COURSE CODE:	ANN 502
COURSE TITLE:	Nigerian Feeds and Feedstuffs
NUMBER OF UNITS:	2 Units
COURSE DURATION:	2 Hours

COURSE DETAILS:

Course Coordinator:	**Dr. Richard Abayomi Sobayo**
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Other Lecturers:	**Prof. Daisy Eruvbetine, Dr. Abimbola Oladele Oso**
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COURSE CONTENT:

Survey of Nigerian feeds and feedstuffs. Classification of feeds into roots, tubers, cereals, roughages, etc. chemistry and processing of livestock feed, their storage, quality evaluation. Feeding standard and ration formulation for various classes of livestock. Toxic and antinutritional factors in feeds. Alternative feedstuff. Feed

COURSE REQUIREMENTS:

This is a compulsory course for all final year students of College of Animal Science and Livestock Production. This course is being offered in lecture format on-campus for 14 weeks, students are expected to attend lectures and practical classes, 2 hours of lecture per week. Students are expected have minimum of 75% attendance to be able to write the final examination.

The course grade will be based on 1 exams, CAT and practical work.

READING LIST:

Basic Animal Nutrition and Feeding, W.G. Pond, D.C. Church and K.R. Pond, Wiley, Fourth Edition, 1995

LECTURE NOTES

INTRODUCTION

Nigeria is blessed with vast range of feed resources such as grains, oilseeds and agro-industrial by-products which could be used in the formulation of good quality livestock feed. These local available feed resources in Nigeria have potential to support a flourishing livestock industry. However, these potentials are grossly under-utilized by the farmers resulting in a depressed livestock industry, thus making it second to crop production in Nigeria.

This low capacity feed resources utilization could be linked to inadequate information based on location and localization of feed resources, processing, preservation/storage and quality enhancement/assessment. On the other hand, it is associated with long time dependence by major players in livestock industry on conventional and imported feed resources while cheap local feed resources suffer a great neglect and low patronage.

Nutrition can be defined as the science involving various chemical and physiological activities which transform feed elements (nutrients) into body elements and activities. Nutrition is the process of anabolism, assimilating or transforming food into living tissue. It is called constructive metabolism or tissue building and the cells in the body are responsible for the transformation into different tissues. Nutrition can be defined as the sum of the processes whereby an organism provides itself or it is provided with the materials (nutrients) necessary for energy release, growth, repair, various secretions, storage, transport, maintenance of internal osmotic and pH environment. It is the science

that deals with the interaction between the animal body and its food supply with the ultimate aim of providing a fully adequate food supply for any type of internal and external uses. It involves the ingestion, digestion, transportation, absorption and assimilation of the various nutrients and their transportation to all body cells and the removal of unusable elements/by-products and waste products of metabolism. Nutrition, in essence, aims at providing all essential nutrients in adequate amounts and in optimum proportions. In other words, nutrition is the scientific way of how feed/food is used by the body man, rabbit and farm animals. Nutrition is one of the major constraints to survival and satisfactory productivity of livestock in this country. Feeds and feeding constitute about 65-75% of total production cost in intensive livestock production e.g. poultry and pig production, the ability to judiciously manipulate feed ingredients to maximize productivity is therefore central to the maintenance of a stable poultry production enterprise.

The rapid success and expansion of the livestock industry, therefore depends on the availability of good quality, quantity and cheap compounded feeds. This is particularly true of the intensive livestock enterprises – poultry, pigs and rabbits, whose performance depends mainly on the use concentrate and balanced compounded feeds. Therefore the single most important constraint facing the livestock industry, several problems relating to the inadequate supply, high cost and poor quality of feeds have seriously threatened the (poultry) livestock industry in recent times.

Nutrition is an aspect of science that deals with the relationship of food to the proper functioning of the living body. It includes the intake of food and body's uses of chemicals that the food contains to sustain life, promote growth and provide energy for day to day living. Thus nutrition is concerned not only with food itself but also with the factors which influence the quality, quantity and availability of food nutrients to the body (animal). Those chemical compounds found in food are referred to as chemicals. Good nutrition therefore involves nutrient intake which are adequate in quantity and quality.

Poor nutrition or malnutrition is classified as either under-nutrition, over-nutrition of imbalanced nutrient intake.

Under-nutrition results from inadequate intake of food and/or impaired utilization of available nutrients.

Over-nutrition result from over indulgence of feed food. Over-nutrition during the pre-school years can lead to adult obesity.

Imbalanced nutrient intake results from inadequate feed/food intake or poor quality protein and insufficient calories, is a poor diet which is liable to be deficient in other essential nutrients thus making adequate growth, improved productive performance, and proper maintenance of body functions impossible.

TYPES OF NUTRITION

There are essentially two types of nutrition and these are:

(i) Autotrophic nutrition

(ii) Heterotrophic nutrition

(i) Autotrophic nutrition – occurs in organisms that are capable of synthesizing organic molecules from simple, inorganic materials such as carbon IV oxide (CO_2) and water e.g. photosynthesis

(ii) Heterotrophic nutrition – is the nutrition that involves dependence upon preformed organic molecules such as fairly complex, energy-rich organic molecules secured directly or indirectly from the environment e.g. poultry nutrition.

THE NUTRIENTS

The food needs of people from developing countries are not different from those of the developed world. There are six groups of nutrients. Nutrient is the name given to the different components of feed/food that are useful to the body. Most foods contain several kinds of nutrients but no one food has all that the body needs. Nutrients are any food

constituents or groups of food constituents of the same general chemical composition that aid in the support of life. This implies that nutrients in feed/food are responsible for preserving life. Nutrients are components of food which have a function in providing energy, starting and controlling various processes, providing materials for growth, reproduction, storage, repairs and protection. They are:

(1) Water - for control of body processes. Sources of water are portable water, tropical fruits and leaf vegetables.
65-70% - of body weight of animal at birth
40-50% - of body weight at slaughter
90-95% - of blood, 80% of egg

(2) Carbohydrates – sources of calories or energy e.g. Yam, maize, sorghum, wheat, breadfruit, cassava, sugar, plants, body building.

(3) Proteins – used for protection, growth, tissue maintenance and repair. May also be used to provide energy e.g. meat, insects, soyabean meal, eggs, fish meal, groundnut cake, cowpea, milk.

(4) Fats – a source of energy and protection e.g. palm oil, coconut oil, groundnut oil, melon seeds, fish oil, butter, margarine.

(5) Minerals – regulates body processes, can be used for growth and replacement of tissue e.g. fruits and salt, leaf vegetable.

(6) Vitamins – regulate body processes, used as co-factors e.g. tropical leaf vegetables, fruits, root vegetables, carrot.

(1) WATER

Water is an important constituent of all forms of life. Its wide distribution within feeds and feedstuffs coupled with its effect on feed quality makes the study of water a significant part of animal nutrition.

Moisture refers to the absolute amount of water present in a feed while water activity has to do with the form in which the water exists in the feed such as free or chemically bound water. Moisture is the amount of water present in a feed as component, relative to all the other solid constituents such as proteins, carbohydrates, oils and non-water liquids. Most

water in foods is called **free water**. Free water is lightly entrapped and therefore easily pressed from feed matter/feed; the water can be seen and felt. Free water acts as a dispersing agent and solvent and can be removed by drying foods.

Adsorbed water or structural water is a second type of water, which associates in layers via intermolecular hydrogen bonds around hydrophilic food molecules.

Bound water sometimes called the water of hydration is a third form of water in feed or food. It exists in a tight chemically bound situation, such as within a crystalline structure via water-ions or water-dipole interactions. Bound water does not exhibit the typical properties of water such as freezing at 0^oC or solvent.

Water Activity – is a measure of the availability of water molecules to enter into microbial, enzymatic or chemical reactions. This availability determines the shelf-life of feed/food. The bound water is inversely related to water activity, as the percentage of bound water in a food increases, the water activity decreases. At any given food/feed moisture, water activity will increase with an increase in temperature.

