

Introduction

- It is obvious that animals provide numerous products and services.
- They serve as source of quality food, power, savings and investments, different social and cultural functions, to earn foreign currency, Manure, etc.
- Animals however are dependent on plants for the continuation of their function
 - because plants possess chemical compounds called chlorophyll that convert the less complex inorganic forms of nutrients like nitrates, mineral salts, H_2O , CO_2 into organic or highly complex type of chemical compounds.
- On the contrary animals are not able to do this due to the lack of chlorophyll, which make them dependent on plants for the continuation of their life.

- Animals in general require both inorganic and organic form of nutrients to renew old tissue and build new tissue.
- The animal system needs inorganic nutrients mainly in the form of minerals, where as the organic nutrients needed in the form of
 - carbohydrates (largest quantity takes by the animals, as most plant parts are made of carbohydrates),
 - protein.
 - Lipid (fat specifically) and
 - vitamins in the order of quantity consumed.
- The primary source of organic material is totally plant tissues.
- Inorganic source of nutrients mainly come from consumption of plant material,
 - ↳ but it is possible to give animals with actually not plant but in the form of pure nutrients (pure mineral) but the

The subject matter of animal nutrition include;

- Understanding the chemical structure (configuration) of the different nutrients.
- Understanding the way how animal system actually functions in which food transform into body tissues and activities takes place.
- ⊗ This involves the ingestion, digestion and absorption of various nutrients, their transport to all body cells, and the removal of unusable elements & waste products of metabolism.
- It is also concerned
 - with the nature of the feed and feed nutrients,
 - nature and requirement of animals
- also contain study of transformation of feed elements to animal products.

- Nutritionally farm animals are divided into ruminants and non-ruminants.
- Ruminants are animals having partitioned large stomach.
- Where as non-ruminants (monogastrics) have simple stomach, not as complicated as ruminant stomach.
- Ruminants having large size and partitioned stomach create favorable environment,
 - for microbial symbiotic activity such as favorable pH, temperature and anaerobic condition.
- For this effect high number of micro-organisms thrive in the reticulo-rumen of ruminants, and
- these micro-organisms have the ability to produce enzymes which can hydrolyse the fibrous (cellulose) part of the feed enabling the animals to utilise such feeds.

- The monogastric stomach on the other hand is simple and its internal environment not allows the development of micro-organisms.
- So these animals are not in a position to utilise highly fibrous feeds therefore, the nutrients in the two groups differ.
- In the case of ruminants one can give them with fibrous feeds or cellulose rich diets and by virtue of the presence of micro-organisms in their stomach,
 - ↳ the inedible products will be converted to edible product in which the ruminant can utilise and transfer it to highly valuable and quality products such as meat and milk (hides, skin, hair, etc).
- In the case of monogastrics, which lack the symbiotic effect of micro-organisms as a result of their simple stomach,
 - ↳ they require very low fibrous feeds but more grains and there is a competition for such feeds with humans

1.1. Significance of animal nutrition in livestock production

- Animal nutrition can be described as the study of feed in the way they are utilized in the animal body,
 - for the purpose of body maintenance, production and reproduction in the most efficient and economic manner.
- It establishes relationships between nutrient intake and the response by animals.
- The response by the animals refers to what are called performance.
- Performance is mostly represented by the condition of health, growth and perpetuation of life/reproduction/.
- Poor nutrition results in low rates of production and reproduction as well as increases in susceptibility of livestock diseases and subsequently mortality.
- Biologically, about two-third of the improvement in livestock productivity is often attributed to nutrition,
 - since animal production is basically a conversion of feed into animal products.

- In economic terms, feed cost accounts for about 70% of the total cost of livestock production,
 - ↳ indicating the feasibility of livestock enterprises is a function of the type of feed and feeding system.
- Ensuring high performance through adequate control of nutrition is determined by three important and interrelated considerations:
 - ↳ The availability of nutrients.
 - ↳ Type of feeding system and
 - ↳ The level of feeding management.

The Animal and Its Feed

- Feed consists of water and Dry Matter (DM).
- If the water content in food is 75%, the DM content is 25%.
- Although water is very important, the DM is crucial to the composition of a ration as all valuable feed substances are contained in the DM.

- Water is vital to any animal.
- The bodies of young animals may consist up to 80% of their live weight.
- Older, and especially fat animals, have less water in their bodies (down to 50%).
- Feeds can contain both high and low water percentages. Examples of feeds with high water contents are young grass ($\pm 15\%$ DM) and cabbage ($< 10\%$ DM).
- Hay and concentrates are feeds with low water contents (85-90% DM).
- It is important to note that a lack of water in the diet results in a reduced appetite, an animal will eat less!
- This might affect DM intake which can have many consequences as the OM and IM found in the DM.

Dairy cattle require water for:

- Chewing and swallowing (saliva).
- Transport of nutrients around the body.
- Formation and maintenance of body tissues.
- Disposal of waste products.
- Regulation of the body temperature.
- Milk production.

Definition of some commonly used terminologies

- ***Ad libitum***:- Feeding system where animals are given unlimited access to feed.
 - ↳ Synonymous terms include full feeding, free choice, self-feeding.
- **Animal Protein**:- Protein of animal origin derived from slaughterhouses, animal product processing plants that can be used as ingredients in feed mixtures.
- **Anti-oxidant**: A chemical compound that prevents oxidative rancidity of polyunsaturated fats;
 - ↳ added to feed ingredients or feed mixtures for protection against oxidation.
- **Average Daily Gain (ADG)**: The mean daily increase in the live weight of an animal.
- **Balanced Daily Ration**: A combination of feeds fed at a time or in portions at intervals, as will provide the essential nutrients in such amounts as will properly

- **By-product feeds:** Secondary products from plant and animal processing and industrial manufacturing that may be used for animal feeding.
- **Complete Ration:** All feedstuff (forages, grains, processed feeds etc.) combined in one feed mixture that is nutritionally adequate for a specific animal in a specific physiological state.
- **Concentrate:** a feed or feed mixture which supplies primary nutrients (protein, Carbohydrate and fat) and contains less than 18% crude fiber.
 - It is a feed material either high in feed supplements of protein or energy (carbohydrate and fat).
 - It should contain greater than 60% TDN (total digestible nutrient).
- **Total Digestible Nutrients (TDN):** is an estimate of how much of feed is digested by the animal to be used as an energy source.
 - For example, if a feed is 80% TDN, that means that for

- **Crop- residue:** Portion of plant growth that remains after harvesting grain or seed crop e.g. Straws, stalks, husks, cobs etc.
- **Digestibility:** The proportion of feed that is not excreted in the faeces and, thus, assumed to be absorbed.
- **Digestion:** Process of changing food to a form that can be absorbed from the digestive tract by the body tissues (mainly the intestines).
- **Feed Additives:** These are ingredients added in small quantities to a basic feed mix for the purpose of fortifying or improving the basic mix.
- **Feed conversion Efficiency:** Measure of the efficiency of feed utilization. It is expressed as unit of animal product per unit of feed.
- **Feed Supplements:** are feed stuffs that will be added to the total diet of an animal to increase the nutritive value

- **Nutrient:** is any substance absorbed by an organism from its external environment and used in the metabolism.
- ↳ It is source of materials needed for growth, maintenance, reproduction and production purpose.
- **Nutrition:** There are many definition of nutrition, so you should not supersized if you get/ find that they are not all alike.
- ↳ The series of processes by which an animal takes in and assimilates feed components for promoting maintenance, growth, reproduction, milk, work and/or production
- ↳ The science which interprets the relationship of feed to the functioning of living organisms.
- ↳ The study of how the body uses the nutrient in feed to

- **Toxicity:** Some nutrients when fed in excess of the animal requirement, it will result in sickness of the animal and in extreme case the animal may die, such condition is called toxicity.
- ↳ Toxicity mainly refers to mineral and vitamins.
- ↳ There is no as such toxicity for major nutrients.

THANKS!!

2. Classification and Characteristics of Feedstuff

2.1. Roughages

- is any material suitable for feeding of livestock which contains more than 18% crude fiber.
- ↳ Therefore, roughages are bulky feeds high in fiber and low in energy.

roughage include;

- ↳ pasture and other grazed forages.
- ↳ hay and dehydrated forages
- ↳ silage and crop residues and other by-products of agriculture.
- **They can be of two categories**, namely dry and succulent based upon their moisture content.
- Succulent feeds usually contain more than 75% moisture and include pasture, cultivated fodder crops, tree leaves, root crops and silage.
- Dry roughages contain only 10 to 15% moisture. Hay

2.2. Concentrates

- are livestock feeds provide the basic nutrients required for animal production,
 - including energy, proteins, minerals, vitamins and other micro-nutrients.
- are feeds that contain a high density of nutrients, usually low in crude fiber content (less than 18% of dry matter (DM)) and high in total digestible nutrients more than 60%.
- Concentrates may be high in energy, referred to as energy concentrates, such as cereals and milling by-products, or
 - high in protein, with over 20% crude protein, referred to as protein concentrates.
- Concentrates can be fed in raw or milled forms.

2.3. By-product feeds

1. Cereal by-Products

A. Brewer's Dried Grains (BDG)

- The dried and extracted residue of barley malt alone or in a mixture with other cereal grains or grain by-products resulting from the manufacture of beer.
- It has a high crude protein content of 16 to 24% of dry matter.
- It also has a high cellulose content of 9-20% of dry matter.
- Has about 80% of the energy content of Barley grain but not as palatable as the original grain.

Chiefly used interchangeably with other feeds of similar

B. Brewer's Dried Yeast (BDY):

- Is the dried, non-fermentative, non-extracted yeast of the botanical classification *Saccharomyces* resulting as a by-product from the brewing of beer.
- It contains more than 35% Crude Protein.
- It is an excellent source of highly digestible protein of good quality.

C. Grain Screenings:

- Consists of 70% or more of light and broken grains along with weed seeds and other foreign material, that is separated in the cleaning of grain with a screen.
- Quality varies according to the percentage of weed seeds and other foreign material.
- Most grain screenings are incorporated in ruminant rations.

D. Wheat Bran:

- The coarse outer covering of the wheat kernel separated from wheat in commercial milling.
- It is rich in Niacin, Vitamin B1, P and Fe.
- Widely used in horse rations because of its bulky nature and laxative effects.
- It is also a favored supplement in sheep rations.

E. Wheat Middling:

- A by-product of the milling industry. It consists of the fine particles of bran, shorts, germ and flour.
- It should not contain more than 9.5% fiber.
- But deficient in calcium, carotene and vitamin D.
- It is widely used as a potential grain replacement in rations for all animal species.

F. Wheat Shorts:

- A similar product to wheat bran and middling.
- but lower in its Crude Fiber content (max. 7%) and richer in its energy composition
- because it contains the finer wheat milling by-products including a larger proportion of flour.

2. By- Products of Oil Mills:

Cottonseed meal:

- The finely flaked residue that remains after most of the oil from cottonseed has been extracted.
- The Crude Protein content of the meal can range between 40 and 50%.
- Cottonseed meal is low in lysine, methionine and tryptophan and deficient in Vitamin D, Carotene and Calcium but rich in Phosphorus.

B. Groundnut meal (Peanut Meal):

- Can contain 45 to 50% Crude Protein depending on the method of oil extraction.
- is used extensively in livestock and poultry diets.

C. Soybean meal:

- It is a product obtained by grinding the flakes that remain after extracting most of the oil from Soybeans.
- Has the highest nutritive value of any plant protein source.
- Contains 40to 50% Crude Protein, very palatable and, thus, suitable for all animal species.

D. Sunflower meal:

- It is a suitable protein supplement for all animal species.
- Crude protein content ranges from 35 to 40%.

3. Agricultural crop residues: They include
(Cereal straws, Pulse straws, Groundnut straw, Husks)

4. Sugar Refinery by -Products:

i) Sugarcane tops

- They are palatable due to its sugar juice.
- Can maintain cattle on tops and little protein supplements.
- Good quality of silage can be prepared.

ii) Molasses:

- Is by-product of the manufacture of table sugar from sugarcane.
- It is a good energy source but low in protein.
- It is very palatable and an excellent appetizer.
- It may be fed to any animal species.
- Molasses is used mostly as a binder to mixed feeds to be pelleted.

5. Meat processing wastes:

A) Tankage: Tankage is a good protein supplement for swine but sheep and cattle do not like it.

B) Meat scrap: Mostly used as protein supplement in poultry feeds.

C) Blood meal: contains 80% CP but poor in Ca & P. It is unpalatable for animals.

D) Feather meal: can be added only after proper processing. It can be added in the ration of broilers at 25% level.

2.4. Minerals and vitamins

- Appropriate intake of key minerals and vitamins is essential for livestock productivity and health.
- Minerals and vitamins account for a very small proportion of daily dry matter intake even though,
- they are very important in livestock nutritional programs for proper animal function,
- such as bone development, immune function, muscle contractions, and nervous system function.
- Cattle growth and reproductive performance can be influenced if a good mineral program is not in place.

2.5. Feed additives

- Feed additives are chemical components that are added to a ration in small amounts, to accomplish one or more of the following:
 - ↳ Increased intake (which would mean increased performance).
 - ↳ Increased gain.
 - ↳ Increased feed efficiency

The most common feed additives:

Ionophores; are feed additives that may improve feed efficiency by 5-10%.

Hormones/Anabolic agents: Anabolic agents are implants that contain steroid hormones that promote growth in cattle.

Beta agonists: This is a new class of compounds that

- The only beta agonist approved for cattle is ractopamine (trade name is Optaflexx).
- These additives alter how the animal's body uses nutrients.
- As a result, beta agonists promote lean growth in beef.

2.6. Feed Supplements

- Supplements are feeds which are high in one or more of the nutrients required by animals (with the exception of water).
- They can be further broken down into protein supplements, energy supplements and vitamin and mineral supplements.
- Many of these feeds are by-products of industries that produce a product destined for human consumption.

Energy supplement

- are feeds that are readily broken down in the rumen and have high values for energy.

Protein supplement

- These may originate from either plant or animal sources, or in the case of ruminants, from non-protein N Sources.
- A protein supplement is a feed which has more than 20% crude protein.
- These are usually the most expensive constituents in animal rations so their selection is affected by cost and availability.
- Protein supplement include urea, animal products, crop products, industrial by-products, poultry manure and litter

Thanks!!

Chapter-3

Classification of Basic Nutrients

- **Nutrient** is any substance absorbed by an organism from its external environment and used in the metabolism.
- It is source of materials needed for growth, maintenance, reproduction and production purpose.
- It includes: Water, Carbohydrate, Proteins, Lipids, Minerals and Vitamin.

Water; Often overlooked and not considered as a nutrient when formulating diets for animals, but extremely important.

