pregnancy
- Milk production
- Work
- Wool production

Maintenance

- Maintaining an animal in a state of well-being or good health from day to day, makes no growth, develops no fetus or yields no product. While formulating rations, the maintenance nutrient requirements are satisfied first and the requirements for other purposes are in addition to maintenance. On an average, about on-half of all feed fed to livestock goes for maintenance.
  The requirements for maintenance are as follows:
- Energy for the vital function: heart beat, respiration, body temperature and for voluntary activity and other vital functions.
- Protein for the repair of body tissues.
- Minerals to replace mineral losses.
- All of the vitamins are essential for maintenance.
- Water is required for essentially all body functions.

Growth

- Increase in muscle, bone, organs, and connective tissue. Growth is essential for an animal to produce meat or to allain mature body weight. The daily growth rate of animals increases up to puberty and then gradually declines. The nutritive requirements for growth are in addition to those listed above for maintenance.
- The primary nutrients required for growth:
- Protein: the dry matter of muscle and connective tissue, and to a considerable degree, also that of bone, primarily is protein,. Hence, prtein is one of the major nutritive requirements of growth. Protein for growth must be of good quality-that is, it must contain the proper proportions and amounts of essential amino acids at the tissue level.

- Energy in the form of net energy must be provided to meet this need in addition to that in the protein of tissue. Also, a certain amount of additional energy is used by the body for growth.
- Minerals: since bone formation is a primary activity of growth and since bone is high in calcium and phosphorus content, these two minerals are very essential for growth. Other minerals are involved in the digestion and utilization of other nutrients needed for growth.
- Vitamins: Certain vitamins function in various metabolic processes related to nutrient utilization for growth.
  Water : Fat-free muscle tissue is about 75% to 80% water.

Milk Production

- Milk is produced and secreted by the mammary glands. Nutrients for milk production are carried by the blood to the mammary glands. The nutrients are removed from the blood by the mammary glands, converted into milk, and secreted into the udder more or less throughout the day.
- Nutrients for milk production must come from the feed, either directly or indirectly via body reserves of nutrients, which come originally from the animal's feed.
- The peak milk production is reached during 4-8 weeks after lactation starts and the animals also lose body weight during early lactation since their appetite is low and they may not take sufficient fed to meet the nutrient requirements. So during peak lactation, milk yield will be high, the feed intake will not be sufficient and the animals lose body weight.
- Nutritive requirements for milk production are in proportion to the amount of milk produced and are over and above those for other physiological phases of production such as maintenance, growth, fattening, fetal development, etc.

The major nutritive requirements for lactation are,

- Protein: must be of good quality at the glandular level. Animals will not produce milk low in protein. If ration is deficient in protein, tissue reserves of protein may be used for milk production
- Energy: Energy over and above that for milk protein is required for the formation fof mok fat and milk sugar. Must be in the form of net energy. May come from carbohydrates, fat, or excess protein of the ration.
- Minerals and vitamins

Wool production

- Wool is practically pure protein and contains Sulphur containing amino acids.
- The primary nutritive requirements for wool production are:

- Protein: Must be sulfur – containing as fed or as synthesized in the rumen.
- Energy: This must be in the form of net energy and can come from any feed energy source.
- Potassium: This mineral is an essential component of the suint in wool. It is more than adequate in most ordinary rations.
- Other minerals and vitamins:

Pregnancy

- Nutritive requirements for development of foetus are energy, protein, calcium, phosphorus, and vitamin D in particular and other minerals and vitamins.
- More than 2/3rd of the foetus growth occurs during the last trimester of pregnancy. Proer feeding during pregnancy is essential to avoid birth of dead foetus or weak foetus, to build up body reserves lost during early lactation and at the same time the animal should not become obese.