SOURCES OF WATER

The main sources of water are potable water

(1) Metabolic water – is produced by metabolic processes in tissues mainly by the oxidation of nutrients, oxidation of 1g of CHO yields 0.6g of H_2O, 1g of fat yields 1.1g of H_2O and 1g of protein yields 0.4g of H_2O, metabolic H_2O is about 5-10% of the total water intake.

(2) Portable water – (stream, borehole, rain, river, bottled water, well, lake)

(3) Tropical feeds and fruits – oranges, water melon and

(4) Leafy vegetables – water leaf

FACTORS AFFECTING WATER INTAKE OF ANIMALS

(i) Type of diet – silage, hay high mineral salt content of feed …. H_2O intake

(ii) Purpose (and physiological status) of the animal – lactating cow, dry cow (lactating, dry …..)

(iii) Type of digestive tract – ruminant, non-ruminant

(iv) Type of urinary system – mammals, birds, sweat excretion reptiles, birds, fish, sheep and goat

(v) Environmental condition – temperature and relative humidity

Approximate water consumption of mature animals:

(i) Swine – 5.68-11.36 litres/head/day

(ii) Sheep – 3.79-11.36 litres/head/day

(iii) Cattle – 37.85-53.0 litres/head/day

(iv) Horses – 37.85-53.0 litres/head/day

(v) Poultry – 2 parts water for each
1 part dry feed

(vi) Rabbits – <3 liter/head/day

EFFECT/SIGNIFICANCE/FUNCTION/USES OF WATER

Water neither produces energy nor heat, yet it is about 75-95% of proportion of the body. Water has an inverse relationship with fat. The higher the amount of water, less fat will be found in that region of the body and vice versa. Water is found in all body cells and water is the most abundant of all the nutrients, it is the cheapest and reduces with age.

Water can be lost from the body through urine, faeces evaporation, sweat and skin (referred to as insensitive losses).

- In respiration and gaseous exchange water helps in moistening the alveoli in the lungs.
- Water has high specific heat and by this property it disperses heat fast
- It regulates body temperature through sweat and consequently cools the body. There always results loss of mineral salts through sweat, hence animal drinks more water to replace that which is lost through sweat.
- Water intake helps to prevent constipation in animals and man.

- Water is responsible for movement of minerals across cells and it helps to remove metabolic wastes from the body.
- Essential for mixing of drugs for man and farm animals
- Water supports chemical reactions like digestion, absorption, excretion and maintains shape of cells.
- Water lubricates and cushions joints and organs in the body e.g. synovial fluid, cerebrospinal fluid.

The quality and type of feed determines the water content of feeds. However, amount of water in a feed affects the following:

(a) The nutritive value of silage for example, because the dry matter content of the feed is affected by the amount of water present in the feed.

(b) High water content (>15%) lowers nutritive value at storage and moulds may occur.

(c) Spontaneous combustion may occur at 12% or lower water content and it destroys the nutritive value of feeds.

(d) High water content wastes money because farmer my end up paying for water i.e. mere bulk storage.

(e) Water make silage making easy where 90% water content is fairly tolerated, at times, however water may be added to mature forage crops to ease packing which is done to exclude air. Water affects silage preservation, excess water content of silage may cause loss of mineral through seapage into the surround oil of silage pit.

(f) Water prevents dustiness of prepared feed/feedstuff but animals get little value when fed feeds of high water content. The …… of the animals wears down (emanciates) depleting the body reserves of fat. This emanciation, will reduce the profit margin of farmers who will have to incur extra costs on feeds to restore normal growth of the animals. Excessive intake of water by animals reduces voluntary feed intake to about 30% which reduces animal's efficiency of feed

utilization. Water dilutes concentration of energy in feeds hence feeds should be supplied to animals on dry matter basis.

(g) Water is a constituent of saliva (serous/mucus fluid), syovial fluid of keen caps, blood and its cell components, tears from tear glands which help to initial and clean eyes, digestive juices, amniotic fluid which supports fetuses against pressures.

(h) Water ensures sensitivity or irritability by maintaining electrolyte level (i.e. acid-base balance) of the body.

(i) Water helps in the absorption and transportation nutrients and hormones in the blood, which ensures coordination of body activities and processes.

(j) Water is the habitat of important animals plants e.g. fish, snails, cray fish and prawn and water leaf.

(k) Water of high quality is particularly important for the canning of foods and production of carbonated beverages and beer.

(l) Water acts as an important vehicle for heat transfer in foods during food processing and in food preparation.

(m) Water as an ingredient. Water is given to farm animals and can be incorporated as component of processed foods.

(n) Water act as a plasticizer – especially in low moisture and frozen foods. A plasticizer is a substance that when added to a food system, makes it softer.

WATER LOSSES: Water is lost from the body constantly

(1) In the respired air by evaporation

(2) From the skin via sweat and

(3) Periodically by excretion in urine or faeces.

Faecal water losses are considerably higher in ruminants than other animals. In diarrhea large losses of H_2O occur with the faeces.

WATER QUALITY

Water is ubiquitous, the presence of water like that of air is taken for granted. Yet water is a most remarkable liquid, having properties which make it uniquely the support of life.

Most rural people in some countries of the tropics depend on rivers, lakes, springs and shallow wells for their water supply. The purity of such water depends on the geological source and local surroundings. In some communities portable water is a luxury commodity and not within the reach of the inhabitants.

Potable water is free from harmful bacteria and chemical impurities. It is clear and bright, colourless, tasteless, odourless and contains no suspended matter or turbidity. In addition it should have an attractive appearance and be pleasant to drink.

Certain chemical substances have maximum allowable concentrations in drinking water while excess is detrimental to health.

Contamination by sewage or human excrement and by animal pollution poses the greatest danger associated with drinking water in most developing countries in the tropics. The organisms most commonly used as indicator of water pollution are E. coli and the coliform group as a whole.

Standards for drinking water have been published by the WHO for European countries and international use.

*Distinguish between SOFT and HARD water – causes, effect and prevention.

CHEMISTRY OF WATER

(1) Hydrogen Bonds – the electrostatic interaction between the hydrogen nucleus of one water molecule and the unshared electron pair of another water molecule is termed a hydrogen bond. Usually weak.

Hydrogen bonding profoundly influences the physical properties of water and accounts for its exceptionally high viscosity, surface tension, and boiling point. On average, each molecule in liquid water associates through hydrogen bonds. These bonds are both relatively weak and transient, with a half-life of about one microsecond. Rupture of a hydrogen bond in liquid water requires only about 4.5

kcal/mol, less than 5% of the energy required to rupture a covalent OH bond. Hydrogen bonding enables water to dissolve many organic biomolecules that contain functional groups which can participate in hydrogen bonding.

(2) Dissociation of water – water molecules have a limited tendency to dissociate (ionize) as follows – H_2O $H^+ + OH^-$

(3) The concept of pH – this is defined as the negative log of the hydrogen in concentration - pH ------- log $[H^+]$

Low pH values (below 7.0) corresponds to high concentrations of H^+ (acidic solutions) and high pH above 7.0 results because of low concentrations of H^+ (basic solutions). Acids are defined as proton donors and bases as proton acceptors.

(4) Solubility – hydrophobic compounds are dissolved/soluble in water e.g. minerals, salts, vitamins, sugar, carbohydrates, proteins which existed as polar (charged) substances dissolve in water.

A water molecule is an irregular, slightly skewed tetrahedron with oxygen at its center. The strongly electronegative oxygen atom pulls electrons away from the hydrogen nuclei, leaving them with a partial positive charge, while its two unshared electron pairs constitute a region of local negative charge. Water therefore greatly decreases the force of attraction between charged and polar species relative to water-free environments with lower dielectric constants. Its strong dipole and high dielectric constant enable water to dissolve large quantities of charged compounds such as salts.

(5) Hydration – this is the process by which water molecules surrounds and interact with solutes by acting as a solvent, water as a carrier.