- It is vital to the life of the organism that the water content of the body be maintained.
- An animal will die more rapidly if deprived of water than if deprived of feed.

Function of Water

- Serve as a solvent in which nutrients are transported about the body and in which waste products are excreted.

- Water serves in absorption of digested nutrients
- regulation of body temperature, because of
 - ↳ High specific heat of water.
 - ↳ high thermal conductivity and high heat of vaporizations ,so there are:
 - ⊗ accumulation of heat.
 - ⊗ ready transfer of heat and
 - ⊗ loss of large amounts of heat on vaporization that regulate body temperature.
- Many animals rely on the cooling capacity of water as it gives up its latent heat during evaporation by panting or sweating.
- Animals heat exchange is efficient i.e.
 - ↳ As 1 g of water changes from liquid to vapor, it takes up about 580 Cal of heat but
 - ↳ To heat 1 g of water from freezing to boiling requires only 117 Cal of heat

Requirement of Water

- It is induced as a result of dehydration of body tissues.
- However, drinking may also occur when there is no apparent need to rehydrate tissues.
- There is ample evidence that passage of water through the mouth is required for a feeling of satiety.
- Most domestic animals generally drink during or soon after eating periods if water is close at hand.
- In very general terms animals will consume 2 to 5 kg of water for every kg of dry feed consumed when they are not heat stressed.
- Activity increases requirements; nervous animals also will likely consume more water than less active animals.
- Physiological, dietary, and environmental factors affecting absorption and excretion alter water requirements.
- Pregnancy also increases the need for water, and

- Swine generally consume 2 to 2.5 kg of water/kg of dry feed at moderate temperatures .
- Young animals generally require more water per unit of body weight than adult animals.
- Horses and poultry consume 2 to 3 kg/kg of dry feed.

The animal obtains its water from three sources:

1. drinking water.
 2. water present in its feed and
 3. metabolic water, this last being formed during metabolism by the oxidation of hydrogen-containing organic nutrients.
- The water content of feeds is variable and can range from as little as 60 g/kg in concentrates to over 900 g/kg in some root crops.
 - Because of this great variation in water content, the composition of foods is often expressed on a dry matter basis, which allows a more valid comparison of nutrient

- The water content of growing plants is related to the stage of growth, being greater in younger plants than in older plants.
- In temperate climates the acquisition of drinking water is not usually a problem and animals are provided with a continuous supply.
- There is no evidence that under normal conditions an excess of drinking water is harmful, and animals normally drink what they require.

Water Quality

- Water quality may affect feed consumption directly because low quality water normally will result in reduced water consumption and, hence, lower feed consumption and production.

Substances that may reduce palatability of water include various salts, and toxic substances.

- Substances that may be toxic without much effect on palatability include nitrates, fluoride, and salts of some heavy metals.

- Expected water consumption of various classes and species of adult livestock in a temperate climate

Animal	Liters/day
Beef cattle	22-26
Dairy cattle	38-110
Sheep and goats	4-15
Horses	30-45
Swine	11-19
Chickens	0.2-0.4
Turkeys	0.4-0.6

→ Effect of water total soluble salt concentration on livestock and poultry.

Total soluble salt mg/L	Effect
1000 and less	Safe for any class of livestock and poultry
1000-3000	Safe but may cause temporary mild diarrhea to animals not accustomed to it
3000-5000	Watery feces and increases mortality in poultry
5000-7000	Acceptable to all domestic animals except poultry
Greater than 7000	Unfit for poultry and swine and should not be used for pregnant or lactating cattle, horses, or sheep or for young growing animals of any species.
Greater than 10,000	Unfit for use as drinking water under any conditions

3.2. Carbohydrates

- Carbohydrates (also called saccharides) are—on the basis of mass—the most abundant class of biological molecules on Earth.
- Carbohydrates consumed by animals serves as source of energy, as a reserve in the form of fat mainly, and also glycogen into which it is readily transformed.

Functions of Carbohydrates.

- Carbohydrates are the main/largest sources of energy in the body.



- Store energy (starch and glycogen).
- Carbohydrates are linked to many proteins and lipids, where they play key roles in mediating interactions among cells and interactions between cells and other elements in the cellular environment.
- Structural components of some cells e.g cellulose in

- Ribose and deoxyribose sugars form part of the structural framework of RNA and DNA.

forms of carbohydrate in plant tissues;

i) Structural carbohydrate; mainly cellulose, in terms of quantity cellulose comprise the largest proportion of carbohydrates in plants.

ii) Reserve carbohydrate; starch is the basic reserve carbohydrates in plant while glycogen is for animals.

- The name carbohydrates owe their name to the fact that,
 - they contains carbon combined with water often in the same ratio as in water and it means hydrated carbon meaning C atom with H₂O molecule.
- although many carbohydrates have the same empirical formula $(CH_2O)_n$ where $n > 3$,
- the definition is not strictly correct, and there are exceptions for this definition.

This includes:

- It is possible that other chemical compounds which are not carbohydrates could have the same ratio of the elements C, H, O.

Example:

-Acetic acid is not CH_2O but has a formula of $\text{C}_2\text{H}_4\text{O}_2$

-Lactic acid $\text{C}_3\text{H}_6\text{O}_3$ ($\text{CH}_3.\text{CHOH}.\text{COOH}$)

- There is a possibility of the carbohydrate without having the elements in the indicated ratio.

} Rhamnose $\text{C}_6\text{H}_{12}\text{O}_5$

} Deoxyribose $\text{C}_5\text{H}_{10}\text{O}_4$

Classification of carbohydrates

- Carbohydrates are usually divided into 2 major groups according to their chemical nature.

1. Sugars 2. Non- sugar

Sugars;

- These are group of carbohydrates containing less than 10 monosaccharide residues.
- These are groups of carbohydrates which are soluble in water and sweet to test.
- These things differentiate sugars from non-sugars which contain >10 monosaccharide's units in their structure;
 - and insoluble in water and not show sweet taste.

A. Monosaccharides

- They are simplest form of sugars, which cannot be further hydrolyzed.
- They represent the building units and hydrolytic end products of the more complex carbohydrates.
- Hexose sugars are most common contains 6 carbon atoms which include Fructose, Glucose, Galactose.
- generally have molecular formulas that are multiples of CH_2O , they may be regarded as hydrates of carbons with one molecule of water for each carbon atom , $\text{1C-1H}_2\text{O}$
- Names of monosaccharaides generally end in "ose"

B. Disaccharides

→ Consists of two monosaccharides joined by a *glycosidic linkage*.

e.g. 2 glucoses make maltose(malt sugar)

1 glucose + 1 galactose = lactose

1 glucose + 1 fructose = sucrose (table sugar)

Lactose is milk sugar;

→ For use as an energy source, must be hydrolyzed to glucose and galactose.

Sucrose;

→ Important plant carbohydrate.

→ Water soluble.

→ Easily transported in plant circulatory system.

→ Cannot be synthesized by animals.

→ Sucrose called: Table sugar; Cane sugar ; Beet sugar.

C. Oligosaccharides

- The name comes from Greek oligos means a few and is frequently used to include all sugars other than the monosaccharides.
- Oligosaccharides contain carbohydrates containing 2-10 monosaccharide units.
 - ↳ Disaccharides - oligosaccharides with 2 monosaccharide units
 - ↳ Trisaccharides - oligosaccharides with 3 monosaccharide units
 - ↳ Tetrasaccharides - oligosaccharides with 4 monosaccharide units

2. Non-sugars

- These contain greater than 10 monosaccharide units.
- Non-sugars have more molecular weight than sugars.
- The non-sugars are also called polysaccharides or glycans.
- So they are polymers of monosaccharide units.
- We have two groups of polysaccharides based on the type of monosaccharide units present in the chain.

a. Homopolysaccharides (Homoglycans)

- Homo means same, hence these are polysaccharides which contain only a single type of monosaccharide units or these polysaccharides result to one type of monosaccharide on hydrolysis.

Example,

- Glucans (glucosan) - homopolysaccharides made of many glucose units attached together like Starch, glycogen, cellulose, dextrans.

b. Heteropolysaccharides (Heteroglycans)

- All polysaccharides which on hydrolysis yield mixture of monosaccharides.
- Therefore, these polysaccharides are made of greater than one type of monosaccharides.
- Non-sugars also contain complex carbohydrates which are ill-defined group of compounds which contain carbohydrates in combination with non-carbohydrates molecules.
- They include the glycolipids and glycoproteins.

They can also be classified into Storage & Structural polysaccharides.

A. Storage polysaccharides

1. Starch

- ⌋ storage polysaccharide of plants
- ⌋ consists entirely of glucose monomers
 - ⌋ amylose = unbranched starch (alpha1-4)
 - ⌋ amylopectin = branched starch (alpha1-6)
- ⌋ most animals have enzymes which hydrolyze starch.

2. Glycogen

- storage polysaccharide in animals (liver and muscles)
- also made of glucose monomers but is more extensively branched than starch.

B. Structural polysaccharides

Cellulose

- major component of plant cell walls
- most abundant organic compound on earth
- Animals lack the enzymes necessary to hydrolyze cellulose
- The bacteria in ruminants (*e.g.*, cows) can digest cellulose so that they can eat grass, *etc.*

3.3. Proteins

- Proteins are complex organic compounds of high molecular weight.
- From the standpoint of nutrition the important distinguishing feature of the various proteins is their amino acid makeup.
- Proteins are basically made of building blocks called amino acids, which is one structurally unifying factor of proteins.
- Proteins are mainly found in active tissues in plants and animals like leaves, shoots, and muscle.
- In common with carbohydrates proteins contain carbon, hydrogen and oxygen but in addition they also contain nitrogen.

Classification of proteins

A. based on composition

1. Simple proteins

- These proteins produce only amino acids on hydrolysis as composed of only amino acid residues

2. Conjugated proteins

- Conjugated proteins contain, in addition to amino acids, a non-protein moiety termed a prosthetic group.
- Some important examples of conjugated proteins are glycoproteins, lipoproteins, phosphoproteins and chromoproteins.
- **Glycoproteins** are proteins with one or more heteroglycans as prosthetic groups.
- They are components of mucous secretions, which act as lubricants in many parts of the body

- **Lipoproteins**, which are proteins conjugated with lipids such as triacylglycerols and cholesterol which are the main components of cell membranes.
- also they are the form in which lipids are transported in the bloodstream to tissues, either for oxidation or for energy storage.
- **Phosphoproteins**, which contain phosphoric acid as the prosthetic group, include the caseins of milk and phosvitin in egg yolk.
- **Chromoproteins** contain a pigment as the prosthetic group.
- Examples are haemoglobin and cytochromes, in which the prosthetic group is the iron-containing compound haem, and flavoproteins, which contain flavins.

B. Based on shape

1. Fibrous proteins

- These proteins, which in most cases have structural roles in animal cells and tissues,
- are insoluble and are very resistant to animal digestive enzymes.
- They are composed of elongated filamentous chains joined together by cross-linkages.
- The group includes collagens, elastin and keratins.

Collagens

- are the main proteins of connective tissues and constitute about 30 per cent of the total proteins in the mammalian body.

Elastin

- is the protein found in elastic tissues such as tendons and arteries.
- is rich in alanine and glycine and is very flexible

Keratins

- are classified into **two** types.
- The α -keratins are the main proteins of wool and hair.
- The β -keratins occur in feathers, skin, beaks and scales of most birds and reptiles.
- These proteins are very rich in the sulphur-containing amino acid cysteine;
- wool protein, for example, contains about 4 per cent of sulphur.

2. Globular proteins

- Globular proteins are so called because their polypeptide chains are folded into compact structures (spherical or globular form).
- The group includes all the enzymes, antigens and those hormones that are proteins.
- Its first subgroup, albumins, are water-soluble and heat-coagulable and occur in milk, the blood, eggs and many

Table 3.6**Examples of globular and fibrous proteins**

Type of Protein	Function
Globular Proteins	
Hemoglobin	Transport (oxygen transport)
Myoglobin	Storage (oxygen storage)
Ribonuclease	Enzyme (RNA hydrolysis)
Lysozyme	Enzyme (bacterial wall hydrolysis)
Cytochrome <i>c</i>	Electron transport
Immunoglobulin	Defense (antibody)
Fibrous Proteins	
Collagen	Structural protein
Keratin	Structural protein
Myosin	Movement (muscle protein)
Elastin	Elasticity

Amino acids

- Proteins are polymers of amino acids.
- Amino acids are produced as hydrolytic end products,
 - where proteins are heated with strong acids, alkalis or when they are acted upon by certain enzymes.
- More than **700** amino acids occur naturally, Out of these only 20 amino acids are commonly found as components of proteins and hence nutritionally important.
- These 20 amino acids are the building blocks of proteins hence called as common/standard aa.
- Amino acid are characterized by having a basic nitrogenous group, generally an amino group ($-NH_2$), and an acidic carboxyl group ($-COOH$).

- Amino acids by virtue of having an amino and carboxyl group, they show different characteristics in different medium solutions.
- They assume acidic or basic proteins depending on the pH of the medium.
- In acidic pH shown basic characteristics (amino acid is a cation) and in basic medium show acidic characteristics (amino acid is an anion).
- Such characteristic is called amphoterism.
- Because of this amphoteric nature amino acids act as buffers, resisting changes in pH.
- Amino acids

→ **They divided into 3 groups depending on their chemical structure.**

1. Aliphatic amino acids; this contain straight chain amino acid.

2. Aromatic amino acids; these are amino acids containing benzene ring somewhere in their structure.

Example, phenylalanine, tyrosine, thyroxine.

3. Heterocyclic amino acids; are amino acids not fit in any one above.

Example, Histidine, proline, hydroxyproline, tryptophan.

→ **Aliphatic amino acids** are the amino acids which contain most of the nutritionally important amino acids.

These group (aaa) can be subdivided into:

1. Neutral amino acids: are amino acids which contain equal no of the amino and carboxylic group.

→ Since this group contain one NH_2 & one COOH , they are

2. Acidic amino acids (monoamino-dicarboxylic acids)

- These are amino acids that contain more number of carboxylic than amino group and hence the acidic property is more.

Example, Aspartic acid, glutamic acid.

3. Basic amino acids (Diamino-monocarboxylic acids)

- These amino acids have more amino than carboxylic group and hence dominant basic character.

Example, Arginine. Lysine. Citrulline.

4. Sulfur amino acids

- these are sulfur containing amino acids like cysteine, methionine

- Plants and many microorganisms are able to synthesise proteins from simple nitrogenous compounds such as nitrates, so can synthesise all the 20 amino acids.
- Animals cannot synthesize the amino group.
- So in order to build up proteins a dietary source of amino acids is essential.
- Certain amino acids could be synthesised in the animal body from others;
- while a number of them cannot be synthesised in the animal body and
- these are referred to as indispensable or essential amino acids, so must be included in the diet.