Work

- Energy, protein, minerals and vitamins are required

CHAPTER – 10

CLASSICIFICATION OF FEED STUFFS

FEED STUFFS

- ROUGHAGE
  - SUCCULANT
    - Pasture – Natural, Cultivated.
    - Grasses
    - Legumes
    - Tree leaves.
    - Silages
    - Roots and Tubers
    - Miscellaneous
  - DRY
    - Hay
    - Straw and Chaff dry fodder
    - Others – Corn cob, Cotton seed hulls, Sugarcane bagasse
- CONCENTRATE
  - ENERGY FEEDS
    - Cereal grains eg Maize, sorghum, barley etc
    - Milling By products eg Wheat bran, Rice bran, etc
    - Molasses
    - Animal and vegetable fat
  - PROTEIN SUPPLEMENTS
    - Oil seeds
    - Animal protein supplements
    - Distillers and brewers dried grains, single cell protein, NPN

- Mineral supplements (Natural or pure elements)
- Vitamin supplements (Natural or pure elements)
- Non nutritive additives
  - Antibiotics
  - Antioxidants
  - Buffers
  - Colours & flavours
  - Emulsifying agents
  - Enzymes
  - Hormones
  - Medicines

Energy Sources –

Cereal grains:

(Maize, barley, oats, wheat, rice, rye, millets, sorghum and Bajra)

- Cereal grains are rich in starch containing 8-12% of crude protein with low lysine and methionine, 2-5% fats, less than 0.15% of calcium and relatively higher phosphorus to the extent of 0.3-0.5%.
- Phosphorus in cereals is present in the form of phytates, which has the ability to immobilize dietarycalcium.
- Cereal grain rich source of thiamine and vitamin E but deficient in vitamin A and riboflavin except yellow maize, which is rich in Provitamin A.
- The commonly used cereals in feed are maize, barley, oats, wheat, rice etc.
- CP: 8-12%, TDN: 68-72%, Fat: 2-5%, Low in lysine, Methionine in the form of phytates, Ca; 0.15%; P 0.3 – 5.0%.

Maize of Corn (Zea maize):

- Maize has high Metabolisable energy value with low fibre content and 8-13% f
- The maize kernel contains two main proteins Zein and Glutelin.
- Recently, new variety of maize (Floury 2) was produced at UK with high methionine and lysine.
- Farm animals are fed with crushed maize.
- Flaked maize decreases the acetic acid to propionic acid proportion in rumen and hence depresses the butterfat content of milk.
- Improperly stored maize having higher moisture content is prone to aspergillus flavus infestation and produce aflatioxin.
- High TDN : 85%
- Prone to Aflatoxin
- Flaked maize depress milk fat%.

Barley (Hordeum vulgare):

- Barley has high fibre content with 6-14% of crude protein having low lysine and less than 2% of oil content.
- Barely is main concentrate food for fattening pigs in UK.
- The awns of barley should be removed, crimped or coarsely ground before feeding poultry or swine.

- Variety "Notch 2" developed at UK is rich in lysine.

Oats (Avena sativa):

- Oats has highest crude fibre of 12 -16% with 7-15% of crude protein.
- Methionine, histidine and tryptophan are deficient in oats but abundant in Gluatamic acid.
- Cattle and sheep are fed with crushed or bruised oats whereas pigs and poultry are fed with ground oats.

Wheat (Triticum aestivum):

- Wheat contains 6-12% of crude protein.
- The endosperm contains prolamin (gliadin) and glutelin (glutenin) protein mixture, which is referred as gluten.
- Wheat gluten decides whether the flour is suitable for bread or biscuit making.
- Strong gluten is preferred for bread making since it form dough, which traps the gasses, produced during yeast fermentation.
- Finely milled wheat is unpalatable to animals because it forms the pasty mass in the mouth and may lead to digestive upset.

Rice (Oryza sativa):

- The crude protein and energy values are comparable to maize.
- It is widely used for human consumption.

Rye

- Rye is similar to wheat in composition and regarded as least palatable among cereals.
- Rye is prone to ergot infestation. Rye should be crushed and fed to livestock.

Millets:

- Millets are cereals having high percent of fibre and produce small grains and are mostly grown in tropics. E.g. Sorghum, Bajra, etc.