(6) The functional properties of water in foods include acting as a diluents and carrier of hydrophilic ingredients, providing a medium for chemical and enzymatic reactions and solvent action.

(7) Condensation and hydrolysis – these are important chemical reactions involving water in the nutrition of farm animals.

(8) Presence of >15% moisture in dry feedstuffs is bad because of subsequent diminution of feeding value and the predisposition of moist feedstuffs to become mouldy or rotten (spoilage).

WATER TREATMENT

When raw water does not meet the standards required for drinking by man and farm animals and food processing, it must be purified by a combination of chemical, physical or biological procedures.

Raw water from a variety of locations can have vastly different chemical, physical, biological and bacteriological characteristics, hence there is need for treatment via processes that will improve the water quality.

However, the major contaminants of water (such as a colour, turbidity, suspended matter, mineral constituents, microorganisms) can be removed or their levels substantially reduced by standard H2O treatment processes, which includes chemical coagulation and flocculation, sedimentation, filtration, disinfection, reduction in corrosiveness, taste and odour control and softening and demineralization.

(2) CARBOHYDRATES

Carbohydrates

- Accounts for a large portion of animal's daily food supply
- Are made up of C, H, O with an empirical formula $C_n(H_2O)n$
- Includes sugars, starch and cellulose
- Very little occurs as such in animal body
- Form largest (3/4) of plant dry weight
- Formed by photosynthesis in plants
- Digested into crude fibre (cellulose, hemicelluloses, lignin) which are poor digested and nitrogen free extract (soluble sugars and starches) which are readily digested
- Stored in animal body by converting its fats

- Functions mainly as energy supply, heat production and building stones for other nutrients.

The major function of carbohydrate in metabolism is as a fuel to be oxidized and provide energy for other metabolic processes. Carbohydrate is utilized by cells mainly in the form of glucose.

The three principal monosaccharide resulting from the digestive processes are glucose, fructose and galactose. Fructose may result from high intake of sucrose while galactose is of major significance when lactose is the principal carbohydrate in the diet (lactation), however, fructose and galactose are readily converted to glucose by the liver.

The intermediary metabolisms of carbohydrate in the mammalian organisms are as follows:

(1) Glycolysis – oxidation of glucose or glycogen to pyruvate and lactate by the Embden – Meyerhof pathway

(2) Glycogenesis – The synthesis of glycogen from glucose

(3) Glycogenolysis – the breakdown of glycogen to glucose in liver and to pyruvate and lactate are main products in muscle

(4) Oxidation of pyruvate to Acetyl – COA – this is a necessary step prior to the entrance of the products of glycoysis into the citric acid cycle, which is the final common pathway for the oxidation of carbohydrate, fat and protein

(5) Gluconeogenesis – formation of glucose or glycogen from non carbohydrate sources mainly in the citric acid cycle and glycolysis. Substrate for gluconeogenesis are glucogenic amino acids, lactate, glycerol and in the ruminant propionate.

(6) Hexose Monophosphate Shunt (pentose phosphate pathway) – is an alternative pathway to the Embden-Meyerhof pathway for the oxidation of glucose.

CLASSIFICATION

Carbohydrates are the ultimate source of most of our food – we act starch-containing grain or tubers or feed it to animals to be converted into meat and fat which we then eat.

A carbohydrate that cannot be hydrolysed to simpler compounds is a Monosaccharide.

A carbohydrate that can be hydrolysed to two monosaccharide molecules is a Disaccharide.

A carbohydrate that can be hydrolysed to many monosaccharide molecules is called a Polysaccharide.

Sweet carbohydrates – contained in large quantities in many foods – confectioneries, soft drinks, cakes because of the sweet taste e.g. refined sugar which supplies only energy. Excessive consumption of sweet carbohydrate causes dental decay especially in children. Others are fructose in fruit, honey, lactose in milk and malt.

Non-sweet carbohydrates – not sweet at all e.g. starch, it is the bulk in our food as in yams, bread, beans and cereals. Contains other valuable nutrients.

The main types of food/feed carbohydrates, their monosaccharide composition and their most common sources are listed below:

Table displaying the common food carbohydrates, types, composition and sources

Type	**Composition**	**Sources**
Polysaccharides		
Starch, dextrins	D-glucose	Cereals, roots, tubers, plantains
Cellulose	D-glucose	Cereals, fruits, vegetables
Glycogen	D-glucose	Liver, animal tissue, sweet corn
Hemicelluoses	L-Arabinose, D-xylose	Cereals, fruits, vegetables
Gums	L-Rhamnose, D-galactose, mannose,	Cereals, legumes, nuts, seaweeds

	glucose, glucuroni	
Pentosan	L-Arabinose, D-xylose	Fruits, vegetables
Oligosaccharides		
Raffinose, Stachyose	D-gal, D-glu,	Legume seeds, cereals
Maltooligosaccharides	D-Glu	Starch syrups, malt
Dissacharides		
Sucrose	D-glu, D-fru	Sugarcane fruits, vegetables
Maltose	D-glu	Starch syrups, malt, honey
Lactose	D-gal, D-glu	Milk, dairy products

3. PROTEINS

Protein is important in feeding farm animals and human beings, because it is the nutrient found in highest concentration (after water) in organic and muscle tissues.

The young, growing animal has the highest requirements for protein when expressed as a percentage of the diet. In addition, productive functions such as gestation and lactation greatly increase the protein requirement because of the needs of the foetus during gestation and for milk protein production during lactation.

Protein is one of the critical nutrient particularly for young rapidly growing animals and for high producing mature animals such as dairy cows and fish. Optimal use of protein is a must in any practical feeding system, since protein supplements are much more expensive than energy, fibrous and fat feedstuffs and wasteful usage increase the cost of production in almost all instances.

If we are short of fat in our diet, then carbohydrates and proteins can be converted into body fat. If we are short of carbohydrate in the diets, fats and proteins can be converted into energy, but if we are short of protein in the diet, carbohydrates and fats cannot be used to build up our bodies or repair the wear and tear that takes place.

It is therefore essential that an adequate quantity and quality of protein is supplied by our feed/food.

Protein quality is a measure of the ability of protein supplement/feedstuffs to supply needed amino acids in the diet when ingested (plant and animal origins).

For practical purposes, protein quality refers to the amount and ratio of essential amino acids in a protein source.

The amino acids contained may either be essential amino acids, which are those amino acids that are required for the functioning of the body but cannot be synthesized in the body, hence, they have to be supplied in the diet (indispensable).

The non-essential amino acids are those amino acids that are necessary for the functioning of the body but can be synthesized within the body (dispensable). Therefore, a good quality protein is that which contains a high proportion of the essential amino acids.

The term biological value is used to express protein quality and it is dependent on the relative quantities of the essential amino acids present. For all practical purposes, egg has a biological value of 100 and considered a standard good quality protein, however, cereals like maize/corn have low biological value of 40 as it lacks the amino acid lysine.

A total of 23 primary amino acids are required by the body. Ten (10) amino acids essentials are Histidie, Arginine, Lysine, Leucine, Phenylelaine, Valine, Tryptophan, Threonine, Isoleucine, Methionine. The 12 non-essential amino acids are – Glu, Gln, Asp, Asn, Pro, Hyp, Cystine, Cysteine, Tyr, Ely, Ala, Ser.

Proteins are complex polymer of amino acids, found in all cells, involved in most of the vital chemical reactions of plant and animals metabolism. It is the specific sequence of amino acids and the manner in which the amino acids strands are connected to each other than determines the physical and chemical properties of each individual protein and its biological functions.

For ruminant animals, the need for a nitrogen source which can be partially degraded in the rumen to ammonia and most likely for some of the essential amino acids such as methionine or for some peptides.

However, high producing ruminant animals also by-pass some ingested proteins into the intestine without it being broken down in the rumen. Hence, it is probable that protein

quality is more important under these circumstances than for animal producing at low levels and consuming much less feed.