→ The others which are not obligatory and can be synthesised within the body are called dispensable or non-essential amino acids.

→ From research done on rats, monogastric animals require the following ten essential amino acids. (**TIM HALL PVT**)

- | Threonine
- | Isoleucine
- | Methionine
- | Histidine
- | Arginine
- | Leucine
- | Lysine
- | Phenylalanine
- | Valine
- | Tryptophan

- The chicks require in their diet the ten amino acids plus glycine and proline as additional essential amino acid.
 - ⊗ Lysine, Methionine and Tryptophane are the limiting aas in poultry ration.

Dispensable amino acids include:

- └ Cysteine
- └ Tyrosine
- └ Glutamic acid
- └ Alanine
- └ Aspartic acid
- └ Serine
- └ Proline
- └ Cysteine
- └ Glutamine
- └ Asparagine

Peptides :

- are built up from amino acids by means of a linkage between the α -carboxyl of one amino acid and the α -amino group of another acid.
- This type of linkage is known as the peptide linkage, a dipeptide has been produced from two amino acids.
- Large numbers of amino acids can be joined together by this means, with the elimination of one molecule of water at each linkage, to produce polypeptides.
- Besides being important building blocks in the construction of proteins, some peptides possess their own biological activity.
- Milk, in particular, is a source of many biologically

- The enzymatic hydrolysis of the milk protein casein releases opioid peptides,
 - which have pharmacological activities such as analgesia and sleep-inducing effects.
- Other peptides, including bombesin, enterostatin, glucagon and leptin, are important in the control of food intake.
- Peptides play an important role in the flavour and sensory properties of foods such as yeast extract, cheese and fruit juices.

3.4. Lipids

- Lipids are group of substances found in plant and animal tissues which are,
 - ↳ insoluble in water but soluble in common organic solvents such as benzene, ether, chloroform, ethanol which is the specific character of lipids.
- The lipids are the structurally the most diverse/heterogeneous group of compounds
- This is because unlike members of the other biomolecules, members of this families do not share a common structural feature, but rather share a common **physical property**; they are **hydrophobic**.
- It includes fats, oils, steroids, waxes, and related compounds, which are related more by their physical than by their chemical properties.
- They are basically made up of the elements carbon,

Classification of Lipids

1. Glycerol based lipids:

- are lipids having glycerol unit in their structure .
- They divided further into:

a. Simple lipids:

- these have one group of compounds that is fat & oils.

b. Compounds lipids: these are of two types

- **Glycolipids:** are lipids that contain sugar attached to the lipid molecule.
- **Phospholipids:** are lipids containing phosphoric acid or phosphorous attached

2. Non glycerol based lipids: are lipids that do not contain glycerol in their structure(Sphingolipids, Steroids, Waxes)

Biological Functions of Lipids

- As an energy source, lipids provide 9 kcal of energy per gram.
- Triglycerides provide energy storage in adipocytes.
- Phosphoglycerides, sphingolipids, and steroids are structural components of cell membranes.
- Source of steroid hormones are critical intercellular messengers.
- Helps in absorption of lipid-soluble vitamins (A, D,E, K)
- Provide shock absorption.
- Helps in insulation to heat change.
- Adds taste & palatability to foods.
- Acts as surfactant, detergent & emulsifying agent.
- Give shape to the body.

→ Plant lipids are of two main types: **structural and storage.**

→ The structural lipids are present as constituents of various membranes and protective surface layers and
 | make up about 7 per cent of the leaves of higher plants.

→ Plant storage lipids occur in fruits and seeds and are, predominantly, triacylglycerols.

→ In animals, lipids are the major form of energy storage, mainly as fat, which may constitute up to 97 per cent of the adipose tissue of obese animals.

→ The yield of energy from the complete oxidation of fat is about 39 MJ/kg DM compared with about 17 MJ/kg DM from glycogen, the major carbohydrate form of stored

Fatty acids

- Fatty acids are classed into two groups, which are saturated fatty acids and unsaturated fatty acids.
- saturated group contain no double bonds in their structure, while the unsaturated fatty acids contain at least one double bond in their structure.
- The term polyunsaturated fatty acids are frequently applied to those having more than one double bond and they have specially significance in nutrition.
- In many nutrition books linoleic, linolenic and arachidonic acids are classed as essential fatty acids (EFA),
- because the lack of these fatty acids in the diet of animal especially at young stage (calves, lamb, kids, pigs, and chicks) result to the development of deficiency symptoms.
- Recent experiments recognize that the most important EFA is linoleic

- The oilseeds are generally rich sources of linoleic acid, linseed is particularly good source of linoleic acid.
- Over supply of polyunsaturated fatty acids may have a nutritional disadvantage as these unsaturated fatty acids increase the requirement for vitamin E,
 - which appears to serve primarily as an antioxidant, which will result to the shortage of vitamin E and
- its deficiency condition such as muscular dystrophy & encephalomalacia.

3.5. Vitamins

- Vitamins are organic compounds that are required in small amounts for normal growth and maintenance of animal life.
- Unlike the nutrients vitamins are not merely building blocks or energy-yielding compounds but,
 - are involved in, or are mediators of, the biochemical pathways.
- Most feed mixes prepared as supplements for ruminants and horses or as the sole feed for pigs, poultry, dogs and cats are supplemented with vitamins.
- The catalysts play a role in chemical reaction but it does not change its nature in the reaction
- That is why vitamins are required in minute quantities.

General characteristics

- Vitamins are of widespread occurrence in nature, both in plant and animal worlds.
- All common foodstuffs contain more than one vitamin.
- The plants can synthesize all the vitamins where as only a few vitamins are synthesized in the animals.
- Some members of the vitamin B-complex are synthesized by microorganisms present in the intestinal tract.
- Most of vitamins have been artificially synthesized.
- All the cells of the body store vitamins to some extent.
- Vitamins are partly destroyed and are partly excreted.
- Vitamins carry out functions in very low concentrations. Hence, the total daily requirement is very small.

Vitamin classification

A. Fat-soluble vitamins.

- These are oily substances, not readily soluble in water.
- They contain only carbon, hydrogen and oxygen.
- Their examples are vitamins A, D, E and K.
- They, however, play more **specialized roles** in certain group of animals and in particular type of activities.
- For instance, they function in the formation of a **visual pigment** (**vitamin A**).
- In the absorption of **calcium and phosphorus** from the vertebrate intestine (**vitamin D**).
- In protecting mitochondrial system from free radicals (**vitamin E**).
- In the formation of a blood clotting factor in vertebrates (**vitamin K**).

B. Water-soluble vitamins

- Most of these are universally vitamins since they perform the same general functions wherever they occur.
- Besides C, H and O, they also contain **nitrogen**.
- The common **water-soluble** vitamins are vitamins of **B complex** such as B1 through B12 (vitamins B4, B8, B10 and B11, however, do not exist) and the **vitamin C**.

Function, Deficiency Signs & Sources of Vitamins

Vitamin A

Function:

- development healthy skin and nerve tissue.
- Aids in building up resistance to infection.
- Functions in eyesight and bone formation.
- All animals require a source of Vitamin A.
- It is important in the ration of pregnant females.

Deficiency signs:

- retarded growth in the young,
- the development of a peculiar condition around the eyes known as **Xerophthalmia**,
- night blindness and reproductive disorders.

Sources:

- whole milk, carotene, animal body oils (cod fish and tuna), legume forages and can be synthetically produced.

Xerophthalmia



Vitamin E

Function:

- normal reproduction.

Deficiency signs:

- poor growth.
- "crazy chick" disease.
- Muscular Dystrophy, "white muscle" disease in ruminants and swine.
- "stiff lamb" disease (affects the nerves and muscles).

Sources:

- synthetic for poultry and swine, cereal grains and wheat germ oil, green forages, protein concentrates, oil seeds (peanut and soybean oil).

Vitamin D

Function:

- is essential for the proper utilization of calcium and phosphorus to produce normal, healthy bones.

Deficiency signs:

- Lack of appetite, retarded growth and weight loss, misshapen bones (rickets, Osteomalacia), lameness and osteoporosis, enlarged or stiff joints, bowed legs, Soft egg shells.

Sources:

- Whole milk, sun-cured hays, forage crops, fish liver oils, irradiated yeast



Rickets in chicks



Vitamin K

Function:

- necessary for the maintenance of normal blood coagulation.

Deficiency signs:

- blood loses its power to clot or the time needed for clotting is longer and serious hemorrhages can result from slight wounds or bruises.

Sources:

- green leafy forages, fish meal, liver, soybeans, and the synthetic compounds.

Thiamine (vitamin B1)

Functions;

- Acts as catalyst in carbohydrate metabolism

Deficiency symptoms

- Constipation.
- Suppressed appetite.
- Mental depression.

- Chronic thiamine deficiency leads to a more severe neurological symptom e.g mental confusion, loss of eye co-ordination.
- Severe thiamine deficiency is known as beriberi.

Sources: Brewers yeast, Eggs, Leafy green vegetables, Whole cereals, wheat, peanuts and legumes.

Riboflavin (Vitamin B2)

Function:

- it serves as a co-enzyme in the metabolism of carbohydrates, fats and protein.
- It also serves in the maintenance of mucus membrane.

Deficiency symptoms:

- Photophobia
- stomatitis.

Sources: by products of Milk, Meat meal and Cereals

Niacin (vitamin B3) or nicotine amide

Functions:

- Required for the synthesis of NAD (Nicotinamide adenine dinucleotide).
- functions as co-factor in metabolism.

Deficiency Symptoms: Dermatitis, Weight loss, Diarrhea and Depression.

Sources: Liver, Poultry and its by products, Meat meal, fish and by products, Whole grain, beans (legumes) and Pea nuts.

3.6. Minerals

- Essential inorganic nutrients, required in small amounts.
- As many as 20 minerals may be required!
- Required for **growth, maintenance, reproduction and lactation.**
- constituents of bones and teeth (structural role), and also essential for synthesis of structural proteins like the mineral sulphur.
- Minerals are components of organic compounds like iron in haemoglobin, cobalt in vitamin B₁₂.
- as soluble salts in blood and other body fluids playing role in maintenance of osmotic relations and acid base equilibrium.

Classification of essential mineral elements

- Essential minerals are classified into two depending upon their concentration in the animal or up on the quantity animals require these elements.
- Major element: are elements required in relatively larger quantities

The Macro-minerals:

- Calcium Ca
- Phosphorous P
- Potassium K
- Sulfur S
- Sodium Na
- Chlorine Cl
- Magnesium Mg

Calcium (Ca)

Function:

- major component of bones and teeth and essential in blood coagulation, nerve and muscle function and milk and egg production.

Deficiency signs:

- retarded growth, deformed bones in young animals (rickets), and soft shelled eggs and osteoporosis in older animals.

Sources:

milk, oyster shells and limestone.

Sodium chloride

- Considered together because of a close biochemical relationship and are provided as common salt (NaCl)

Function:

- required for the formation and retention, concentration and pH of body fluids, such as protoplasm, blood.
- Important in the formation of **digestive juices** and functions in **nerve and muscle activity**.

Deficiency signs:

- poor condition and depressed appetite.
- Most farm produced feeds are deficient in these two minerals.

Sources:

- salt supplements and injectable products.

Phosphorus (P)

Function:

- essential for the formation of bones, teeth, and body fluids. Required for metabolism, cell respiration and normal reproduction.

Deficiency signs:

- similar to calcium deficiency, lack of appetite, poor reproduction and unthrifty appearance.

Sources:

- Di-calcium phosphate, bone meal, and low fluorine phosphates.

Potassium (K)

Function:

- retention and formation of body fluids, pH concentration of body fluid and rumen digestion.

Deficiency signs:

- nonspecific and unlikely under most conditions but may have decreased feed consumption and efficiency.

Manganese (Mn)

Function:

- Fetal development, udder development, milk production and skeleton development.

Deficiency signs:

- Abortions, reduced fertility, deformed young and poor growth.

Sources: Most use trace mineralized salt.

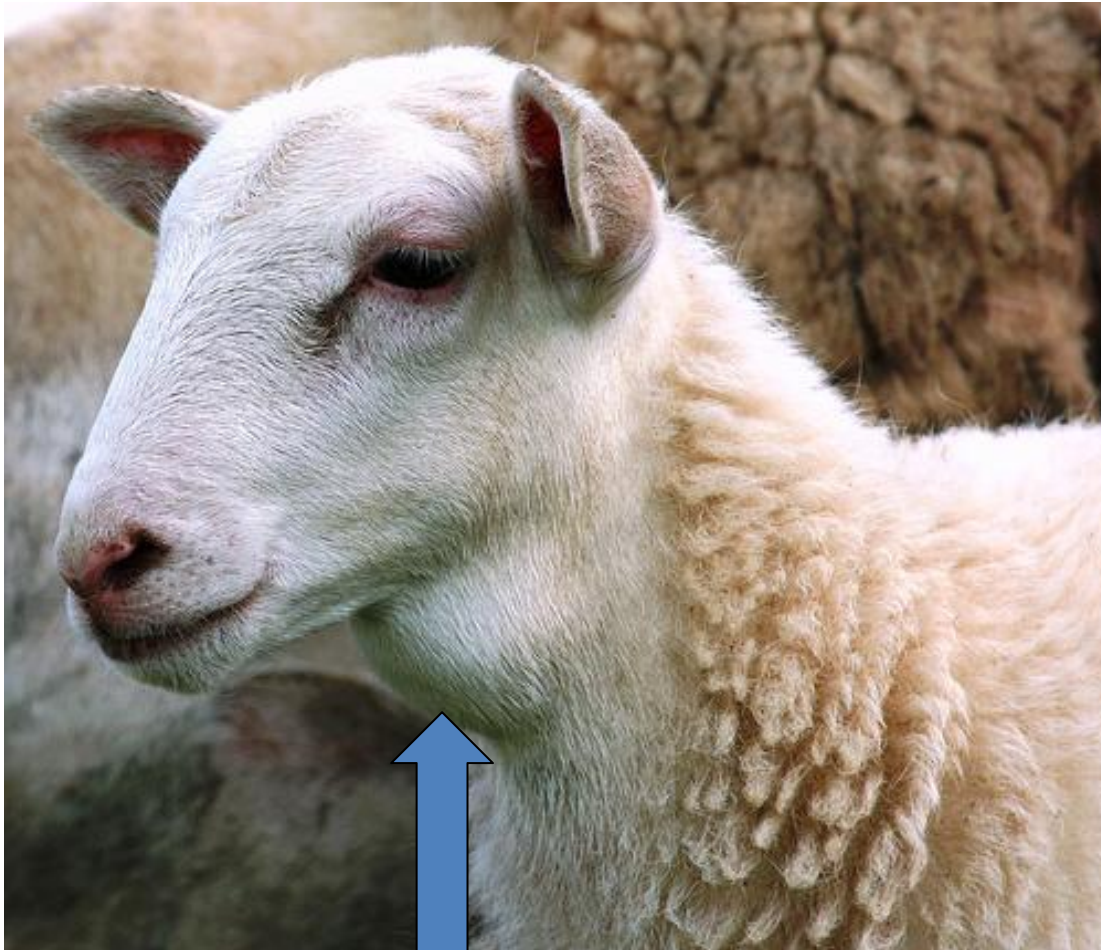
The Micro-minerals includes:

- Iodine (I)
- Copper (Cu)
- Iron (Fe)
- Selenium (Se)
- Manganese (Mn)
- Molybdenum (Mo)
- Zinc (Zn)

Iodine Deficiency: Goiter (Arrow).