Sorghum/Jowar/Milo (Sorghum vulgare):

- Sorghum is similar to maize in chemical composition but they have higher protein and low fat than maize.
- Pig and poultry can be fed with cracked grain whereas cattle are fed with ground sorghum.

Bajra/Cumbu (Pennensetum typhoides):

- Nutritive value of Bajra is similar to sorghum with 8-12% of crude protein and rich tannin content.
- Seeds are hard so they have to be ground or crushed before feeding to cattle.

MILLING BY – PRODUCTS :

Bran:

- It is the outer coarse coat of the grain separated during processing. E.g. rice bran, wheat bran, maize bran.

Rice bran:

- Rice bran is a valuable product with 12-15% of protein and 11-18% oil mostly with unsaturated fatty acids and hence it becomes rancid rapidly.
- The oil removed rice bran is available as deoiled rice bran in the market for livestock feeding.

Wheat bran:

- Wheat bran is an excellent food for horses with more fibre content.
- It is laxative when mashed with warm water but tends to counteract scouring when it was given dry.
- It is not commonly fed to pigs and poultry because of the fibrous nature and low digestibility.

Flour :

- Flour is soft, finely ground meal of the grains with 16% protein and 1-1.5% crude fibre consisting primarily of gluten and starch from endosperm. E.g. corn flour.

Gluten:

- Gluten is a tough substance obtained after the removal of starch from flour.
- This is not usually given as a feed to non – ruminants due to poor quality protein, bulkiness, unpalatability.
- E.g. corn gluten.

Middling:

- A byproduct from flour milling industry comprising several grades of granular particles of bran, endosperm and germ.
- Middlings contain 15-20% protein and deficient in calcium.

Grain screening:

- Small imperfect grains, weed seeds and other foreign materials of value as a feed, separated through cleaning of grains with screen is called grain screening.
- Nutritive value varies according to proportion of weed and foreign materials.

Polishing:

- It is a byproduct produced during juice/extract prepared from selected plant material.
- It is a concentrated water solution of sugars, hemicelluloses and minerals.
- Four varities of molasses are commonly available viz.
- Cane molasses,
- Beet molasses,
- Citrus molasses and
- Wood molasses.
- Cane molasses is a product of sugar industry and contains 3% protein with 10% ash.
- While Beet molasses is a product during production of beet sugar and has higher protein. (6%).
- Citrus molasses is bitter in taste with highest protein (14%) and produced when oranges or grapes are processed fro juice.
- Wood molasses is a product of paper industry with 2% protein and palatable to cattle.
- Molasses is a good source of energy and an appetizer.
- It reduces dustiness in ration and is very useful as binder in pellet making.
- Molasses can be included upto 15% in cattle ration and upto 5% in poultry ration.
- The molasses quality in terms of sweetness is indicated in Brix unit.
- Cane molasses usually have 80.0 degree Brix unit.

Protein supplement –

S.N.	Animal protein	Plant protein
1	Mostly over 47% protein	Mostly under 47% protein
2	Mostly over 1% ca	Mostly under 1% ca
3	Mostly over 1.5% phosphorus	Mostly under 1.5% phosphorus
4	Mostly under 2.5% fiber	Mostly over 2.5% fiber
e.g.	**Bone meal, blood meal, fish meal, meat meal**	**Eg. Oil seed cake**

Oil seed cake -

- Oil seed proteins have low cysteine and methionine and lysine content.
- Oil bearing seeds are grown for many purposes like vegetable oil for human, for paints and other industrial purposes.
- The byproducts left after extraction of oil seeds are used for feeding all kinds of livestock.

Groundnut cake -

- Groundnut cake is one of the best protein supplements for livestock feeding.
- Groundnut cake has about 45% protein, which is deficient in cysteine, methionine and lysine, but good source of Vitamin B12 and calcium.

Soyabean meal -

- Soybean meal contains 44% crude protein with all indispensable amino acids except cysteine, methionine whose concentrations are sub – optimal.
- It can be fed to all livestock including poultry up to 30% of the ration.
- The common adulterant includes urea castor husk and Mahua oil cake.