TYPES OF PROTEIN BASED ON ORIGIN

There are two main types of proteins –

(i) Proteins from animal origin

(ii) Proteins from plant origin

(1) Proteins from animal origin

These are proteins of animal origin characterized by a better quality protein than vegetable proteins. They have high biological value meaning high profile of essential amino acids. They are called "complete" protein. They are costly (high price), not affected by seasonal variations, available all year round. Lack of or limited antinutritional factors. Require little or no processing before incorporation in human or animal feed/food. Included in small quantities in animal feeds. Chemical composition is relatively standardized. Crude protein greater than 65% CP. Examples include fish meal, meat meal, blood meal, egg, milk or dairy products, feather meal, chicken offal meal, maggot meal, termite meal, grasshopper meal, frog/toad meal.

(2) Plant Proteins (PP)

These are proteins of plant origin, often termed "incomplete" proteins. Characterized by low biological value (BV) compared to animal proteins meaning lower profile of essential amino acids. PP is included in higher percentages in animal feed, percentage constituent crude protein of PP is between 20-45% CP. Its use is affected by seasonal availability. Not available all year round. It contains antinutritional factors especially in the raw state, proximate composition or chemical composition is not standardized i.e. variable. However the price of PP compared to animal proteins is very low. PP requires a lot of processing before incorporation in animal feed. Deficient in one or more essential amino acids and the quality is lower compared to animal proteins.

Examples include – soybean meal, groundnut cake, cottonseed cake, sunflower cake, palm kernel cake, rapeseed meal, jack bean, pigeon pea meal, castor seed meal.

FUNCTIONS OF PROTEINS

Proteins are highly complex nitrogenous organic compounds occurring naturally in al living matter and forming an essential part of animal feed requirements.

They are very important for many cellular functions as follows:

- Proteins are the chief structural units of protoplasm
- Proteins in diets serve as primary source of amino acids the building block of cellular proteins
- The biological catalysts known as enzymes are proteins
- Some of the hormones, the regulators of chemical reactions are proteins or peptides
- Antibodies are complex proteins
- Protein play an important role in the transport of water, inorganic ions, organic compounds and oxygen
- They can contribute through functional properties of proteins, in foods by contributing to colour, flavor, odour, foam formation e.g. maillard and browing reactions.

4. FATS

Fats are essential components of all cells. The distinction between an oil and a fat is simply that at a normal temperature oils are liquid and fats are solid. A molecule of fat consists of glycerol, a trihydroxyhic alcohol, esterified with three ope chain fatty acids.

1 Glycerol + 3 fatty acids ---------- fat + 3 H_2O

Fats supply essential fatty acids needed for adequate nutrition and normal health. They are mainly included as energy sources as they furnish 9.3 calories per gram compared to 4.1 calories per gram from carbohydrate. Fats are found in foods of animal and vegetable

origin, we have “visible” fat such as butter, palm oil, groundnut oil and fat in pork, but fat can also be “invisible” like the fat contained in egg yolk, fish, oil seeds.

Functions

- Supply energy, a concentrated energy source
- Fats act as carriers for vitamins A, D. K
- Fats are important for maintenance of the skin and coat
- Steroids hormones and cholesterol are also fats
- Insulation of organs and storage of fat soluble vitamins
- Improves palatability
- Reduce dustiness of feed especially cassava and sweet potato based diets
- Protection and insulation

The common dietary fat is the triglyceride composed of both saturated, monosaturated and polyunsaturated fatty acids. Levels of up to 20% are acceptable in the diets, however, large levels may reduce feed intake and other essential nutrients thereby resulting in reduced growth.

There are four (4) essential fatty acids dietarily – Oleic, Linolenic, Linoleic and Arachidonic. Deficiency of these fatty acids leads to defective growth, dry hair, scaly skin and susceptibility to infections. These essential fatty acids are found in soyabean oil and groundnut oil. Another problem with fat inclusion is the problem of RANCIDITY.

Lipids are classified into:

(a) Simple (Neutral) lipids
  (1) Fats and oils (2) Waxes

(b) Compound lipids
  (1) Phospholipids (phosphatides) e.g. Lecithins, Cephalins, Sphingomyelins
  (2) Glycolipids e.g. cerebrosides, sialic acid, gangliosine

(c) Derived lipids
  (1) Sterols (2) Bile acids

Food may contain any or all of these substances, but those of greatest concern are the fats or glycerides and phospholipids.

5. VITAMINS

Vitamins are a group of complex organic compounds which are generally required in the diet in rather small amounts for normal growth and maintenance of health.

In contrast to other nutrients, vitamins are not used for structural or energy requirements or as raw materials for synthesizing other compounds.

In the tropics, the lush vegetation is full of fruits, leafy vegetables, insects and meat animal that provides source of all vitamins.

A varied balanced diet will supply all the necessary vitamins however, in complete absence of a vitamin, clinical conditions known as deficiency diseases develop with fatal consequences.

Animals obtain vitamins through feed they consume, additional supplements of salt lick, microbial synthesis or through maternal transfer.

Vitamins are of two types – FAT SOLUBLE and WATEE SOLUBLE, as shown below:

(A) FAT SOLUBLE VITAMINS:

	Names	**Function(s)**	**Deficiency Symptom(s)**	**Source(s)**
i.	Vitamin A (Retinol)	Normal vision Epithelium formation	Night blindness Keratinisation Retard growth	Provitamins in green leafy vegetables Milk, fat, liver, carrot
ii.	Vitamin D (Cholicalciferol)	Absorption of minerals Ca, P and phosphotase levels Bone formation Efficiency of feed utilization Reproduction	Rickets Irregular teeth	Dry forage Fish oils

iii.	Vitamin E (Tocopherol)	Normal reproduction and lactation Antioxidant	Low fertility	Egg yolk, germ oils, oils from oilseeds
iv.	Vitamin K (Phylloquine)	Formation of prothrombin	Failure of blood to clot	Green leafy material, liver Eggs, fish meal

(B) WATER SOLUBLE VITAMINS

	Names	Function(s)	Deficiency Symptom(s)	Source(s)
i.	Thiamine (B_1)	Carbohydrate metabolism	Beriberi Anorexia, paralysis, convulsions, impaired gastric secretions	Yeast, cereals Plant proteins
ii.	Riboflavin (B_2)	Electron transport system Energy metabolism	Watery eyes "blood shot" Fatty liver Low hatchability of eggs	Yeast, green leaves Milk products
iii.	Niacin	Electron transport chain	"Black tongue" Pellagra Nervous symptoms	Yeast, distillers soluble, rice Wheat bran
iv.	Pyridoxine (B_6)	Amino acid metabolism	Improper heart function Microcytic anaemia Convulsion	Yeast, cereals Animal tissue

v.	Panthothenic acid	Carbohydrate Lipid metabolism	Intestinal disturbances Convulsions	Yeast, liver
vi.	Cobalamine (B_{12})	Amino acid synthesis Protein and nucleic acid synthesis	General weakness	Animal tissue
vii.	Folic acid	Transfer of single carbon units Synthesis of choline & N_2-bases	Anaemia	Groundnuts Liver, leafy vegetables
viii.	Biotin	Fatty acid synthesis Carbohydrate metabolism	General weakness	Yeast, distillers soluble, liver
ix.	Choline	Formation of acetyl-choline	Fatty livers	Plant protein, wheat Animal tissue
x.	Vitamin C	Formation of tissues Wound healing	Bleeding and swollen gums Scurvy	Fruits and vegetables Liver Green peas

6. MINERALS

The total mineral content of plants or animals is called ash. These are inorganic elements useful to the body in many ways. Like proteins, we cannot make minerals in our body; hence, minerals must be supplied by our feed/food as they are widely distributed in the average diets. They yield no energy but have important roles to play in many activities in the body.