Treatments: Not effective once symptoms appear.

Prevention: Feeding iodized salts, Rare disease.



Copper (Cu)

Function:

- should be present in animal tissues for iron to be properly utilized, hemoglobin formation and synthesis of keratin for hair and wool growth.

Deficiency signs:

- poor pigmentation of feathers, stringy wool, sway back lambs, lack of muscle coordination and anemia.
- De-pigmentation classically occurs as grey/brown discoloration of the coat especially around the ear margins and eyes.

Sources: forages and copper salts.

Copper deficiency



Iron (Fe)

Function: essential for the function of every organ and tissue of the body (Hemoglobin).

Deficiency signs: seldom occurs in older animals, nutritional anemia, labored breathing and pale eyelids, ears and nose.

→ Loss of appetite, emaciation in suckling young, Rough hair coat, pale membranes, Swelling in head and shoulders

Sources: forages and copper

Disease: Anemia

Cause: -Iron or copper deficiency
- parasites



Cobalt (Co)

Function:

- required as a nutrient for the microorganisms in ruminants and thereby aids in rumen synthesis of Vitamin B₁₂.
- Because swine cannot manufacture B₁₂ from cobalt, the diets are supplemental with vitamin B₁₂ instead.

Deficiency signs:

- lack of appetite, loss of weight, rough hair coat, anemia, decreased milk and wool production and death in extreme cases.

Sources:

- legume forages and salt containing cobalt.

Magnesium (Mg)

Function: similar to calcium and phosphorus.

Deficiency signs: Animals are irritable, their heart beat is irregular and there is severe kidney damage.

Sources: mineral supplements and ordinary feeds.

- Although we have been considering the essential role of minerals in animal nutrition,
 - ⊗ it is important to realize that many are toxic – causing illness or death – if given to the animal in excessive quantities.
- Supplementation of any diet with minerals should always be carried out with great care, and
- the indiscriminate use of trace elements in particular must be avoided.

THANKS



Digestion, Absorption and Metabolism of Nutrients

- Many of the organic components of feed are in the form of large insoluble molecules,
 - which have to be broken down into simpler compounds, before they can pass through the mucous membrane of the alimentary canal into the blood and lymph.
- The breaking down process is termed 'digestion', and the passage of the digested nutrients through the mucous membrane 'absorption'.
- The processes important in digestion may be grouped into mechanical, chemical and microbial activities.
- The mechanical activities are mastication and the muscular contractions of the alimentary canal.
- The main chemical action is brought about by enzymes

- Microbial digestion of food, also enzymic, is brought about by the action of bacteria, protozoa and fungi, that are of special significance in ruminant digestion.
- In monogastric animals, microbial activity occurs mainly in the large intestine,
 - although there is a low level of activity in the crop of birds and the stomach and small intestine of pigs.
- Digestion is a process whereby large insoluble feed particles are broken to simple, soluble and absorbable particles.
- Absorption on the other hand is the passage of the digested nutrients through the mucous membrane into blood circulation or lymph.
- Metabolism is a general term given to the sequence of chemical processes that take place in the living animal.

Digestion in monogastric mammals.

- The term “monogastric” refers to the structure of the stomach.
- In a monogastric digestive system, the stomach has a simple structure consisting of a single compartment.
- A number of species have a monogastric digestive system, including swine, horses, dogs, rabbits, and fowl.
- All of the mammals listed here have similar systems, although some minor differences do exist between them.
- Fowl, however, have a digestive system that differs from the others, including organs not found in the other species.

- The digestive tract can be considered as a tube extending from mouth to anus, lined with mucous membrane, whose function is the prehension, ingestion, digestion and absorption of food, and the elimination of solid waste material.
- The various parts are mouth, pharynx, oesophagus, stomach, and small and large intestine.
- Digestion begins when feed enters the mouth.
- The feed is then carried through a tube called the esophagus to the stomach.
- When leaving the stomach, the feed moves into the first section of the small intestine, which is called the duodenum.

- Then emptied into the part of the large intestine named the cecum and then into the colon.
- Finally, the waste products are passed into the lower end of the large intestine, which is referred to as the rectum, and out of the body through the anus.
- While they are not a part of the digestive system, the pancreas, gall bladder, and liver also play a role in digestion.
- They release substances that aid the digestive system in performing its function. However the horse, unlike the other animals, does not have a gall bladder.
- The path followed by feed in fowl differs somewhat due to the different parts of its digestive system.

Digestion in the fowl

The gut of poultry differs from other monogastric animals in many aspects.

A. In the fowl the lips and teeth are absent and replaced by another structure called beak. Taste in poultry is limited.

B. Esophagus in birds is modified to form a pear-shaped sac called crop.

- The main function of crop is as a reservoir for holding food and plays little role in the digestion process.
- Some microbial activity occurs there and results in the production of lactic and acetic acids.
- Action of salivary amylase also occurs here.

C. The esophagus terminates at the proventriculus of glandular stomach, also called true stomach, because there are certain glands that produce gastric juice, similar

- It contains pepsinogen & HCl.
- The need for crop becomes obvious when you see the size of proventriculus which is small in capacity.
- Therefore, crop serves as an additional store so that the feed will be stored temporary until transferred to proventriculus and only small quantity of food is gradually brought to proventriculus.

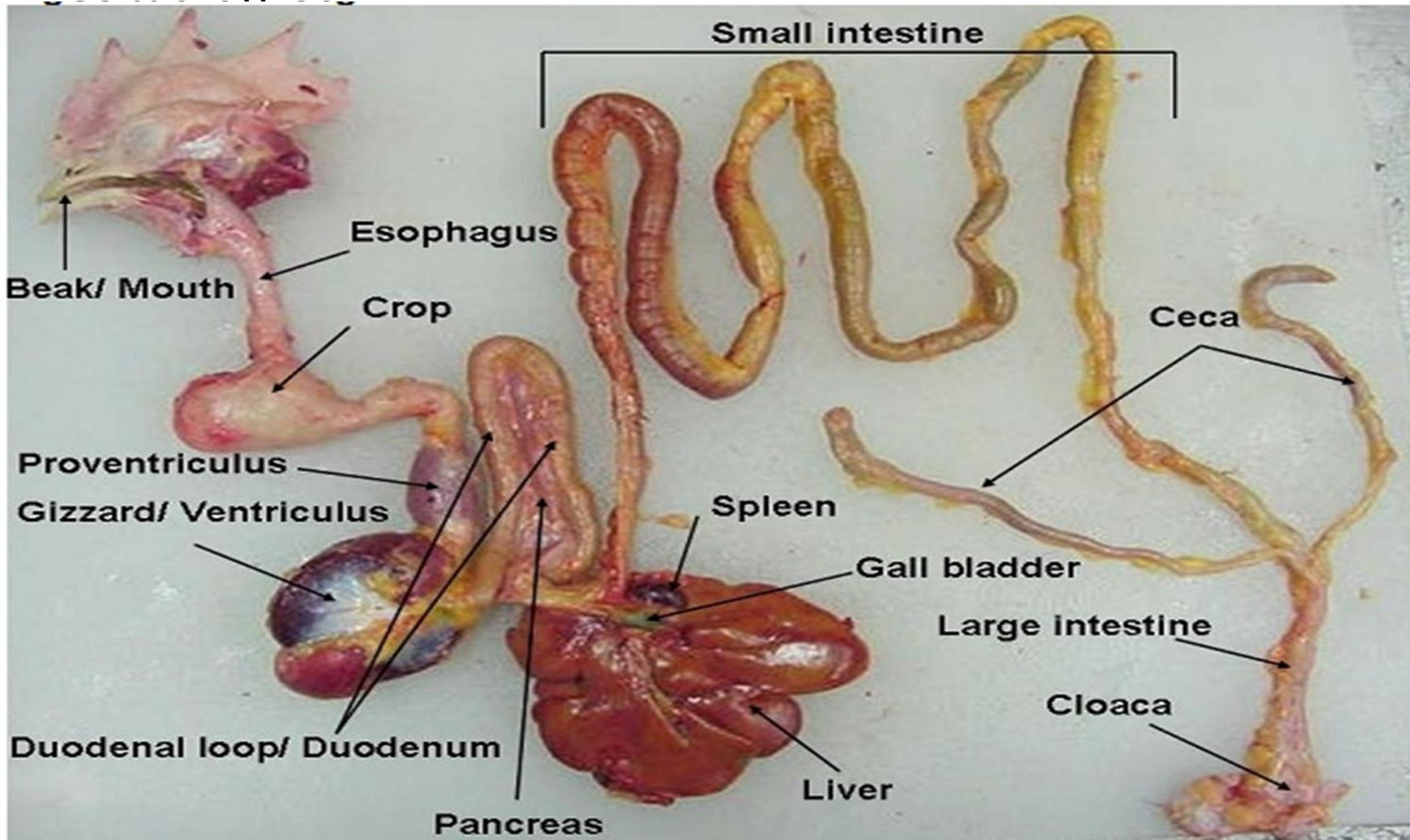
D. The glandular stomach leads to the gizzard which has no counterpart in the pig.

- This is a modification of gut of poultry, made up of very strong muscles which are in constant motion thereby facilitating physical breakdown of feeds.
- Gizzard is a muscular organ which undergoes rhythmic contraction and grinds the food with moisture into a smooth paste.

- These are small stones in the gizzard called grit, which facilitate physical degradation of feed by about 10%.
- This structure or grit could be assumed as substitute of teeth found in other farm animals.
- After feed materials get mixed with gastric juice in the proventriculus, the feed goes to the gizzard and chemical degradation is limited in the proventriculus because of hard nature of the feed.
- In the gizzard there will be physical degradation which increase the surface areas of the feed to be attacked by enzymes of proventriculus, but gizzard not produce enzymes.
- Therefore, proventriculus & gizzard are equivalent in function to the mammalian stomach.
- From the gizzard the feed goes to small intestine which

- In fowl two bile ducts and three pancreatic ducts pour to small intestine.
- From small intestine feed goes to large intestine which you find two large blind sacs (ear like structure) called caeca at the junction of small intestine and large intestine.
- The caeca functions mainly as absorption organs, but not essential to the fowl as surgical removal causes no harmful effects.
- It does not play significant role in fermentation to poultry.
- The whole structure of large intestine is much shorter in poultry and found very short colon in fowl whose function is to transport digesta to cloaca.
- The large intestine terminates in the cloaca, a special structure not equivalent to the anus since functions as an orifice where digestive, urinary and reproductive

- Elimination of feces (grayish or black portion) and urine (white portion) together occur here.
- Urine is mostly uric acid. Egg is also removed by this



Digestion in ruminants

- In contrast to an animal with a monogastric digestive system, a ruminant has four stomach compartments and can utilize some feeds more efficiently than a monogastric animal.
- Ruminants are important to the animal industry because they can change hay and pasture to nutritious product.
- In the GIT of the ruminant, ingested food is exposed to very extensive pregastric fermentation.
- Most of the ingesta is fermented by microbes before it is exposed to typical gastric and intestinal digestive chemicals and enzymes;
- thus, this is quite a different system than for typical monogastric animals.
- The largest proportion of the ruminant stomach is the rumen and reticulum which are said to be fermentation bags.

- This large capacity is essential to allow feed retention to give enough time to break cellulose and other complex carbohydrates, which mammalian enzyme cannot.
- They are only separated by a fold in the wall and there is no specific orifice which joins the two organs together.
- However, there is a considerable difference in the appearance of the wall of the rumen and reticulum.
- The reticulum is the most cranial compartment.
- It is also called honeycomb, as it contains honeycomb like compartments.
- Its location is just behind the heart.
- Materials enter the rumen from oesophagus they residue at the junction of rumen & reticulum.
- For this reason foreign bodies such as stone or nails (wire) frequently accumulate in the bottom of the reticulum and are in a very good position to penetrate

- The reticulo-rumen provides a continuous culture system for anaerobic bacteria and protozoa, and also some fungi that produce enzymes that hydrolyse various nutrients.
- The chemical breakdown of food in the reticulo-rumen is brought by enzymes secreted, not by the animal itself but by micro-organisms.
- The fate of rumen micro-organisms is that they pass into the abomasum and intestine and are then digested by the host animal.
- Fibrous feeds are digested more efficiently in the rumen than in the large intestine or cecum.
- Cellulose and hemi-cellulose can be digested by microbes.
- Bacteria can utilize simple forms of nitrogen such as urea, to synthesize their cellular proteins.

- A further benefit is that rumen synthesis is extensive for all vitamins except vitamin A, D, and E and as a result, the animal is not dependent upon a dietary source of these vitamins.
- One of the chief disadvantages of rumen fermentation is that most dietary proteins are partially degraded and the ammonia which is produced is re-synthesized into microbial proteins. This is a wasteful process.
- In addition, readily available carbohydrates such as sugars and starches are rapidly and completely degraded the major end products are the volatile fatty acids, namely acetic, propionic and butyric acid.
- These VFAs are used readily by the animal's tissues and are used less efficiently for energy than the original carbohydrates.

- In the fermentation process as much as 8-10% of the energy consumed is converted to methane (CH_4), as gas which is wasted and animal can not utilize.
- The feed conversion efficiency is low in ruminants than monogastric animals.
- The feed conversion ratio (FCR) in ruminants is twice or more that of monogastric species and the FCR is defined as the units of feed consumed per unit of product produced.
- The overall effect of rumen fermentation is that these animals can survive and do well on less complex and lower quality diets than monogastric species,
- but on the other hand good quality dietary ingredients are used less efficiently than by monogastric.

Conditions in the Rumen

Here are certain generalizations that we can make regarding the rumen:

- Temperature is usually maintained within the range of 38-41°C with 39°C used as a common mean temperature.
- Rumen pH can range from around 7.0 on forage diets to as low as 4.6 on high-grain diets.
- Mean redox potential is -350 mv reflecting the strong reducing environment and the absence of oxygen.
- Carbon dioxide and methane are the major gases present in the rumen.
- The solid and liquid digesta leave the rumen at different rates.
- The reticulo-rumen is a very muscular organ undergoing frequent movements for adequate mixing of the mass of fermenting material, so as to bring the

- The lining of the reticulum is more symmetrical and forms a trellis-like pattern or honeycomb, hence its name.
- The mass of papillae present in the rumen which increases the surface area in contact with the ingesta.