Sunflower cake –

- Sunflower cake contains 40% of protein with low lysine and twice the amount of methionine than soy protein.
- It has very short shelf – life.
- The expeller variety of sunflower seed meal or cake has high content of polyunsaturated fatty acids that tends to produce soft port in pigs and soft butter in cows when fed in large amount.
- It can be fed to cattle ration up to 20% level and 10% to poultry ration.
- Sunflower cake is not recommended for calves, lambs, chicks and young pigs.

Cotton seed cake –

- It has a good quality of protein but with low content of cysteine, methionine and lysine.
- The calcium to phosphorus ratio is about 1:6, so calcium deficiency may occur.
- It cannot be feed to pigs and poultry due its dusty nature.
- Lactating cows can be fed with cotton seed meal but when it was given large amount, milk may become hard and firm, so butter make from such milk fat is difficult to churn and may also tend to develop tallowy taints.

Coconut meal cake –

- It contains 20 – 26% crude protein with low lysine and histidine content and 2.5 – 6.5% oil content.
- The higher oil in meals tends to get rancid and may cause diarrhea; hence low oil content meal should be preferred.
- It should be restricted in swine and poultry as it contains low protein and high fibre and low fibre coconut meal can be fed to monogastrics animals with lysine and methionine supplements.
- Coconut meal produces firm milk fat that is most suitable for butter making.

Linseed meal –

- Linseed cake/meal is not suitable to poultry but good feed to horses and ruminants.
- Linseed is rich protein source with low methionie and lysine content and also rich in phosphorus part of which is present as phytates but has only moderate content calcium.

Mustard oil cake -

- Its nutritive value is lesser than groundnut cake.
- D.C.P. and T.D.N values are 27% and 74% respectively.
- Up to 10% of the ration, it can be fed to poultry and for pigs it may be up to 20%.
- It has rich calcium and phosphorus content of about 0.6% and 0.1% respectively.

Sesame seed meal/gingelly oil cake/till oil cake –

- It contains 40% protein rich in leucine, arginine and methionine but low lysine.
- Sesame seed meal has lasative action and can be included in the cattle ration upto 15%.
- Sesame seed meal is not suitable to young pigs and poultry.

Beans and peas

- Beans rich source of good quality protein.
- Similar to that of fishmeal protein it has high lysine content but low cysteine and methionine than common animal and vegetable protein source.s
- Peas are similar to beans but low protein with 26% of dry matter and crude fibre with leess than 6% of dry matter.
- The oil content is higher than beans but with similar degree of saturation.
- Like beans, peas are primary source of protein.

Animal protein –

Fish Meal –

- It has high levels of protein, amino acids like lysine, methionine and tryptophan and minerals like calcium and phosphorus.
- Apart from these, fishmeal is rich in vitamin B complex and growth promoting effect of Animal Protein Factor (APF).

Bone meal & Meat meal –

- The carcasses of animals can be used as meat meals after drying or grinding.

- The product must be substantially free of hooves, horns, bristle, hair and feathers, skin and contents of stomach and viscera.
- Its protein content ranges from 60-70% useful as lysine supplemtn but less amount of amino acids like methionine and tryptophan affect their protein quality.
- It has fat level upto 9%.

Liver residue meal -

- A good quality of this meal should contain 65% protein, 5%lysine, and nearly 1%methionine and cysteine.
- It is offered at about 5 to 10% diet level in poultry and animal feeding.

Blood meal -

- This meal is obtained by drying the blood of slaughtered animals and poultry.
- Rich source of lysine, methionine, leucine with 80% protein but deficient in isoleucine and hence low biological value.
- It is a good food for boosting dietary lysine levels but is unpalatable.

Hatchery waste -

- It is otherwise known as incubator waste or Hatchery by Product Meal (HBPM).
- The mixture of infertile, unhatched eggs and eggshells have been cooked, dried, and powdered to produce this kind of meal.