They can be classified as major minerals required in large quantities in the diet these include – Ca, P, Na, Cl and those required in minute quantities called trace/micro minerals e.g. Fe, Cu, Co, K, Mg, I. Zn, Mg, Mo, F, Se and S as shown below.

	Names	**Function(s)**	**Deficiency Symptom(s)**	**Source(s)**
i.	Calcium	Ossification of bones and teeth Muscle tone Coagulation of blood Selective cell permeability	Rickets Osteomalacia Enlarged parathyroid	Bones Milk Animal products
ii.	Phosphorus	Ossification of bones and teeth Fat and CHO metabolism Nucleic acid metabolism	Rickets Osteomalacia Retarded growth	Animal products Plant material
iii.	Sodium	Osmotic regulation Electrolyte and water balance Nerve and muscle action	Muscular cramps General weakness Vascular collapse	Common salt Animal products
iv.	Chlorine	Maintains osmotic concentrations Transport of CO_2 Solubility of proteins Activates salivary amylases	Alkalosis Hyperexcitability	Animal products Common salts
v.	Potassium	Osmotic regulation Enzyme reactions Electrolyte and H_2O balance Nerve and muscle action	Slow growth Muscular weakness Herpetrophy of the adrenals	Most ingredients
vi.	Magnesium	Ossification of bone and teeth Enzyme activator	Nervousness Twitching	Oilseed meals Cereals Bones

		Decrease tissue irritability		
vii.	Sulphur	Component of some amino acids and vitamin Component of cartilage	Reduced moth, cyt, thiamine synthesis	Most ingredients
viii.	Iodine	Thyroxine synthesis	Goitre Stillborn births Cretinisms	Sea food Iodized salts
ix.	Iron	Component of Hb and Myglobin Component of cytochrome and Xanthine oxidase	Anaemia Reduced growth Difficult breathing	Meat Green vegetables
x.	Copper	Increase iron absorption Formation of erythrocytes Component of enzymes	Anaemia De-pigmentation Impaired bone formation Impaired reproduction	Plant materials
xi.	Cobalt	Synthesis of Vit. B_{12} Activator of peptidases	Emaciation Macrocytic anaemia	Plant materials
xii.	Manganese	Bone formation Functioning of reproductive system	Defective ovulation Testicular degeneration	Grains and roughage
xiii.	Zinc	Co-factor of enzymes Bone and feathers RNA synthesis	Lesions on epithelium Atrophy of male reproductive	Animal products

			organs	
xiv.	Selenium	Component of enzyme Glutathione peroxidase	Degeneration of pancreas Muscular dystrophy	Feed ingredients
xv.	Fluorine	Prevent dental caries	Enamel density reduction	Drinking water

DIGESTION AND ABSORPTION

The body of man and farm animals may be compared to a machine – it needs fuel to make it work. Feeds and food are the fuel for the body and the amount of energy we get from our food is measured in calories for our physical and metabolic activities.

Additionally, feed/food gives us what we need for growth (young animals) and repair and it protects us from diseases.

To achieve these objectives, feed/food goes through a kind of sorting-out process called digestion to separate the different parts of feed/food called nutrients, which have their special functions in the body.

The waste is rejected and the useful nutrients are absorbed, metabolized or stored in the body. There are a lot of factors which affect the process of digestion and absorption in the body.

Summarily, digestion is the breaking down of large macromolecules of feed/food into smaller units, which are then absorbed and either incorporated into the body or metabolized to produce energy.

Digestion is necessary because animal feed consists of organic materials – mainly carbohydrate, proteins and fats. Digestion is achieved in the digestive tract (GIT) with the aid of enzymes.

Intracellular Digestion – this takes within cells. In a unicellular organism, digestion is usually of necessity inside the cell e.g. of a protozoan takes food into the digestive vacuole and enzymes that aid in the digestion of CHO, fat, and proteins are secreted into the vacuole. It also occurs in sponges, coelenterates and turbellarians.

Extracellular Digestion – involves digestion outside the cells. This allows animals to ingest larger pieces of feed/food. It is also associated with a well-developed tract where digestive enzymes secreted by the various tissues associated with the GIT to act on the feed/food materials. The GIT has two openings – the mouth and the anus. Quite common in higher animals.

GASTRO-INTESTINAL TRACT (G.I.T)

The digestive tract comprises four main parts:

(a) It begins at the **mouth** where the food is broken down mechanically by the process of mastication.

(b) From the mouth, food passes down the **oesophagus** into the **stomach**.

(c) The partially digested food is expelled from the stomach largely in liquid form, in a series of squirts through the **pylorus** into the **small intestine**. This is a long, narrow, convoluted tube made up of three sections – the **duodenum**, the **jejunum** and the **ileum**.

(d) The ileum of the small intestine leads to the **large intestine** which is made up of four parts – the **caecum**, the **ascending colon** on the right side of the abdomen, the **transverse section** extending from right to left and the **descending colon** on the left side of the abdomen. The large intestine terminates at the anus.

DIGESTION PROCESSES

(1) **The Mouth** – (Little is absorbed in the mouth. Absorbs salt, Vit. C, glucose, alcohol and certain soluble drugs).

Essentially teeth and tongue begin mechanical digestion by breaking feed/food particles apart via mastication. Contributes to the digestive process by the secretion of saliva by salivary glands controlled by reflex action.

Saliva has two (2) functions in digestion

(i) Contains mucin which lubricates dry food, assisting with its mixing and makes swallowing easier.

(ii) Contains enzyme amylase, ptyalin concerned with the break-up of large molecules of starch into dextrins and maltose.

(2) **Stomach** – (Absorbs soluble substances as alcohol, sugars, salts, water-soluble vitamins and some of the products of protein digestion

The stomach has two functions in the digestive process –

(i) It acts as a container for food undergoing digestion.

(ii) Allows salivary digestion to starch to continue until it is stopped by the (HCl) acid present and the digestion of protein and of a small amount of fat to begin together with the hydrolysis of some disaccharides.

(a) Gastric Enzymes: Three digestive enzymes are secreted in the stomach:

Pepsin – which break down protein

Rennin – converts the soluble protein in milk – caseinogens into a form which can combine with calcium to produce calcium – caseinate which can then be digested by pepsin (in children/lactating animal)

Lipases – present low concentration breakdown fats.

(b) Hydrochloric acid – secreted in the stomach and allows the normal functioning of pepsin enzyme to breakdown proteins. The hydrochloric acid and pepsin acts to digest and destroy bacteria, thus acting as antiseptic (protection against food poisoning bacteria).

(c) Mucus – a slimy, viscid substance secreted by the stomach and in conjunction with enzymes and HCl, serves to protect the stomach itself against its own acidity.

(d) Stomach environment – waves of muscular contraction of the stomach occur at intervals which help digestion by moving the stomach contents about mixing them with gastric secretions.

Gradually the chime is forced into lower part called pylorus, then into the small intestine.

(3) **The Small Intestine** – (Absorbs sugars from CHO, amino acids from protein digesta respectively. Glycerol and other products affect digestion, vitamins)

The long convoluted tube of the small intestine is a highly effective digestive organ. The contents of the small intestine are slightly alkaline. Further digestion occurs by enzymes produced by glands outside the small intestine.

(i) Pancreatic enzymes

The pancreas is made up of a group of specialized cells which lie in the loop of the duodenum and functions mainly to supply protein, carbohydrates and fat-splitting enzymes to the small intestine. These are:

(a) Protein – splitting enzymes – Trypsin breaks down protein mor completely and undigested proteins too. Chymotrypsin which supplements the action of trypsin in breaking down partially degraded proteins.

(b) Carbohydrate – splitting enzymes – pancreatic amylase splits starch much more efficiently than ptyalin present in saliva. Present in adults and absent in infants/babies.

(c) Fat – splitting enzymes – Lipase secreted by pancrease splits fats into fatty acids and glycerol which are soluble in water. The alkali present in the small intestine changes part of the fatty acids into their alkali-metal salts which facilitate the absorption of far through the intestinal wall; eventually into blood stream.