Microbial population in the Rumen

- Bacteria = 10^{10} / ml of rumen liquor.
- Cellulolytic bacteria = 10^7 / ml of rumen liquor.
- Protozoa = 10^5 / ml of rumen liquor.
- Fungus = 10^3 / ml of rumen liquor.
- Yeast = very small numbers.

Rumen fermentation of carbohydrates

- is very important phenomena, thereby grazing animals or ruminants depend upon grazing vegetation which is almost carbohydrates with less proportion of fats, proteins and minerals.
- Thus the degradation of carbohydrates is very important aspect of utilisation of feeds of ruminants.
- The diet of ruminants contain considerable quantities of cellulose, hemicellulose, starch & water soluble carbohydrates.
- Young pasture frequently sole feed for ruminants; contain about 40% cellulose and hemicellulose, and 20% water soluble carbohydrates.
- In mature herbages (hays and straw) the proportion of cellulose and hemicellulose is much higher (60%) and water soluble carbohydrates content decrease.

- The breakdown of fibrous complex feed material is accomplished by the enzyme called Cellulase present in the micro-organisms of the rumen.
- For these microbes the rumen provides both the capacity and other factors which are most favorable to its activity.
- In addition to the digestion and break down of the higher CHO these organisms are responsible for the synthesis of certain essential nutrients, specifically amino acids and vitamins
- Mainly three types of volatile fatty acids (VFA'S) are produced in the rumen, namely acetic, propionic and butyric acid by action of microbes from the intake of feeds.
- The proportion of the acids formed varies with the nature of the ration, the organisms present and other factors.
- Acetic makes up from two-third to three-fourths or more

- roughage diets high in cellulose give rise to acid mixtures particularly high in acetic acid.
- As the proportion of concentrates in the diet increase, the proportion of acetic acid fall and propionic acid proportion rise.
- With all concentrate diet propionic acid may even be more than acetic acid because of the decrease in the number of cellulolytic bacteria which are favoured by high cellulose diets,
- but promote starch fermenting bacteria which promote propionate production which is needed in fattening animals.
- The volatile fatty acids not only produced by the fermentation of CHO, some may come from the fermentation of protein or nitrogenous compounds in the rumen.

- Much of the VFA (>90%) is absorbed in foregut rumen, reticulum and omasal walls.
- Some may pass through the abomasum and be absorbed in the small intestine (about 80% VFA is absorbed in the rumen wall).
- After the VFA absorbed by diffusion through the rumen wall they go to the portal blood circulation then to the liver.
- Acetic acid is the major end product of carbohydrate digestion, in the ruminants.
- This VFA pass almost unchanged to the rumen wall to the liver which is little affect by the liver and goes to the peripheral blood or systemic blood in significant amounts.

- Propionic acid passes across the rumen wall where a little is converted to lactate, the remainder carried to the liver where it is changed into glucose which may be changed to liver glycogen, or to fatty acids for triglyceride synthesis.
- The remainder of glucose goes to systemic blood supply and is carried to various tissues and used as source of energy or fatty acid synthesis, & for glycogen synthesis.
- Only a small amount of propionate present in the peripheral blood supply which can be used directly for energy production.
- Butyric acid (butyrate) is changed in its passage across the rumen wall or metabolised by rumen epithelium to hydroxybutyric acid (BHBA) and passes into the portal

- The remaining small amount of butyrate that may appear in the portal blood will be removed entirely by the liver, leaving negligible amount in the arterial blood.
- BHBA pass liver to systemic blood and serve as source of energy and for synthesis of fatty acids in various tissue notably skeletal muscles.

Digestion of lipids in the reticulo-rumen

- Compared to carbohydrates and proteins, lipid comprise small but non negligible proportion of ruminants diet with the lipid content of forages ranging up to 3%.
- In fact in ruminant diets fat content in excess of 2-3 % of feed DM are inhibitory to microbial activity in the rumen.

Lipids for ruminant animals are basically three types,

- Galactolipid, found in grasses and clovers which form major dietary fat of ruminants.
- Triglycerides most abundant in seeds of plants. So it is

- The galactolipids will be hydrolysed by bacterial lipases into free fatty acids, glycerol and galactose.
- Triglycerides into free fatty acid and glycerol, Phospholipids are hydrolysed into fatty acids and glycerol with phosphate attached.
- After this secondary type of reaction takes places, Galactose is a monosaccharide, so will be converted to VFA (acetic, propionic, butyric).
- Glycerol is a three carbon compound (trihydroxy alcohol), so it will be changed to propionic acid not to acetic (C2) and butyric (C4) compounds.
- In general the capacity of the rumen microbes to digest lipids is strictly limited and influenced somewhat by the

Digestion of protein in the reticulo-rumen

- Food proteins of plants and animal origin are hydrolysed to polypeptides then to smaller peptides and amino acids by extracellular microbial proteases.
- The amino acids are degraded further by intracellular microbial deaminases to ammonia and organic acids, and CO₂.
- The ammonia produced together with small peptides and amino acids is utilised by rumen micro-organisms to synthesise microbial proteins.
- 60-90 % daily nitrogen intake of ruminants is converted to ammonia, which is a preferred or essential source of nitrogen for rumen microbial protein synthesis.
- 60-80 % bacterial nitrogen is derived from ammonia balance from amino acids or peptides.
- NPN sources(amides, ammonium salts, nitrate) also readily degraded in the rumen to ammonia then to microbial protein

- After this when the organisms are carried through to the abomasum and small intestine they will be digested by the proteolytic enzymes of the host and absorbed as amino acids.
- The microbial protein so formed is of high biological value as measured by growth trial.
- It has been shown experimentally that the true digestibility of crude protein of bacteria is 83% containing 53% CP, while that of protozoa + bacteria having 47% CP the true digestibility is 81%.
- An important feature of the formation of microbial protein is that bacteria are capable of synthesising indispensable and dispensable amino acids, thus

Omasum:

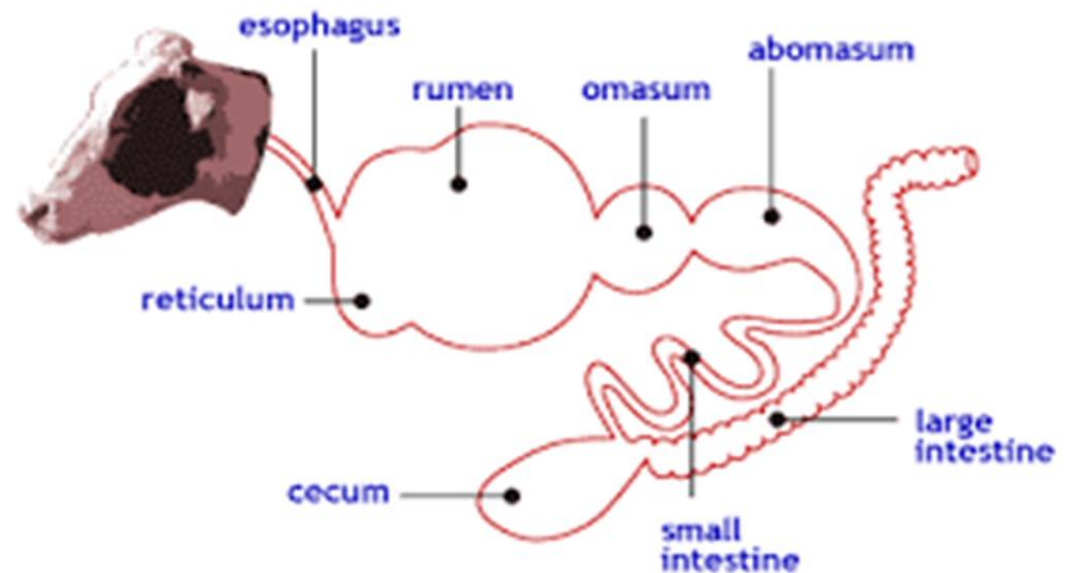
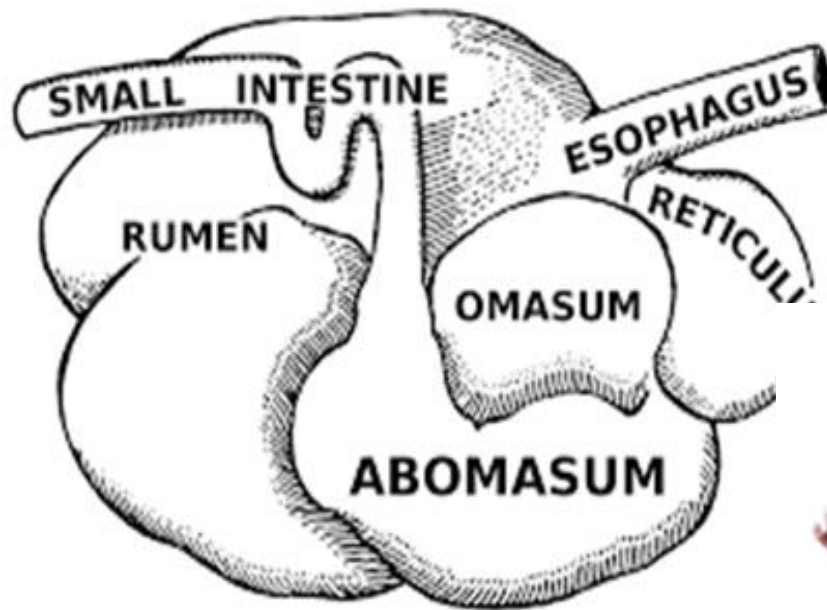
- The word omasum means a book, and the organ is so named because
 - the inside surface is formed by a large number of layers of epithelial tissue giving the appearance of the leaves of a book.
- The feed passes into the omasum only when it has been ground down or fermented into fine particles of the same consistency as finely chopped mint in a well-made mint sauce.
- The main function of omasum is to absorb water from the digesta, so that the material can enter the **abomasums** and mid-gut in a more concentrated state.

Small intestine:

- The surface area of small intestine is proportionally greater than its length because, the internal surface contains many villi, small rod-like projections which increase the surface area many times.
- The villi ensure that the maximum amount of digesta is

Colon (Large intestine):

- The main function of colon is to remove excess water from the digesta.
- Colon is inhabited by numerous micro-organisms and some secondary fermentation takes place throughout its length



Organs associated with ruminant digestion

Salivary glands:

- are situated in the head and they secrete copious quantities of saliva into the mouth and gut, up to 150 lit/day.
- Saliva provides water to enable the feed to be masticated into a sort of paste before being swallowed.
- The saliva acts as the buffering agent when enter the reticulo-rumen.
- Saliva is beneficial for production of VFA's in the rumen.

Liver:

- the liver stores energy in the form of glycogen.
- liver extracts ammonia from the blood stream and converts it into urea and it converts numerous complicated chemicals from one form to another, to enable them to be utilized with greater efficiency at the appropriate anatomical site.

Pancreas:

- the function of pancreas is to secrete numerous enzymes into the duodenum ,which continue the process of protein and carbohydrates digestion and commence the process of digestion of fats.
- The pancreas produces the insulin which is secreted into the blood and plays a vital role in intermediate carbohydrates metabolism in the body tissues.
- One of its functions is to assist in the conversion of blood glucose to glycogen which is stored in liver as energy reserve.

Kidneys:

- the function of kidneys is to excrete waste products from the blood and to discharge in the form of urine to the bladder.
- Three types of waste products are excreted by the kidneys, namely

Absorption of digested nutrients

- The main organ for the absorption of dietary nutrients by the monogastric mammal is the small intestine.
- This part of the tract is specially adapted for absorption because its inner surface area is increased by folding and the presence of villi.
- Although the duodenum has villi, this is primarily a mixing and neutralizing site, and the jejunum is the major absorptive site.
- Absorption of a nutrient from the lumen of the intestine can take place by passive transport, involving simple diffusion, provided there is a high concentration of the nutrient outside the cell and a low concentration inside.
- The vascular system in the villi is arranged so that the concentration gradient is maximized.
- Alternatively, absorption may be by a process of active transport (or co-transport).

- Here, the carrier has two specific binding sites and the organic nutrient is attached to one of these while the other site picks up a sodium ion (in the case of monosaccharides and amino acids) or a hydrogen ion (in the case of dipeptides).
- The sodium or hydrogen ion travels down the chemical gradient and the loaded carrier thus moves across the intestinal membrane and deposits the organic nutrient and the sodium or hydrogen inside the cell.
- The empty carrier then returns across the membrane, free to pick up more nutrients.
- A third method of absorption is by pinocytosis 'cell drinking', in which cells have the capacity to engulf large molecules in solution or suspension.
- Such a process is particularly important in many newborn suckled mammals in which immunoglobulins present in colostrum are absorbed intact

***Metabolism of absorbed
nutrients
(Your assignment)***

THANKS!!

5. Nutritional Disorders in Farm Animals

- Some of these diseases are more prevalent in animals with a high production potential others to improper nutritional management and
- Many of them by the combination of the two factors.
- These factors result to metabolic disorders /disease.

1. Bloat (Tympanites)

- Bloat is a disorder of ruminants and is an excessive accumulation of gases in the rumen.
- Excess rumen gas production like CO_2 and CH_4 which are results of nutrient fermentation.
- Bloat is characterized by the distension of the rumen by a foaming mass of contents which the animals cannot eliminate by belching

Bloat can be divided into two;

1) frothy bloat (primary rumen tympany)

2) free gas bloat (non-frothy bloat, secondary rumen tympany).

→ The 1st one is caused when the gas is mixed in the rumen digesta and form a very small bubbles like the foam.

→ This is the most common form of bloat.

→ It is acute bloat which can kill the animal in as short as half an hour.

→ The 2nd one is caused due to oesophageal obstruction or

- Non-frothy bloat is the least form of bloat encountered.
- Except in the case of complete obstruction, this form of bloat arises more gradually and is chronic or intermittent depending up on the cause.