Father meal -

- Poultry feathers are more prone to get Salmonella infection easily, so strict controls have to be maintained while processing this meal.
- This meal is not recommended for weaner, creep fed pigs or chicks.

Poultry litter –

- Dried poultry excreta have been used as ruminant feed.

SNF – it's used in simple stomach animal.

Whey -

- Most of the whey protein is B-lactoglobulin and is used as a constituent in milk replacer for young calves.

NPN -

- NPN is an important source of nitrogen for ruminant animals.

- It is a nitrogen rich (46%), white, crystalline compound with the formula NH2 – C= O – NH2.
- Rumen microbes hydrolyze urea with the help of urease enzyme and produce ammonia.
- The wastage of nitrogen may occur with excessive absorption of ammonia from the rumen leading to ammonia toxicity which causes ataxia, muscular twitching, tetany, excessive salivation, bloat and respiratory disorders.
- Growing and lactating ruminants are fed with urea, which is incorporated into the concentrate portion of the ration at 3% or at 1% of total dry matter intake through complete diet.
- The maximum safe limit is 136g of urea per animal over 260kg of body weight.
- Urea should never be fed to monogastrics animals, birds and young rumiants.

Biuret -

- Heating urea produces Biuret.
- It is a colourless, crystalline compound having 40.8% nitrogen equivalent to 225% of crude protein.

Feed additives.

What is an additive ?

- An additive is a substance that is added to a basic feed, usually in small quantities, for the purpose of fortifying it with certain nutrients, stimulants or medicines other than as a direct source of nutrient.
- In general, the term "feed additive" refers to a non-nutritive product that affect utilization of the feed or productive performance of the animal. Feed additives and implants can be classed according to their mode of action.

Types of feed additives

Additives that influence feed stability, feed manufacturing and properties of feeds.

- Anifungals
- Antioxidants.
- Pellet binders

Additives that modify animal growth, feed efficiency, metabolism and performance

- Feed flavours.
- Digestion modifiers
- Enzymes

- Prebiotics
- Buffers
- Acidifiers
- Ionophores
- Antibloats compound
- Isoacids
- Salivation inducers
- Probiotics
- Defaunating agents
- Metabolism modifiers
- Hormones

Beta – adrenergic agents (repartitioning agents)

- Growth promotants
- Antibiotics
- Chemotherapeutic agents
- Additives that modify animal health
- Drugs
- Immunomodulators
- Additives that modify consumer acceptance
- Xanthophylls

Antioixidants

- Antioxidants are compounds that prevent oxidative rancidity of polyunsaturated fats. Rancidity once develops, may cause destruction of vitamins A, D and E and several of the B complex vitamins.
- Breakdown products of rancidity may react with lysine and thus affects the protein value of the ration. Ethoxyquin of BHT (butylated hydroxytoluene) can serve as antioxidant in feed.

Flavouring Agent

- Flavouring agents are feed additives that are supposed to increase palatability and feed intake.
- There is need for flavouring agents that will help to keep up feed intake.
- When highly unpalatable medicants are being mixed.
- During attacks of diseases.
- When animals are under stress, and k

- When less palatable feedstuffs is being fed either as such or being incorporated in the ration.
- Ruminants prefer sweet compounds. Additionally cattle and goats respond positively to salts of volatile fatty acids.
- Horses will often refuse musty feed when there is so little mould that the owner fails to detect it.

Grit

- Poultry do not have teeth to grind any hard grain, most grinding takes place in the thick musculated gizzard.
- The more thoroughly feed is ground; the more surface area is created for digestion and subsequent absorption. Hence, when hard, coarse or fibrous feeds area fed to poultry, grit is sometimes added to supply additional surface for grinding within gizzard.
- When mash or finely ground feeds are fed, the values of grit become less. Oyster shells, coquina shells and limestone are used as grit.