Pancreatic – lipase activity is related to bile secreted by gall bladder.

(2) Intestinal enzymes

These are secreted by the cells lining the small intestine. This includes:

(a) Protein – splitting enzymes – Peptidases are a group of enzymes which complete the breakdown of protein fragments into their constituent amino acids. Nucleases can split nucleic acids, which are concerned with protein synthesis and are present in the nuclei of the cells of both animals and plant feeds.

(b) Carbohydrate – splitting enzymes – maltase, sucrose (also called invetase) and lactase are supplementary CHO – splitting enzymes. Maltase split sugar maltose into glucose, sucrose split sucrose into glucose and fructose while lactase split lactose into glucose and galactose (in milk) present in large quantities in infants/babies on milk diet (lactation).

(c) Fat – splitting enzyme – intestinal lipases supplements the action of lipases secreted in the stomach and by the pancrease (gastric lipase and pancreatic lipase respectively).

(3) Bile – is an alkaline liquid with a colour varying from reddish-brown to yellow and even green, with musky smell and bittersweet taste. Bile is secreted by the liver and gradually fills up the gall bladder through bile duct. Bile itself has little digestive action, however, it greatly increases the extent of the splitting of fats in the small intestine by the pancreatic lipases.

- Bile promotes the emulsifying of the fats in the liquid contents of the intestine.
- Bile also assists the absorption of the fat-soluble vitamins – A, D, K.
- Bile also increases the efficiency of the enzymes which digest CHO and protein.

(4) The large intestine – (Absorbs vitamins of the B-group and small amount of sugars arising from the breakdown of fibrous material)

The large intestine has three digestive functions:

(i) It absorbs any remaining food broken down by the digestive activities of the mouth, stomach and small intestine which has not already passed into the blood stream.

(ii) Re-absorbs much of water which is the major component of the mainly fluid mixture in which digestion takes place in the stomach and small intestine. Waste material and bacterial debris can therefore leave the body in dry form as faeces.

(iii) Serves as an incubator in which certain harmless bacteria can grow, they break down some tougher food components which are resistant to the digestive enzymes. By this action they multiply inside the large intestine, the bacteria synthesise some vitamins (B-group) which contribute to the body's total nutritional intake.

FEEDS AND FEEDING

Feed is a material, which after ingestion by the animal is capable of being digested, absorbed and utilized to satisfy metabolic needs i.e. being transformed into body elements of the animal. The compounds of a fed that are capable of being transformed into body elements are known as nutrients.

The metabolic needs include:

(i) Maintenance – supply of energy for physiological processes whether new tissue or products are formed.

(ii) Growth – this is a building process of the body. Growth may be defined as correlated increase in mass of body indefinite intervals of time in a way characteristics of the animal specie. There are two types of growth – Hyperplasia which is the increase in number of cells. Hypertrophy – which refers to increase in size of cells.

(iii) Growth of hair and feathers

(iv) For work – muscle action. Energy is needed for work

(v) For reproduction – including egg production in poultry

(vi) For fattening – specialized production activities

(vii) Milk production – Lactation in milk producing animals, man, pigs, rabbits and pigeons

(viii) For synthesis of specialized products – synthesis of enzymes, hormones, haemoglobins, etc

(ix) Catalysis – in stimulating and regulating body activities e.g. vitamins, hormones and enzymes

(x) Sleeping, breathing are important activities requiring good nutrition.

TERMINOLOGIES AND DEFINITIONS

(1) Nutrition – the science involving various chemical and physiological activities, which transform feed elements (nutrients) into body elements.

(2) Feed – is a material, which after ingestion by the animal is capable of being digested, absorbed and utilized i.e. before transformed into body elements of the

animal. A feed is merely the carrier of nutrients. No feed has been found that is nutritionally complete for and balanced to the need of a given animal.

(3) Feedstuff/Feed ingredients – a feeding stuff is any product, whether of natural origin or artificially prepared that when properly used has nutritional value in the diet. It includes natural feeds of animal origin, synthetic and other pure nutrients.

(4) Nutrients – a nutrient is defined as any feed constituent or group of feed constituents of the same general chemical composition or a pure chemical compound that aids in the support of animal life. The constituents of a feed that are capable of being transformed into body elements are known as nutrients.

(5) Ration or Diet – is a 24-hour allowance of feed or of mixture of the feedstuffs/feed ingredients making up the diet.

(6) Feeding – is a practical application of nutrition, i.e. consideration of management, formulation, palatability, economics, etc.

(7) Formulation – is the process of constructing a feed or diet formular.

(8) Balanced diet – the food or feed that supplies all the essential nutrients in the proper amounts required for optimum performance of the animal.

(9) Complete feed – a balanced ration for the animal in a single form. It provides all the nutritional requirements (except water) needed to maintain normal health or to promote production.

(10) Basal (Energy) Feeds – nutritionally, basal feeds are mainly concentrated sources of energy being especially rich in starches and sugars. They are grains and grain by-products that contain not more than 16% protein and 18% crude fibre.

(11) Supplement – is a feed or a feed mixture use with another feed to improve the nutritive balance of the total ration or diet.

(12) Concentrate – is usually described as feed or feed mixture which supplies primary nutrients (protein, carbohydrates and fat). It is a commercially prepared supplement which refers to a concentration of protein, minerals or of vitamins in excess of those found in basal feeds. Have digestibility.

(13) Husks – is leave enveloping an ear of maize or outer covering of kernels or seeds especially in the dry form.

(14) Ear of maize – entire fruiting head of Zea mays including only cob and grain.

(15) Cob – the fibrous inner portion of the ear of maize from which the kernels have been removed.

(16) Kernel – refers to a whole grain.

(17) Hulls – outer covering of grain or kernel.

(18) Forage or roughage – any material substance for feeding livestock, which contains more than 18% crude fibre, materials making up the fodder.

(19) Anorexia – loss of appetite in disease condition.

(20) Appetite – is a desire or inclination for food. It is a conditioned reflex. It is related to taste, smell and appearance of food. Well developed in man than in farm animals.

(21) Additive – a substance (or mixture of substances) added to the feed to meet a specific purpose. An additive may enhance the nutritive value, sensory value or shelf life of the feed. Additive is involved in the production, processing, packaging and/or storage of the feed without being a major ingredient.

(22) GIT – gastro intestinal tract, responsible for the digestion, absorption and assimilation of feed and nutrients.

(23) Ration Formulation – this is the act of combination and re-combination in specific ratios of feed ingredients/feedstuffs to obtain feed for the nutrient requirement of farm animals.

(24) Feedmill – is an establishment/place where feeds/commercial feeds are provided using specialized equipment according to the feed formulation.

(25) Feedmillers – owner of a feedmill, for commercial/personal use.

(26) Proximate Analysis – this refers to the analysis of chemical constituents of feed, feed ingredients using established standard methodologies/procedures AOAC (1995).

(27) Nutrient Requirements – this refers to specific requirements for nutrients by farm animals and this can be affected by a number of factors.

(28) Antinutritional factors – these refers to chemical compounds/metabolites which interfere with the normal process of digestion, absorption and assimilation of nutrients from feedstuffs/feeds.

(29) Feed Microscopy – this is the science of identification, evaluation of feeds/feedstuffs by visual appraisal using a microscope, hand lenses. Essentially it involves physical and textural examinations.

(30) Nutrition evaluation – refers to the assessment of feed/feedstuff for its nutritional adequacy. This can be physical, chemical, biological or microbiological in nature.

NUTRIENT REQUIREMENTS

Nutrient requirements deal with the adequacy of the feed to the needs of the farm animals. Adequate nutrition seems to be the most important environmental factor that influences the ability of the animal to attain their genetic potential for growth, reproduction, longevity and respond to stimuli.

There are at least 40specific nutrients (chemical elements) that need to be present in the diet to support life, growth and optimum reproduction. These consist of 13 important amino acids, 13 vitamins, 13 essential minerals and 1 fatty acid known as linoleic acid.