Treatment

- If the life of the animal is compromised one can use trocar and canula. A knife may also be used in emergencies.
- If the life of the animal is not in danger, the other recommended measured is to use a large stomach-tube, but this is appropriate in free gas boat.
- In frothy bloat, administering anti-frothing agents like poloxalene (Intra-ruminal injunction).
- Other anti-frothing agents are corn oil, peanut oil, soybean oil, vegetable oil, paraffin.
- Mild cases may be home treated by keeping the animal on its feet and moving and drenching above mentioned

2. Indigestion or acidosis:

- This happens when there is a sudden shift from high roughage to a high concentrate ration.
- Sudden change in the dietary of animals on high grain feeding of wheat, corn etc. leads to acute and fatal indigestion in ruminants.
- Feeding ruminants on large quantities of grains contains soluble sugars leads to,
 - ↳ massive production of lactic acid in the rumen as results of rumen fermentation.
- The accumulation of lactic acid in the rumen as a result of fermentation causes the pH to fall between 4-5 in extreme cases.
- Under these conditions the rate of absorption of VFA are increased but lactic acid absorption is unaffected.
- An acidic condition in the rumen inhibits the normal contractions of reticulum and rumen, which affects the

- Cattle fed entirely on concentrates without any roughage develop acidosis.
- This acidity also causes gastro-enteritis causing ulcers.
- The microbes may also go to other organs and cause infections, particularly in liver causing liver abscesses.
- Toxic products may also be produced and absorbed causing cardiac, hepatic, CNS & renal damages.
- The lactic acid produced will be absorbed and may decrease blood pH.
- In addition diarrhoea and dehydration occur due to the gut fluid hypertonicity.
- In severe cases coma, death occurs.

- This can be ascertained by the determination of pH of the urine which is between 5 & 6.
- That indicates as acid-base equilibrium of the animal has been disturbed as the normal animal should have pH between 7-8.
- If the animal survives the initial acute acidosis, the animal still exhibits symptoms of loss of appetite.
- This is due to modification in rumen microflora and damage to the rumen epithelium.

Treatment

- Removing rumen content and replacing by contents of an animal on a normal ration (rumenotomy)
- Feeding a high level of antibiotic to suppress lactic acid producing bacteria.
- Drenching (intravenous injection) with a solution of sodium bicarbonate to restore the acid base balance.
- Lessening total amount of the ration and returning to a high forage feed.

3. Milk Fever (Hypocalcaemia):

- In high producing cow immediately after parturition, the calcium level goes down so much that animal becomes unconscious and dies if treatment is not given.
- Also referred to as *Parturient paresis* because it manifests soon after parturition, as an increase in the blood flow to the mammary gland.
- Not only Ca but sometimes P level also goes down.
- This condition is more common in cross-bred and exotic cows as they are high producing animals.

Causes:

- Low blood calcium concentration.

Symptoms:

- Loss of appetite, constipation soon after calving
- Nervousness, loss of consciousness
- Head turned/twisted toward shoulder

Treatment:

- Administering calcium salts intravenously .

Prevention:

- Diet with proper phosphorus: calcium (ratio)
- High Vitamin D ration 5 days before calving.



Milk Fever in sheep

Symptoms:

- Loss of appetite
- Depression
- Muscle tremors
- Grinding teeth
- Muscular paralysis
 - ↳ Lies on sternum
 - ↳ Head to side
- Possible death



4. Ketosis (acetonemia)

- In cattle it is observed in early lactation and in sheep in the last month of pregnancy especially when they are carrying twins and triplets.
- Under conditions of nutritional and/or physiological stress, where energy demand exceeds the available tissue glucose fat is mobilised for energy purposes.
- That yields more number of acetyl coenzyme A which is a potential source of ketones due to oxidation of fats,
 - ↳ In which all of them cannot enter the TCA cycle at a rate at which it can be oxidized, therefore ketone bodies are formed.
- Such ketone bodies include acetone, acetic acid, B-hydroxybutyric acid accumulate that results in ketosis.

- As the bodies accumulate in the blood, **acetonemia** results and they spill over into urine, producing **acetonuria**.
- Two of the ketone bodies are strong acids and their excessive production uses up the alkali reserve of the blood, producing **acidosis**.
- Ketosis is the physiological condition responsible for two serious livestock troubles,
 - ↳ acetonemia in dairy cattle and
 - ↳ pregnancy disease in sheep.
- **In both species;**
 - ↳ high blood and urine ketone levels,
 - ↳ a low blood sugar and
 - ↳ depleted glycogen reserve, accompanied by a lack of appetite

Treatment

- like injection of glucose, propylene glycol or sodium propionate daily (glucogenic substances, either with grain or drench).
- Cortisone or ACTH is effective as they mobilise tissue amino acids, some of which can be converted to glucose.
- Intravenous injection of corticosteroid.

4. Urea/Ammonia Toxicity:

- Characterized by neurological symptoms and possible disorder of brain metabolism.

In practice, it occurs following rapid intake of urea that could be due to

- 1) Insufficient mixing of urea in compounded diets.
 - 2) Leaching of urea in troughs, permitting animals to drink solutions containing high concentrations of urea.
 - 3) Excessive consumption of urea from blocks that have been softened by rain.
- The likelihood of toxicity is greater in animals that have not been adapted to urea supplements.
 - Animals that have been fasted for a day or more, and in those with liver dysfunction (eg. Fluke infestation or damage from toxic plants) that prevent them from converting ammonia to urea, are also at risk.
 - Urea itself is not toxic; it is the ammonia produced from

- When large amounts of urea are consumed, the pH and the concentration of ammonia in the rumen increase, and
- more ammonia is absorbed which is normally converted to urea in the liver and excreted in the urine.
- The usual explanation of urea toxicity is that the liver can't cope with the increased absorption of ammonia;
- that the level of ammonia in peripheral blood raises;
- ammonia is carried to the brain in the blood and brings on the clinical symptoms.

- An alternative explanation that has recently been put forward is that when ammonia is in high concentrations in the rumen, some diffuses into the peritoneal cavity and from there goes by lymph drainage to the jugular vein, thus bypassing the liver.
- If this is the case, the efficiency with which the liver removes ammonia is less important than previously supposed.
- Clinical neurological symptoms may not be the only manifestation of urea toxicity.
- Milder forms of toxicity may decrease growth rate without producing any obvious clinical symptoms.
- Vinegar, dilute acetic acid (5% solution), ice-cold water

5. Hypomagnesaemia:

- This condition is a result of Mg deficiency in the diet and leads to muscle tremors/tetany.
- It is more common in grazing cows and is often known as **grass tetany**.
- Intravenous or subcutaneous injections of Mg chloride or Mg sulfate are generally given to alleviate the condition.

6. Dysphagia:

- animals during grazing are sometimes being observed to consume or lick materials which in nutritional terms are INERT materials.
- Such could be manifested as the licking of bones, stick, paper eating as well as soil eating.
- These behavioral symptoms are noticeable to deficiencies of phosphorus in the diet of such animal.

- The condition dysphagia also results in metabolic symptoms similar to those of phosphorus deficiency which include.
 - i. Muscular weakness
 - ii. Low fertility and
 - iii. Low productivity
- The practical and effective solution of dysphagia on the farm is:
 - ↳ Introduction or inclusion of adequate amount of phosphorus in the diet.
- The Ca:P ratio of ruminant ratio should always be kept between a range of 1.5:1 to 2:1

7. Abortion:

- This is a condition which results in the expulsion of life or dead fetus by pregnant animals.
- Among several factors, nutrition stands out as a major

- In pregnancy, the fetus develops over time and this calls for increase calcium, phosphorus and other nutrients.
- When the feed is unable to supply required quantity of these nutrients, the fetus development is affected and may be expelled.
- The level of blood glucose is also very important in this condition.
- When an animal is under-fed, the glucose level in the blood becomes lowered and the animals become depressed.

8. Post Parturient Haemoglobinuria:

- Haemoglobinuria has been reported in mature dairy animals when there is **P** deficiency .



10 Q

6. Evaluation of feedstuffs

6.1. Analysis of chemical compositions of feed

- Feed quality assessment can be achieved through its **chemical composition, digestibility** and **palatability** parameters.
- It helps to obtain the highest quality feed for animals and the most profit to produce.
- Feed chemical composition assessment can establish the ground how potent feedstuffs are in supplying the nutrient for the animals.
- Feed chemical composition is vary depending up on number of factors such as
 - ↳ stage of plants maturity.
 - ↳ processing methods.
 - ↳ the genetic make-up of the plants.
 - ↳ the growing soil condition and damage associated with insect.

Feed analysis provides information for:

- Farmers to optimize nutrient utilization in animal feeds;
- Feed compounders to prepare feed mixtures suitable for different animal production systems;
- Researchers to relate animal performance to feed characteristic; and
- Plant breeders to optimize the nutritive value of new varieties.

6.1.1. Proximate analysis system

- Under this scheme various nutrients that had some common properties were grouped together and analyzed.
- These nutrients are known as proximate principles of feed and the analysis called as proximate analysis.
- The method is based on the separation of feed components into fraction or groups in accordance with their feeding value.

Steps involved in obtaining and preparing samples.

- Obtain a small quantity from several locations within a lot of feed.
- Insure that samples are randomly selected and sufficient in amount.
- Finely grind or chop the sample and mix until each spoonful is representative of every other spoonful within the given lots of feeds.
- Keep the sample in a tightly closed container or refrigerate if necessary to avoid further change in chemical composition.

1. Water/Moisture

- Usually it is recorded as the loss in weight of the sample as a result of,
oven-drying it to a constant weight at atmospheric pressure and at a temperature just above the boiling point

Procedure for determining the water content

- Weigh a small amount of the sample into an appropriate container (W1)
- Drying a feed sample in appropriate an oven set at 100-105°C for 12-24 hours After drying weight the sample residue (W2) and calculate.
- **% Water = $\frac{W1-W2}{W1} \times 100$ or $\frac{\text{weight lost upon drying}}{\text{sample weight}} \times 100$**
- Once the moisture content of the feed is determined the dry matter content of the feed sample is calculated,
as the difference of water content from 100 as broadly feed is partitioned into dry matter and water part.
- Forage and other feedstuffs analysis should be done on DM basis.

2. Ash

- Ash is the inorganic residue from the burning of a sample at about 500- 600°C.
- Ash embraces the most part of the inorganic or mineral composition of the feed.
- On ignition all the organic matter is oxidized and inorganic matter remains.

Procedure;

- Weight small quantity of the prepared sample into a small container.
- Ignite the sample in muffle furnace at 600°C for 2 hrs.
- Weight the ash with its container.
- Calculate the % mineral or **%Ash = Weight remain in contai. X 100**

Sample weight

⊗ **NB:** Once the ash value was known ash minus 100 will

3. Crude protein

- Protein always seems to be in short supply, so a good estimate of the protein content is vital in diet formulation.
- In the procedure, protein is not directly measured but nitrogen is determined and multiplied with conversion factor to estimate the protein value of the feed.
- Probably the protein content of a feed is also an indirect measure of its digestible energy,
- because the protein component of feeds is usually highly digested as compared with the coarser carbohydrates.

Crude Protein determination procedures have three phases:

1. The digestion phase:

- In this phase the feed sample will be digested by concentrated H_2SO_4 in the digestion tube to oxidize

2. Distillation phase:

- In this phase the digested product ($(\text{NH}_4)_2\text{SO}_4$) will be cooled, diluted with water and basic solution of NaOH added.
- The addition of the base in this phase liberates ammonia from the sulfate form.

3. Titration phase:

- in this phase the quantity collected will be determined by titration or automated colorimetric method.
- It is simply neutralizing the ammonia with a standard acid (HCl or H_2SO_4).
- The acid is formulated so that 1ml of the acid will neutralize 1 mg of **N**.
- Once ml of the acid used for titration are known, **N** content can be easily calculated.

$$\%CP = \%N \times 6.25$$

4. Ether extracts (EE)

- This is a group that insoluble in water and soluble in organic solvent.
- Ether extract or crude fat is estimated by extracting the known amount of feed sample through fat solvent for a time of specific hours, 8 hrs, at 55°C to 60°C in specially made soxhelets apparatus.
- The weight of the residue left after evaporation of the solvent is called ether extract.

$$\%EE = \frac{\text{Weight of EE} \times 100}{\text{Weight of the sample}}$$

5. Crude Fiber

→ refers to the residue of a feed that is insoluble after successive boiling with dilute alkali and dilute acid.

Procedure:

- Weight out small quantity of prepared sample (W1).
- Boil the sample in dilute H_2SO_4 for 30 minutes and filter.
- Then boil in dilute NaOH for another 30 minutes and filter it.
- These extraction removes protein, starch, sugars, more soluble hemicellulose and minerals and possibly some lignin.
- Dry the residue and weight (W2) this residue contain CF and insoluble mineral matter.
- Ash the residue to oxidize off the CF and weigh the ash (W3)

$$\rightarrow \%CF = \frac{W2-W3}{W1} \times 100$$

Van soest fiber analysis

- This system was developed because it was determined that the ADF did not accurately estimate the energy content of forages for ruminants.
- This method consists of measuring NDF(Neutral Detergent Fiber)and ADF (Acid Detergent Fiber) fractions in forages.
- Van Soest separated these two components successfully by use of two detergents, a neutral detergent and an acid detergent solutions.
- The concept behind is that plant cells can be divided into less digestible cell walls (hemicellulose, cellulose and lignin) and mostly digestible cell contents (contains starch and sugars).
- Hemicellulose , Cellulose and Lignin are NDF.
- Cellulose and Lignin are ADF.
- Neutral Detergent Fiber is a good indicator of "bulk" and

- **Neutral Detergent Fiber (NDF)** – Neutral detergent fiber is determined by boiling the sample in a detergent solution with a pH of 7.0.
- The soluble portion is removed (sugars, starch, pectins, lipids, soluble carbohydrates, protein, non-protein nitrogen), and the insoluble NDF fraction remains.
- The NDF contains cellulose, hemicellulose, lignin, silica, and any heat-damaged protein.
- Neutral detergent fiber estimates the intake potential of the forage.
- Forages with a high NDF content are considered to be lower in quality.
- High levels of NDF cause forages to be eaten in lesser amounts than forages with low NDF levels.
- The NDF content increases with advancing maturity of forages.

Procedure

- 1 50 mg of oven dried sample (W1).
- 2 Add 50ml of NDS.
- 3 Heat until boiling.
- 4 Let cool for 60 minutes.
- 5 Transfer to crucible and wash the residue twice with hot water and finally filter.
- 6 Dry the crucible containing the sample in oven at 100c° for 8hrs.
- 7 Take the weight (W2)

$$\% \text{ NDF} = \frac{\text{W2} - \text{Crucible wt}}{\text{W1}} \times 100\%$$

Acid Detergent Fiber (ADF)

- Acid detergent fiber is determined by boiling the sample in an acid detergent solution.
- The soluble portion is removed, and the insoluble ADF fraction remains.
- The ADF contains cellulose and lignin.
- Most laboratories use ADF to estimate the digestibility and energy value of forages.
- High levels of ADF cause forages to be less digestible, and have a low energy value.