Buffers and neutralizers

- During maximum production stage ruminants are given high doses of concentrate feeds for meeting demands for extra energy and protein requirement of the animal.
- The condition on the other hand lowers the pH of the rumen. Since many of the rumen microbes cannot tolerate low pH environment, the normally heterogeneous balanced population of microbes become skewed, favouring the acidophilic (acid – loving) bacteria.
- The condition often leads to acidosis and thereby upsets normal digestion.
- The addition of feed buffers and neutralizers, such as carbonates, bicarbonates, hydroxides, oxides, salts of VFA, phosphate salts, ammonium chloride and sodium sulphate have been shown to have beneficial effects.
- Recently the use of baking soda ($NaHCO_3$) has been shown to increase average daily gain by about 10 per cent, feed efficiency by 5 to 10 per cent, and milk production by about 0.5 liter per head per day.

Chelates

- Organic chelates of mineral elements, which are cyclic compounds, are the most important factors controlling absorption of a number of mineral elements.
- A particular element in chelated form may be released in ionic form at the intestinal wall or might be readily absorbed as the intact chelate.

- Chelates may be of naturally occurring substances such as chlorophyll, cytochromes, haemoglobin, vitamin B_{12}, some amino acids, etc. or may be of synthetic substances like thlylenediaminetetracetic acid (EDTA.)

Antibiotics

- These are substances which are produced by living organisms (mould, bacteria or green plants) and which in small concentration have bacteriosatic or bactericidal properties.
- They were originally developed for medical and veterinary purposes to control specific pathogenic organisms.
- Later it was discovered that certain antibiotics could increase the rate of growth of young pigs and chicks when included in their diet in small amounts.
- Soon after this report a wide range of antibiotics have been tested and the following have been shown to have growth promoting properties: penicillin, oxytetracycline (Terramycin), chlortetracycline, bacitracin, streptomycin, tyrothricin, gramicidin, neomycin, erythromycin and flavomycin.
- Increased weight gain is most evident during the period of rapid growth and then decreases.
- Antibiotics should be used only for
  - Growing and fattening pigs for slaughter as pork or bacon;
  - Growing chicks and turkey poults for killing as table poultry.
- Antibiotics should not be used in the feed of ruminant animals (cattle, sheep and goats), breeding pigs and breeding and laying poultry stock.

Probiotics

- It is defined as a live microbial feed supplement, which beneficially affects the hot animals by improving its intestional microbial balance.
- Thus resulting in increased growth rate, improved feed efficiency.

Hormone

- These are chemicals released by a specific area of the body (ductless glands) and are transported to another region within the animal where they elicit a physiological response.
- Extensive use is being made of synthetic and purified estrogens, androgens, progestogens, growth hormones and thyroxine or thyroprotein (iodinated casein) to stimulate the growth and fattening of meat producing animals. There is concern, however, about possible harmful effect of any residues of these materials in the meat or milk for the consumers.

Antibloat compounds:

- Surfactants such as poloxalene is used as a preventive for pasture bloat, several other products have been shown to be highly effective to prevent bloat are also available in the market.

Antifungal additives :

- Mould inhibitors are added to feed liable to be contaminated with various types of fungi such as Aspergillus flavus, Penicillium cyclopium etc.
- Antifungals such as Nystatin and copper sulphate preparations are also in use to concentrate feeds to prevent moulds.