Amino acids – Arg, Cystine, Gly, Hist, Ile, Lys, Met, Phe, Thr,Tryp, Tyr,Val

Minerals – Ca, P, Mg, Na, K,Cl, Mn, Zn, I, Cu, Fe, Co, Se

Vitamins – A, D, E, K, Thiamine, Riboflavin, Niacin, Pantothemic acid, Pyridocine, Biotin, Choline, Folic acid, B_{12}

Fatty acid – Linoleic acid

The essence of nutrition is to define the nutrients required by the animal to perform at a certain level, identify a suitable source of those nutrients and match these two in a diet formulation to obtain a balanced diet.

The requirement for any nutrient may be defined as the amount of that nutrient which must be supplied in the diet to meet the needs of the normal healthy animal given an otherwise completely adequate diet in an environment compatible with good health.

Summarily, nutrient requirement is the amount of a given nutrient required by the animal to maximize performance e.g. a specified rate of growth or a stated level of production.

The nutrient requirements of farm animals are documented and published by National Research Council (NRC), USA, Agricultural Research Council (ARC), UK, Nutrient Requirements Table, Aduku (1993), Nutrient Requirements of Poultry by Fetuga (1984); Nutrient Requirements Table by Olomu (1995).

FACTORS AFFECTING NUTRIENT REQUIREMENTS

Certain factors affect the levels of nutrients required for optimum performance of farm animals. These includes –

(1) Texture of feed – feed particle size affects nutrient requirement. Coarse feed may not be consumed sufficiently by very young animals. Pelleting of a bulky diet will increase the nutrient density per unit volume thus increasing nutrient consumption.

(2) Energy content of the diet – the largest single dietary need of animals is for energy. Energy is required for all processes of life. This energy is bound in molecules of carbohydrate, fat, protein and alcohol. Birds tend to satisfy their energy requirements first hence the energy content of the diet tends to influence the intake of other essential nutrients. Efficient utilization of proteins is dependent on the amount of energy available, hence, the concept Protein:Energy ratio in farm animal nutrition.

(3) Environmental condition – Temperature, climatic conditions have marked effect on energy requirement and hence on feed intake and other nutrients. Animals tend to eat less in warm/hot than in cold environments – rainy/harmattan. Temperature also influences the requirement for (vitamins).

(4) Age – nutrient requirements change with age of the animals. Age relates to growth and increased metabolic activities.

(5) Sex – boars, bucks (male farm animals) require more energy and nutrients than, sows, does (female animals).

(6) Physiological/Productive state – rate of growth, egg production, amount of milk produced, pregnancy lactation can affect the nutrient requirements of farm animals. Mature cockerel will have low requirement for amino acids (nutrients) than the laying hen producing eggs.

(7) Physical activity – active farm animal require more energy and nutrients than inactive/less active animal e.g. Athletes and non-athletes.

(8) Size of the animal and breed – large animals and people need more feed and hence nutrients than smaller animals. Breed effect is important e.g. light breed and heavy breed, fish (genetical) vs. rabbit.

(9) Effect of health status – this can affect the requirement for nutrients. Diseased condition or ill-health, absence or presence of internal parasites. Animals recovering from illness need more energy and nutrients than healthy animals e.g. diarrhea and H_2O.

(10) Balance between nutrients – the balance between amino acids, dietary protein levels versus individual amino acids, this may affect the metabolic utilization of individual nutrients and hence their requirements.

(11) System of management – in poultry and pigs, floor or cage rearing, intensive or extensive management system can affect requirements for specific nutrients.

(12) Presence of antinutritional factors – availability of nutrients from various feedstuffs may be affected by certain substance (anti-metabolites) e.g. phytase, oxalate may render ions of Zn, Mn and Ca completely unavailable to the animal.

(13) Destruction or loss of nutrients in feed/feedstuffs – improper processing e.g. overheating of a feedstuff may result in denaturation of protein or the browning reaction of Maillard's reaction.

(14) Stress – stresses occur in every day life and these may affect nutrient requirements e.g. hot weather and vitamin C supplementation in feed or water.

(15) Competition for absorption due to nutrient imbalances and competition for active transport of nutrients. Metabolites may react with the epsilon amino groups of lysine thereby decreasing protein value of diet.

NUTRIENT/CHEMICAL COMPOSITION OF FEEDSTUFFS

This refers to the chemical constituents of feedstuffs. It depicts the amount of nutrients present in a feed ingredients/feedstuffs which confers specificity on the feed ingredients. This composition indicates is a pointer on the usefulness and for what purpose the feedstuff can be incorporated or used in the nutrition/feeding of farm animals. Most importantly, nutrient composition assists in the classification of the different feedstuffs. The nutrient/chemical composition of feedstuff is affected by

(1) Processing method
(2) Season/climatic conditions
(3) Age/growth stage in forages
(4) Presence of antinutritional factors
(5) Storage

INTRODUCTION TO FEEDS AND FEEDING OF DIFFERENT CLASSES OF LIVESTOCK

The term 'food' is usually used in relation to human diets while the term 'feed' is used in relation to farm animals. However, foods and foodstuffs are sometimes used for both farm animals and human beings to describe foods or and feed ingredients are the sources of nutrients in the diet.

The expression concentrate foods' is used to describe those foodstuffs that contain less than 15% water.

Succulent foods are those that contain 70% or more of water. Succulent foods can be classified into 2 broad groups

(a) Roots and Tubers
(b) Green fodders

Classification of foods and Feeding stuffs

Foods and feeding stuffs can be broadly categorized into 5 as follows:

1. Energy sources:
2. Protein sources
3. Mineral Supplements
4. Vitamin supplements
5. Feed additives or non - nutritive additives

ENERGY SOURCES

This consists those foods, grains and feed ingredients that contain less than 20% of protein in dry state. Examples are cereals and some of their by-products, starchy roots, fats and oils, sugars and syrups.

STARCHY ROOTS AND TUBER

Starchy roots (i.e. tubers and roots crops) most widely cultivated in tropical and sub-tropical part of the world are cassava, yams, cocoyam's and sweet potatoes in that order roots are also eaten in small quantities in some tropical countries. In temperate countries, the most widely cultivated root crop is irish potato. irish potato are also grown in some tropical areas.

Starchy roots contain large quantities of starch and so are high in energy per hectare than most cereal. They are however, generally low in protein (1 – 4%) minerals and vitamins. Starchy roots forms the major part of the diet of man in many party of the world. They are sometimes used in feeding of farm animals e.g. cassava and its products like gari, cassava flour or fermented cassava meal may be used to replace a large pro-portion or all of the grains in poultry and pig diets. In using cassava, care must be taken to balance the diets for protein and amino acids, especially methionine.

Starch and root crops are relatively easy to grow with high yield even on poor soils. They contain large quantities of starch and so are good energy source. They produce more energy per hectare than most cereals but are generally low in protein (1- 4%), minerals

and vitamins. Starchy roots form the major part of the diets of man in many parts of the world. They are sometimes used in the feeding of farm animals.

CASSAVA

It is a very popular tropical plants use in feeding man and all classes of livestock. There are two main types. These are the varieties like types *manihot utilisima* or *manihot esculentus* and the sweet types *manihot palmate*.

It is easy to propagate from stem cutting and is one of the most productive root crops in the tropical areas. Its yield is between 10 and 20 tons per hectare. It is available all the year round. Cassava contains between 50 and 70 % water. It is low in protein (1 – 3 %), oil, ash and crude fibre (up to 5% CP can be obtained from some of the new variety). The protein content of cassava tuber is deficient in lysine, methionine, tryptophan, tyrosine and phenylalanine but high in arginine. It is low in minerals and most vitamins but it is high in energy content.

The peels of cassava are richer in protein, oil and ash than the peeled protion. On a dry basis, cassava leaves have protein content that range between 14 and 69% DM. It is fair in lysine content marginal in tryptophan and isoleucine but deficient in methionine.