Procedure

- 1 50 mg of oven dried sample (W1).
- 2 Add 50ml of ADS.
- 3 Heat until boiling.
- 4 Let cool for 60 minutes.
- 5 Transfer to crucible and wash the residue twice with hot water and finally filter.
- 6 Dry the crucible containing the sample in oven at 100c° for 8hrs.
- 7 Take the weight (W2)

$$\% \text{ ADF} = \frac{\text{W2} - \text{Crucible wt}}{\text{W1}} \times 100\%$$

6. Nitrogen Free Extract (NFE):

- This part is determined by difference rather than following specific system.
- As a result, the deduction of the above five fraction from hundred give us the NFE portion of a feed.
- **$NFE = 100 - (water + ahs + EE + CF + CP)$**

6.2. Digestibility determination

- Nutrients present in the feedstuffs are not completely available to animal body.
- Large portion of the nutrients are excreted in the feces because of being not digested in the alimentary tract.
- Digestibility measures the availability of feed nutrients and provides a very good index of nutritive value of the feed.
- Therefore, the digestibility of a feed is most accurately defined as that portion of the feed not exerted in the feces and which is, therefore, assumed to be absorbed by the animal.

Methods of digestibility determination

1. In vivo methods of digestibility test

- It takes place within the digestive tract of live animals and assumed to be the most reliable method.
- However, it is more expensive, time consuming and labor demanding activity.
- Because, three or more animals per treatments are required, as well as time needed for adaptation of animals to the feed and consequent time required for intake and feces determination period and also labor needed to manage the animals under trial.
- With simple theoretical assumption the digestibility determined in this method is the difference between dry matter of feed intake and that of feces.
- The feed under investigation should be given to the animals in a quantified amount and the amount of refusal and feces voided should be correctly recorded.

→ But the value generated is called apparent digestibility rather than true digestibility as some endogenous components are excreted in feces in addition to feed fecal output.

→ DM digesti. (%) = $\frac{\text{DM intake} - \text{output DM}}{\text{DM intake}} \times 100$

} Endogenous loss include epithelial cells of the intestine, enzymes and products of bacteria fermentation.





2. In vitro methods of digestibility test

- Since conventional method of digestibility trial is laborious to undertake and expensive,
- there have been numerous attempts made to determine the digestibility of a feed by simulating in the laboratory, this is among those.
- involves the combination of chemical system with rumen fluid which is faster and often gives better replication but give a poorer reflection of biological reality.
- It is commonly applicable for ruminant than for non-ruminants as it is difficult to simulate the environment that is relatively similar to digestive tract.
- As a result in ruminant animals digestive tract secretions are collected through canola and to use them to digest feeds in vitro.
- the finely ground sample of feed is incubated for 48 hours with rumen liquor and buffers (based on the

- In the second stage the rumen bacteria are killed by acidifying with hydrochloric acid and then digested by incubating them with pepsin for 48 hours.
- Dry matter disappearance is determined by subsequent filtration, drying and weighing of the residues.
- DM digestibility % = $\frac{\text{sample weight} - \text{residual wt.}}{\text{sample weight}} \times 100$

3. In sacco digestibility technique

- The system is also called in situ, nylon bag, cloth bag methods.
- The nylon-bag technique provides a means of *ranking feeds* according to the *rate* and *extent* of degradation of dry matter, organic matter, nitrogen or other nutritional parameters.
- It involves incubating samples of feeds in the rumens of fistulated animals for periods of from 6 to 120 hours and subsequent determination of the disappearance of the

- The disappearance of the feed from the bag is an estimate of degradability.
- It uses a bag with 6.5cmx14 cm made of nylon mesh/pore size of 30-50 μ m.
- The pore size of the bags must allow entry of rumen microbes and escape of accumulated gases, and keep solid particle losses to a minimum.
- Then incubate the sample on the intended time based on the nature of the feed with one extra empty bag to correct for passage of material from pressure applied to the nylon bags during washing.
- Remove and immediately wash the bags (including the zero hour samples) with cold water for about 30 minutes in a washing machine, or under running tap water while rubbing gently between thumb and fingers until the water runs clear.

- Dry and determine the dry matter of the residue samples using the same method as with feed samples.
- Finally, calculate the disappearance using the formula:
- $$\text{Disappearance} = \frac{(\text{SWa} - \text{BW}) \times \text{DMa} - (\text{SWb} - \text{BW}) \times \text{DMb}}{(\text{SWa} - \text{BW}) \times \text{DMa}}$$

where:

- SWa = Weight of the original sample + nylon bag
- BW = Weight of empty nylon bag
- SWb = Weight of the sample + nylon bag after incubation
- DMa = Dry matter of feed sample
- DMb = Dry matter of residue sample.

6.3. Determination of Energy Value of Feeds

- Energy may be defined as the capacity to do work.
- The ability of a feed to supply energy is therefore of great importance in determining its nutritive value.
- The amount of energy that a feed will supply to an animal can be estimated by measuring the amount of energy that is produced when the feed is completely burnt.
- This gives the Gross Energy (GE) content of the feed, measured in MJ or kilocalories.
- However, it is only of limited use since all feeds (apart from those with a very high fat or oil content) have about the same gross energy content.
- All carbohydrates have similar ratios and therefore have approximately the same GE content (approximately

- However, triglyceride fats typically have a higher ratio (contain less oxygen) and therefore have a higher GE value (39.0 MJ/kg DM).
- Some other means of evaluating energy values is clearly needed, since straw obviously has lower energy content than maize grain, but the two have very similar gross energy contents.
- Not all of the GE in feeds is available for use by the animal.
- Some is lost from the animal as various solid, liquid or gaseous excretory products, and some is lost as heat.
- The subtraction of these energy losses from a feed's GE content produces further descriptive measures of feed energy supply; for example,
- subtracting fecal GE from the GE in feed gives a

- Digestible energy represents energy absorbed by the animal.
- DE calculated as the GE of feed minus the GE of the faeces resulting from the consumption of that unit of feed, is the amount of energy that is lost in the feces, having not been absorbed and utilized by the animal.
- As faecal energy loss represents by far the most important and variable loss of energy from animal feed.
- DE is a far better measure of the energy available to support animal production than GE.

Metabolisable energy (ME)

- In addition to energy lost in faeces, energy is also lost as energy-containing compounds in urine, and as combustible gases,
- such as methane produced as a consequence of microbial fermentation in either the rumen or hind gut.

- It represents energy that is available for use by the animal and is calculated as DE minus energy lost in urine and combustible gases.
- The energy in the feed, minus that lost in the feces, urine and as methane, is known as the metabolizable energy (ME).

Net energy (NE) and energy retention

- Subtraction of the heat increment of a feed from its ME value gives the net energy (NE) value of a food.
- The NE value of a feed is the energy that is available to the animal for useful purposes,
- i.e. for body maintenance and for various form of production.
- Animals are continuously producing heat and losing it to their surroundings, either directly by radiation, conduction and convection, or indirectly by the evaporation of water.

THANKS



7. Nutrient Requirement and Ration Formulation

7.1. Nutrient Requirement

- the quantities of nutrients to be fed to the various classes of livestock,
- for different physiological functions like maintenance, growth, production and reproduction.

Nutrient requirement for maintenance

- Animal is in a state of maintenance when its body composition remains constant,
- when it does not give rise to any product such as milk and does not perform any work on its surroundings.
- Animals deprived of feed are forced to draw upon their body reserves to meet their nutrient requirements for maintenance.
- Since the energy so utilized leaves the body as heat, the animal is then in a state of negative energy balance.

- The purpose of maintenance ration is to prevent this drain on the tissues and the maintenance requirement of a nutrient can therefore be defined as,
- the quantity which must be supplied in the diet so that the animal's experiences neither net gain nor net loss of that nutrient which is,
- sufficient to maintain the body weight, besides maintaining normal physiological functions under resting conditions.

Nutrient requirement for growth

- Growth defined as the increase in size of bones, muscles internal organs and other parts of the body.
- It is normal process before birth, and after birth until the animal reaches its full mature size.
- Growth is influenced primarily by nutrient intake, so the nutrient required termed as NRFG.
- Growth pattern of an animal determines nutrition requirements.

Nutrient requirement for reproduction

- Reproduction increases the animals' requirements for nutrients but conversely,
- the nutrient supply of animals can influence their reproductive process.
- The influence of nutrition on reproduction begins in the animal life as the plane of nutrition in young animals can affect the age at which they reach puberty.
- In mature animals, poor nutrition can reduce the production of ova and spermatozoa.
- So that the female either fails to conceive or produce fewer offspring than normal (i.e. litter size is reduced).
- In pregnancy, females have specific nutrient requirements for the maintenance and growth of the fetus.
- Puberty in cattle is markedly influenced by the level of nutrition at which animals have been reared.
- In general terms, the faster an animal grows, the earlier it reaches sexual maturity.

Nutrient requirement for production

- The amount of feed offered to any animal growth, milk production, reproduction, work purpose, over and above maintenance is known as nutrient production purpose.

For Wool production:

- sheep needs more protein for wool growth.
- The lack of protein in sheep ration makes the wool rough and coarse quality.

For milk production:

- The composition and quality of milk varies with breed and species of animals.
- All nutrients of milk come from blood, which should be replaced by feed ingredients.
- The level of milk production will be maintained as low as these nutrients are supplied in diet according to needs of animals,
- therefore cow needs additional nutrients for milk production of energy 3 kg of milk one kg concentrates in addition be given to the cow.

For egg and meat production in poultry

- Egg contains 67% water, 13% protein, 9% fat and 11% minerals.
- All these nutrients are supplied by blood for egg formation.
- The feeds of nutrients are more nutritive therefore all essential minerals, vitamins and amino acids should be present along with enough energy in the feed.
- Also the protein in poultry ration is of good quality containing, lysine, and methionine, arginine, and cysteine, tryptophan for egg and meat production otherwise production will be lowered.

For fattening purposes

- pigs, goats and sheep and calves for beef raised for meat production nutrients,
- should be such that can give a quick return as for growth and meat is concerned for better profit.

7.1.1. Ration Formulation

- Ration is the feed allowed for a given animal during a day of 24 hours.
- The feed may be given at a time or its portion at intervals.
- Balanced ration is a ration which provides the essential nutrients to the animal in proportion and amounts,
 - ↳ Which are required for the proper nourishment of the particular animal for 24 hours for maintenance, growth, production and reproduction.
- Ration formulation is a process by which different feed ingredients are combined in a proportion,
 - ↳ necessary to provide the animal with proper amount of nutrients needed at a particular stage of production.

Information needed for ration formulation

1. Nutritional requirement of the animals.
 - 1 Different species, strains or classes of animals have different requirements for energy (carbohydrates and fats), proteins, minerals and vitamins in order to maintain its various functions like maintenance, reproduction, production (egg production, lactation and/or growth).
2. Nutrient composition of the available feedstuffs.
3. Desired production level (ex. rate of gain).
4. Nutrient availability (digestibility).
5. Cost of available feedstuff.
6. Expected daily feed intake.
7. The ration should be palatable and will not cause any serious digestive disturbance or toxic effects to the animal.

- It should be remembered that rations for animals are formulated as-dry matter basis,
 - ↓ due to wide variations in moisture content of feeds from as-fed base.
- Dry matter basis refers to the feed with the water removed, as-fed basis refers to the feed as it is fed to the animal (it includes the water).
- The following example can help you convert between these two forms.

Converting nutrients on an as-fed basis to a dry matter basis:

% nutrient (DM basis) = % nutrient as-fed ÷ % DM (make sure to put this value on a decimal basis, ex. 50% = 0.50)

Ex. A commercial steer feed contains 12% CP on an as-fed basis and is 90% DM. What is the percent CP on a dry matter basis?

$$\begin{aligned}\% \text{ nutrient (DM basis)} &= 12\% \text{ CP as-fed} \div 0.90 \\ &= 12 \div 0.90 \\ &= 13.3 \% \text{ CP on a dry matter basis}\end{aligned}$$

Converting nutrients on a DM basis to an as-fed basis:

$\% \text{ nutrient (as-fed basis)} = \% \text{ nutrient as-DM} \times \% \text{ DM}$
(make sure to put this value on a decimal basis, ex. 50% = 0.50)

Ex. A commercial steer feed contains 16% CP on a dry matter basis and is 85% DM. What is the percent CP on an as-fed basis?

$$\begin{aligned} \% \text{ nutrient (as-fed basis)} &= 16\% \text{ CP} \times 0.85 \\ &= 16 \times 0.85 \\ &= 13.6\% \text{ CP on an as-fed basis} \end{aligned}$$

Converting amount of feed on an as-fed basis to a DM basis:

$\text{Kg of feed on DM} = \text{Kg of feed as-fed} \times \% \text{ DM}$

Ex. You have 2000 kg of corn silage which is 35% DM. How many kg of corn silage on a DM do you have?

Converting amount of feed on a DM basis to an as-fed basis:

$\text{Kg of feed as-fed} = \text{Kg of feed as DM} \div \% \text{ DM}$

Ex. A beef animal requires 12 kg of DM per day. If the ration is 75% DM, how many kg of feed do you need to feed this animal?

$\text{Kg of feed as-fed} = 12 \div 0.75$ (remember, divide DM by 100)

$= 16 \text{ kg as-fed}$

- ⌘ It is best to balance rations on a dry matter basis and then convert the ration to an as-fed basis, due to the moisture differences found in feeds.
- ⌘ When converting from "as-fed to DM?"
 - 1) The nutrient content will increase.
 - 2) The weight will decrease
- ⌘ When converting from "DM to as-fed?"
 - 1) The nutrient content will decrease.

- We can balance rations by hand or by using specifically designed computer software (Trial and error)
- One of the more common and useful methods of hand balancing rations is the Pearson Square.
- This method allows you balance for a single nutrient using two feeds. however, one or both can be a mixture.
- Here are the steps;

1. Draw a square:



- 2. Place the concentration of the nutrient you want at “E” (example: balance for 15% CP, DM basis)
- 3. Place the concentration of the nutrient in each of the two feeds at “A” and “B”.
- 4. Subtract diagonally ($B - E = C$ and $A - E = D$) and don't worry if you have a negative sign.

A. Corn = 10% CP

C. $45 - 15 = 30$ parts

15% CP

B. Soybean Meal = 45% CP

D. $15 - 10 = 5$ parts

5. "C" represents the part of the ration that is from Feed A (corn) and "D" represents the part of the ration that is from Feed B (soybean meal).
6. Sum "C" and "D" ($30 + 5 = 35$ total parts)

- Now you can calculate the appropriate proportions of each ingredient!
- To do this you divide the “part” by the “total”, and multiply by 100, to express as a percentage.

$$\begin{aligned}\text{Corn} &= (30 \div 35) \times 100 \\ &= 0.856 \times 100 \\ &= 85.6\% \text{ corn}\end{aligned}$$

$$\begin{aligned}\text{Soybean meal} &= (5 \div 35) \times 100 \\ &= 0.143 \times 100 \\ &= 14.3\% \text{ soybean meal}\end{aligned}$$

$$\text{Check} = 85.6 + 14.3 = 100\%.$$

Factors to be considered in making good feed formulations are:

- Acceptability to the animal.
- Digestibility.
- Cost.
- Presence of anti-nutritional factors and toxins.