Anticoccidials -

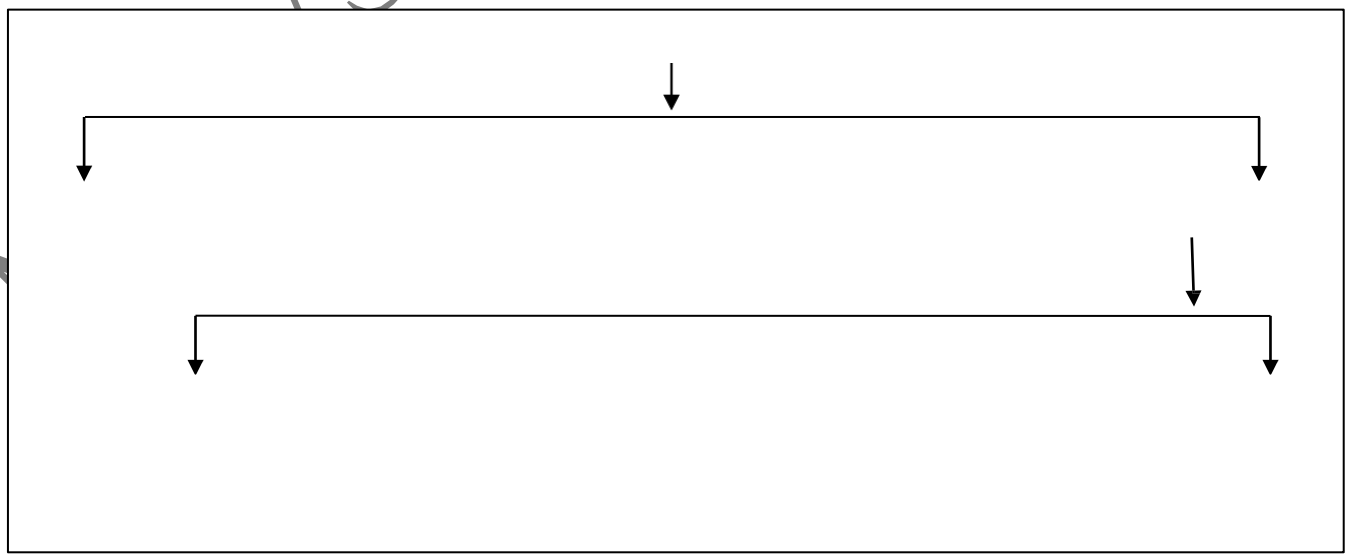
- Various brands of anticoccidials are now available in the country to prevent the growth of coccidia which are protozoa and live inside the cells of the intestinal lining of livestock.

Antihelmintics -

- Under some practical feeding conditions Antihelmintics have also been used. The compounds act by reducing parasitic infections.

Forages -

	Non legumes	Legumes
C.P.	5-10%	20-25%
Ca	0.3 – 0.5%	1.4 – 1.6%
P	0.2 – 0.35%	0.1 – 3%



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Nutrients in the pasture -

2. C.P. - 3-30%
3. C.F. – 20 – 40%
4. Moisture – 6- - 85%
5. Rich in carotene

Nitrate poisoning –

- Nitrate is a non protein nitrogenous fraction (NPN) present in forages.
- Nitrate itself is not toxic to animals.
- The toxic effect on ruminants is caused by the reduction of nitrate to nitrite in the rumen.
- Recently fertilized plants have higher nitrate levels.
- Grazing herbage containing more than 700 ppm of nitrate nitrogen/kg dry matter is considered to produce toxic effect by converting to nitrite.

Bloat -

- Occurs in grazing land with predominant legumes like Lucerne and clover.
- Ruminants carry an active population of microorganisms that generate large volumes of gas either is belched up or passes through the gastrointestinal tract.
- Bloat occurs when eructation of gas is interfered.
- Natural foamin agents (Saponin) in legumes cause stable foam to form in the rumen.
- Gas is trapped in smallbubbles in this foam in the rumen and the animal cannot belch up the gas.
- Pressure builds up in the rumen causing an obvious swelling on the left side of the body.
- Vegetable oils are effective for preventing and treating pasture bloat because they break down the frothy condition in the rumen contents.

Phyto – estrogens –

Causes infertility, dystocia other reproductive problem.

Goitrogenic substance –

The genus Brassica includes cabbages, turnips and cauliflower. They contain goitrogenic substance – thiocyanate which interferes with the uptake of iodine by thyroid gland leading to goiter.

System of grazing –

Three system of grazing are followed.

- Continuous grazing.
- Rotational grazing and
- Strip grazing.

o In continuous grazing animals are kept on the same area throughout the year.
o In rotational grazing, the livestock are periodically moved to fresh paddocks, to allow pastures to regrow.
o Strip grazing is a grazing management system that involves giving the livestock a fresh allocation of pasture each day.

Cereal fodder -

- Cereal crops cultivated for fodder includes sorghum, maize, oats and Bajra.
- On dry matter basis the crude protein content ranges from 8-12% with calcium content of 0.4-0.6% and phosphorus content of 0.2-0.5%.
- Cereal fodders are annual crops and the fodder should be harvervested at 2/3rd or 50% flowering stage (around 45 to 60 days for most of the crops).

Cultivated grasses -

- Cultivated grasses includes Bajra Napier hybrid, Guinea grass, para grass. On dry matter basis the crude protein content ranges from 6-10% with calcium content of 0.4-0.6% and phosphorus content of 0.2-0.4%.
- Grass fodders are perennial in nature and have to be harvested at the recommended intervals. First harvest of Hybrid Napier, Guinea grass and Para grass is done at 75 days after planting and the subsequent cuttings are done at 45 days interval.

Cultivated legume fodder –

- Berseem, cowpea, Lucerne, desmanthus and stylo are the common leguminous crops grown in India. On dry matter basis, they contain from 15-25 per cent crude protein with 1-2% calcium and 0.2-0.4% phosphorus leading to wide calcium to phosphorus ratio.
- Annual fodders such as Berseem and cowpea should be harvervested at 50% flowering stages and are ready by 50-60 days.

Tree fodder -

- The crude protein content ranges from 7-9% in non-leguminous tree fodders to 19-22% in leguminous tree fodders.

- The calcium content ranges from 1-3% and phosphorus ranges from 0.3-0.5%.
- The major constraint in the use of tree fodders is the presence of antinutritional factors.
- Subabool – Mimosine:

Root and tubers

Roots are underground parts of plant e.g., Turnip, beet root, carrot etc.,

Crop residues.

Straw	Stover	Aerial portion	Other
Wheat	Maize	Sugarcane tops	Corn cobs
Paddy	Sorghum	Groundnut haulms	Bagasse
Oat		Soyabean haulms	Reanut hull
Barley			Rice hull
Millets			

Non – conventional feed resources (NCFR) -

NFCR refers to all those feeds that have not been tradionally used in animal feed or are not used in the rations of commercially produced animals.

Uses –

- Increase demand in feed, rapid growth in population and shrinkage of land area reduces the further hopes of animals of livestock'
- It is therefore good the examine for cheaper feed resources that improve the digestibility of low – quality feed and also improve intake.
- Feed stuff such as sugar beet pulp, citrus pulp, fish offals, poultry litter, cactus, kitchen wastes, cassava, field and plantation crops are commonly used.

Nutrient composition of unconventional feeds

S.no.		CP%	DCP%	TDN%	ME (Kcal/kg)
1	Corn cobs	3.5	0	43	1500
2	Sugarcane tops	6.4	2.7	45	1600
3	Banana stem	3.3	0	40	-
4	Coffee husk	10.0	3.4	42	1500
5	Brewery grains	19.2	-	-	-
6	Groundnut Husk	6.7	0.9	24.0	850

7	Tamarind seed	15.4	5.3	60.0	2200
8	Tapioca waste	4.9	2.0	65.0	2300
9	Bagasse	2.5	0	45	-
10	Acacia pods	14.0	10.5	73	2600
11	Water hyacinth	-	4	40	-
12	Chicken excreta	33.6	23.1	-	-
13	Silk worm pupae meal	65.6	-	-	-
14	Gram chuni	-	-	-	-
15	Mango seed kernel	8.5	6.1	70	2600

	CP	DCP	TDN
Acacia	11.0	3	50
Albizia lebbeck	21.0	12	50
Arto carpus	12.8	5	50
FICUS sp	9.13	3-5	50
Banana leaves	9.5	0-2	40-50
Banana stem	2.8		
Banana tuber	8.7		
SESBANIA sp	37	20	50
LEUCAENA sp	30	17	50
ZIZYPHUS sp	11	3	50