Anti- Nutritional Factors

- substances which either by themselves or through their metabolic products,
- interfere with feed utilization and affect the health and production of animal or
- which act to reduce nutrient intake, digestion, absorption and utilization and may produce other adverse effects.
- Many plant components and seeds of legumes and other plant sources contain in their raw state wide varieties of anti-nutrients which are potentially toxic .
- Being an anti-nutritional factor is not an intrinsic characteristic of a compound but depends upon the digestive process of the ingesting animal.
- Trypsin inhibitors, which are antinutritional factors for monogastric animals, do not exert adverse effects in ruminants because they are degraded in the rumen.

- In general ANFs usually affect mono-gastric species unlike poly-gastric animals as they are not degraded in their stomach except cyanide.
- They are classified on the basis of type of nutrients they affect directly or indirectly, and the biological response produced in the animals.

A. Substances depressing digestion or metabolic utilization of proteins:

- I. Protease inhibitors
- II. Lectins
- III. Saponins
- IV. Tannins

B. Substances reducing the solubility or interfering with the utilization of mineral elements:

- I. Phytic acid
- II. Oxalic acid
- III. Glucosinolates
- IV. Coumarins

C. Substances inactivating or increasing the requirements of certain vitamins:

- i. Anti-vitamin A, D, E and K
- ii. Anti-thiamine, nicotinic acid, B₆ and B₁₂

Methods of reducing anti-nutritional substances

A. Heat treatment

- It is widely accepted as an effective means of inactivating the thermo labile ANFs of legume grains.
- particularly cowpea, Soybean, pigeon pea and winged beans are notably improved by heat treatment.
- It improves protein quality by inactivating anti physiological factors, particularly trypsin inhibitors and lectins.
- by unfolding the protein structure, thus making them more susceptible to attack by digestive enzymes.

B. Cooking (boiling)

- It generally inactivates heat sensitive ANFs such as trypsin and chemotrypsin inhibitors and volatile compounds.

C. Autoclaving

- It entails cooking under pressure.
- thermo labile substances such as cyanogenic, glycosides, saponins, and alkaloids would not be detected after autoclaving.

D. Germination

- Germination has been shown to be an effective method to reduce ANFs contents by mobilizing secondary metabolic compounds.

E. Chemical treatments

- Various chemical treatments have been employed in attempt to improve the nutritional values of legumes.
 - the use of polyethylene glycol, by far the most used reagent to neutralize these secondary compounds .
- ⌘ So we have to consider these anti-nutritional factors and use the method that reduces their effect while we formulating a ration.

8. Feed processing Techniques

- It refers to the operation necessary to achieve the maximum potential nutritive value of feedstuff to maximize their nutritive value and the net returns from their use.
- It involves changing ingredients of widely ranging,
 - ↳ physical
 - ↳ chemical and
 - ↳ nutritional composition into a homogenous mixture (mixed compound feeds) which is
- suitable for producing a desired nutritional response in the animal to which the mixture is fed.
- They designed to provide all known nutrients

- Feed processing is basically a physical one and chemical changes are few.
- Physical changes involve addition or removal of moisture, treatment with heat or pressure, agglomeration (a clustering together) and particle reduction.
- Chemical changes may involve structural changes in the starch and disrupting the protein matrix that may result in changes in digestibility and metabolic end products.
- In some cases both physical and chemical changes occur at the same time and are usually

Storage and care of raw materials for processing

- Bagged grains are stored in warehouses which are also known as conventional godowns.
- The scientific requirement to minimize the storage losses; the storage facility should be:
 - ↳ Moisture proof.
 - ↳ Air tight
 - ↳ Insects, birds and rodent proof.
 - ↳ Fire proof.
 - ↳ Should have good aeration system to keep the grains dry and cool.

- The losses due to rats, insects and moisture are considerably higher if the storage structures are not rodent, moisture and insects proof.
- If the storage structure is not air tight then the storage material can not be fumigated which results in higher storage losses.
- Storage is the most important post harvest operation.

Precautions/ measures for reduction of storage losses:

- The grain/ feeds should be properly and reasonably dried before storage.
- The temperature in the storage structure should be maintained below optimum by aeration to avoid moisture migration and reduce activities of microbes.
- Insects should be kept under control to avoid dry and wet heating.
- Storage structure should be rodent proof, leak proof and free from dampness.

Feed processing methods for raw materials

Grinding;

- is the process by which feedstuff is reduced in particle size.
- It is the most common, cheapest and simple methods of feed preparation.
- It is usually accomplished by means of a hammer mill which reduces the particle size of the grain until it passes through a screen of certain size.

Pelleting;

- Pellet can be formed into shapes of varying thickness, length and hardness.
- The larger shapes, commonly fed to cattle and sheep on a range are referred to as cubes.
- The smaller shapes, given to poultry.



- Pelleting decreases wastage of relatively unpalatable forages such as ground alfalfa.
- Pelleting forages prevents animals from selectivity.
- They are less bulky and easier to store and handle.
- Pelleting roughages increases intake by 50% or more.

Rolling;

- is the process by which grain is compressed into flat particles by passing it between rollers.
- It can be without the addition of water (dry rolling) or after subjecting the grain to steam (steam rolling)

Gelatinization;

- Heating(cooking) with steam in order to soften grains/grinded materials.
- Series of irreversible changes take place consequent upon heating the starch granules in water.
- The starch first swells undergoes rapid gelatinization with tremendous increase volume, thereby loses the original granules structure.
- The continued heating causes the swollen starch granules to gradually disintegrate, solubilize and formation of colloidal solution.
- The gelatinization of starch in various media is attributed to chemical affinity of starch molecules.

Micronisation;

- It is a process by which feed subjected to dry heat by microwaves emitted from infrared burners, followed by rolling.

Roasting/heating

- The feed is heated to a desired temperature in an oven for a period of time.
- Roasting increases the availability of carbohydrates and may reduce protein breakdown in the rumen.
- Also it eliminate anti-nutritional factors in a grains.

Soaking;

- a way of immersing the feeds in water to bring out some toxins and to make ready for other process.

Steam processing and flaking;

- processing technique for cereals that subjects the grain to steam under atmospheric conditions for usually 15-30 min, before rolling.
- Heavy roller mills make the grain completely flat and rupture the cells, making the nutrients available more freely to the animal.
- Increases feed efficiency and rate of gain compared with feeding dry rolled cereals.

Chopping:

- it involves cutting forage not less than 5 cm in length.

Ensiling:

- it is refers to the change, which take place when forage or feed with sufficient moisture to allow fermentation is stored in a silo in the absence of air.
- The entire ensiling process requires 2 to 3 week, during which time a small amount of oxygen is deleted with aerobic respiration and anaerobic fermentation occurs.

Cobing (wafering):

- it is a process of compressing long or coarsely cut forages into rectangle about 1.25 inch

Effect of processing of raw materials:

Reduction or alteration in particle size:

- Most of the processes modify the particle size of the raw material and,
- this result in a change in retention time in the rumen and a consequential change in degree of rumen fermentation and in subsequent true digestibility.

Effect of processing on palatability and feed intake:

- The more extreme the processing treatment the greater the effect on animal acceptability and hence on voluntary intake.
- Heat-expanded materials are generally more palatable than the same raw materials in the

Effect of wet or liquid diets;

- The consumption of dry pelleted feed by dairy cows requires about 2 minutes eating time/kg of feed consumed.
- Wetter feeds allow more rapid ingestion and liquid feeds (mixture of 4 kg concentrate/10 kg water) can be consumed in only 0.5-0.8 minute/kg of DM.

To enhance rumen bypass & nutrient accessibility.

To detoxify or remove undesirable substances:

- Excess of certain toxic substances present in feeds may affects animal's performance adversely or even causes death.

Processed Feed Quality Control

- Quality has been defined by various individuals as “fitness for use” or “meeting an expectation” or “degree of excellence” or “conforming to a standard.”

Feed quality control programs were defined as

- “all actions directed towards ensuring the product meets the specifications established by the manufacturer” or
- as “A system for making sure that proper standards are maintained through use of periodic inspections”.

Process control

- The process by which high-quality ingredients are made into high-quality feeds involves three

Personnel;

- Three general characteristics should be sought in new mill employees productivity; interest, alertness and ability to work as a team member.
- Employees should be quickly and efficiently trained to do their jobs.
- The training should include what job to do and why.

Machinery;

- Equipment selection, operation, repair and troubleshooting can become a very complicated matter, which can not be covered adequately in a short period.
- However, applying the following general points to each specific piece of equipment will help

Installation:

- Was the equipment installed according to the manufacturer's recommendations?

Adjustment:

- Are the critical adjustment points within the machine set correctly?

Operation:

- Is the machine being operated according to the manufacturer's recommendations?

Capacity:

- Is the equipment being run within the rated capacity?

Lubrication:

- Is the correct amount of the proper lubricant used within the correct time frame in the machine?

Maintenance:

- Can you predict when maintenance and possible repairs will be needed on each piece of equipment?

Procedures;

- Procedural difficulties are usually fairly easy to identify since problems will tend to repeat.
- However, every procedure instituted should incorporate the following:
- **Communication;** Does the person doing the procedure understand what is expected? If another person had to take over this job would he/she understand?
- **Identification;** Are controls on equipment clearly identified? Are bagged ingredients clearly labeled and stored in an orderly manner?
- **Verification;** Are samples being taken and stored that will allow you to verify the source of the problem?
- **Records;** Are all records being kept of use? Useful records should be stored in a clean, safe and accessible place.

Finished Feed Quality

- finished-feed assays are necessary and important because they provide the mill with a “final report card” on how well quality was controlled.
- As general rule of thumb is to collect one sample of each formula per week or one sample per 100 tons of production, whichever is greater.
- When a problem is discovered, it should be addressed and resolved as soon as possible.

9.Feed treatment methods

The need for feed treatment

- quality pasture is declining and insufficient to support animal nutrient requirements that necessitate looking for other alternatives.
- The increasing pressure on land and the growing demand for livestock products,
 - ↳ makes it crucial to ensure the effective use of feed resources, including crop residues and other agro-industrial by-products.
 - ↳ Because of the increased crop production at the expense of pasture/grazing lands; there will be more crop residues that can be utilized as animal feed.
 - ↳ However, crop residues are of generally low nutritive value and are fibrous.

- crop residues are low in available nutrients, taking longer lag time and slow in rate of microbial fermentation.
- These characteristics of roughage limit its intake and digestibility;
| thereby hamper the productivity of farm animals.
- However, poor quality roughages have the potential for improving animal feeding by employing different treatments/strategies.

Methods of feed treatment

Physical treatment

These modify the physical structure of the

Chopping (by machines with knives or sticks)

- cuts the blades of straw into relatively long sections (from 1 to 10 cm).
- a technique for improving the presentation of long and somewhat tough forage matter, easing its manipulation and handling by the animal.
- Chopping is useful, for example, when feeding long maize stalks.
- It is also done for improving the handling characteristics and in the process of making silage.
- The forage is chopped to facilitate packing and for removal of air.
- Anaerobic fermentation results in the production of acid which stop further microbial breakdown and thus the food can be preserved

Laceration, also called defibering

- gives shorter but variable sections due to bursting the stalk along its length.
- This technique, which increases the absorptive capacity of the forage, is used in developed countries to form a carrier for liquid feed supplements such as molasses and whey.

Grinding (with a hammer mill)

- produces forage particles, which are less than a centimeter in length to reduce their volume and ease handling.
- It has received the most attention; it is also the most common physical treatment in current use.

- Physically treated forage which has been condensed, compacted or compressed is,
 - ↳ normally ingested by ruminants in quantities which are 60 to 80 % superior to that of untreated forage which is more voluminous.
- This phenomenon occurs because the rumen is able to physically process and rid itself of the reduced size forage particles more quickly, hence physically regulating the ruminant's appetite.

Chemical treatments

- These treatments may use one or other of the following chemical agents,
 -] **Oxidizing agents** (peroxyacetic acid, acidified sodium chloride, ozone, etc.) which decompose fairly efficiently the lignin
 -] **Alkali based agents** (lime, potassium, caustic soda and, more recently, ammonia),
- which are able to hydrolyze the chemical bonds formed between the indigestible lignin and the parietal polysaccharides (cellulose; hemicellulose) which respectively, are completely digestible or partially digestible.

NaOH treatment of roughages:

- Poor quality fodders and straws are treated with chemicals like sodium and potassium hydroxides and urea to increase the availability of the nutrients to livestock.
- The alkali is a powerful agent for swelling of cellulose.
- it will also solublize the silica and hemi-cellulose.
- At least 50-60 ml of solution/ 100 g straw was needed adequately to wet the roughage and ensure complete reaction of the added alkali.

Liquid ammonia treatment:

Urea treatment:

- All poor quality of straw, stovers or roughages can also be treated with 4% urea and ensiling for 3-4 weeks improved palatability and digestibility by 10 units.
- Take 100 kg straw + 4 kg urea + 100 lit water, make it air tight.
- It acts in just the same way on the vegetal matter as if anhydrous ammonia is used:
 - ↳ **Dissolving** the parietal carbohydrates (mainly the hemicelluloses),
 - ↳ **Swelling** the vegetal matter in an aqueous environment, so easing access by the rumen's cellulolytic microorganisms,
 - ↳ **Reducing** the physical strength of the cells, so easing mastication by the animal and digestion by the microbes

Biological treatment;

Single cell production

- the cellulose is very resistant to enzymatic hydrolysis so the treatment of cellulosic material is essential.
- The removal of lignin is also very important.
- Hexoses, pentoses obtained on hydrolysis of cellulose and hemi-cellulose are used for SCP production by the action of *Candida* species, but ascertain its economic feasibility.
- Cultivating fungi such as white or brown decomposition rot,
 - which enable the enzymes to break or loosen the bonds between the lignin and the parietal carbohydrates, also decompose the lignin itself.

Feeding treated feeds and supplementation

- The animal will be given the treated straw aerated for overnight for about 15 days of adaptation at most to reduce the pungent smell of ammonia.
- The animal will be given the treated straw at ***ad libitum*** basis.
- They should be provided adequate water than the normal.
- During the morning, the animal should be fed another roughage or let them graze around, and then they should be fed the treated starw *adlibitum*.
- A little amount of mineral mixture should be supplemented

I HANK YOU!!!



LES GRANDES RACES ÉTRANGÈRES