Cassava is able to serve as substitute to maize in livestock feeds at levels between 5 and 50 %, well processed cassava leaves and peels are widely fed to cattle, sheep and goats.

LIMITATIONS

Both the bitter and sweet varieties contain cyanide. The content of cyanide in fresh tuber of bitter varieties contain less than 100mg/kg. The peels contain 3 – 10 times more cyanide than edible portion. Levels of cyanide less than 50mg/kg are considered harmless, 50 – 80mg/kg slightly poisonous, 80 – 100mg/kg toxic and above 100mg/kg fatal.

Symptoms of eating raw or improperly processed cassava in man include feeding of sickness nausea a, vomit by abdominal distention respiratory difficulty and collapse. Over a long period of consumption, raw cassava may caused goitre, deformed and mental defective cretinism, ataxia, neuropathy with mental retardation. Detoxification of cyanide is required.

Cyanide is detoxified into thiocyanide and thus involves the use of sulphur. Some of these sulphur are obtained from sulphur containing amino acid. Cyanide also interfere with thyroid gland and therefore interfere with iodine metabolism.

However, much of the cyanide is removed during processing of cassava. The processing method include cooking, frying, boiling, washing, grating, soaking, fermentation and sun drying and long period of storage. Properly processed cassava products are virtually free of HCN. High levels of cassava in feed make the feed to become dusty, hence molasses and oil may be added to reduce the level of dustiness.

The leaves and peels of cassava are widely fed to cattle, sheep and goats, although with fatal consequences sometimes.

YAM

It is mainly cultivated for human consumption. There are different species of yam. The most popular ones are:

1. Water yam Dioscorea alata
2. Aerial yam Dioscorea bulbifera
3. Yellow yam Dioscorea cayeneusis
4. Tritollate yam Dioscorea dumetorium
5. Chinese yam Dioscorea esculenta
6. White yam Dioscorea rotundata

Yam is high in water content, high in soluble carbohydrate, low in cp (1-4%), low in fibre and fair in ash. The protein content is low in lysine, methionine, tryptophan but contain fair amount of valin, arginine and isoleucine. It also contains fair amount of B. Complex and minerals. Yam peels are valuable as livestock feed especially in ruminant animals.

LIMITATION

The major set back in the use of yam as livestock feed is the content of its major antinutritional factor (alkaloid) which can reduce the level of intake with time. It also

have an itching effect on the palate. Some varieties contain tannin up to 0.4% and saponin. Most of these antinutritional factors are destroyed during cooking and drying.

COCO YAM

Cocoyam can be fed to livestock. However cocoyam should be cooked before being fed to livestock particularly pigs since the acid (Ca – oxalate) or saptoxin contained in the corn is irritating to the digestive tract and may even be poisonous. The pods and leaves of cocoyam are valuable feed for ruminants (cattle sheep and goats).

Cocoyam are edible aroids. There are two major species and they are

1. The yaro cocoyam, colocasia esculenta (koko funfun) and
2. The yannia cocoyam, xanthosoma sagitt, folium (koko pupa)

Cocoyam produces cormes, a form of underground stem. The big central corm is surrounded by smaller ones called cormels. The cormels are the commonly used as human food. Cocoyams are fair high in water and carbohydrate contents. The starch of coco yam contains predominantly amylase and small amount of amylopectin. It is low in fat (less than 0.5%) and protein content. Proteins of cocoyam have fair amount of the essential amino acids but are low in lysine and hutidine. The peels are richer in oils than the inner content tuber. The leaves have higher nutrient content than the corms.

Limitations

-Cocoyam can be fed to livestock. However, cocoyam should be cooked before fed to livestock especially pig. The peels and leaves of cocoyam are valuable feed for ruminants (cattle goats and sheep)

-Cocoyam contains some toxic factors. Cocoyams are irritating to the body because of the presence of calcium oxalate in them. However, when boiled or roasted, the irritation disappears.

-The corms of cocoyam contain a gastrogenic substance.

SWEET POTATO

It is cultivated in both tropical and temperate areas. There are varieties. The varieties are colour yellow or red.

Fresh potatoes contain 70-80% of water. It is low in crude fibre, fat and protein. However, the protein content have high biological value and it is rich in essential amino acid. On dry basis over 90% of sweet potatoes tuber is made up of carbohydrate. The CHO is highly digestible when cooked but low when raw. Much of the starch in sweet potatoes is converted to maltose during cooking (i.e. heat, enzymatic hydrolysis and starch) and this is responsible for the sweet taste in cooked sweet potatoes.

Potato tuber is rich in carotene (especially yellow varieties), ascorbic acid (especially yellow varieties) and B-vitamin. However, storage and cooking reduce the content of vitamins. It has fair amount of ash and minerals e.g. phosphorus, calcium sodium, chloride and potassium. Its leaves are rich in protein, minerals and vitamins.

Sweet potatoes are good for all classes of live stocks. The leaves and vines of potato are useful feed for ruminants.

Sweet potato has been used in diets of pigs and can be used in poultry diets along with suitable protein supplements. The leaves and vines of potato are useful feed items for cattle. Cooked Irish potato can be used effectively in the diets of pigs.

Other energy supplier feedstuffs include

- Confectionary products
- Bakery wastes
- Cull fruits and vegetables
- Snack food waste

Kitchen/cafeteria/canteen waste

SUGARS AND SYRUPS

SUGARS: sugars are cheap and easily digested forms of energy. Sugars are obtained from sugar came and sugar beet. After extraction, the crude sugar is refined and made into cubes (crystalline sugar).

Raw sugar, obtained from chewing the cane directly, contain small amounts of protein,

minerals and vitamins refined sugars are however essentially carbohydrates and lack every other nutrients.

All white sugars i.e. crystalline table sugar cube sugar, icing are practically 100% sucrose and are free of any toxic factors. Brown sugar is less highly refined sucrose and contains traces of other sugars, minerals and colouring matter.

Syrups: Syrups are highly concentrated solutions in which the sugar unable to crystallize out because of the presence of small qualities of other substances. Some syrups, such as molasses and golden syrup are by-products of the manufacture of crystallize cane sugar. There syrups contain some ants of protein (0.3%), Ca (0.03%) and Fe (1.5 mg/100g). They are devoid of any other ingredients.

Molasses: Molasses are mainly by products of the manufacture of sugar from either sugar cane or sugar beets. Their sugar content is about 50-60% and water content is between 22% (beet molasses) and 27% (cane molasses)

Beet molasses is higher in C.P (7-11%) then cane molasses (3-4%). Molasses have a mineral content of 8-10% composed mainly of Na and K salts. The Ca and P content are 0.10 and 0.02% respectively (for beet molasses) and 0.8 and 0.8% (for can molasses). The thiamine and riboflavin contents are each 0.05 mg/100g while the means content is about 1.5 mg/100g. The Fe content is between 0.01 and 0.02%

The use of molasses in poultry diets is limited by its laxative effects when used at high levels. Any level above 5% is laxative. Molasses may be used to prevent dustiness in mixed feeds and in the treatment of poultry blue comb diseases because of its sugar content.

Molasses can be used at a rate of 3-5% in the diet of sows to help prevent constipation enhance feed intake. It is also used to ensile forage during silage production for ruminant animals. The difficulties in obtaining the product limit the use of molasses in animal diets. Molasses is increasingly being used by human beings. It is sometimes used in place of honey.

Honey: Honey is made by bees. Most honeys glucose and fructose known as the invert sugars. Honey also contains some protein (0.4%), minute traces of Ca (0.005%), and

small amounts of Fe (0.4 mg/100g) thiamine 0.05 mg/100g, riboflavin 0.05 mg/100g and niacin 0.2 mg/100g. Honey is an attractive, pleasant and sweet food.

Jams: Jams are prepared by boiling fresh fruit, or a pulp preserved with sulphurdi-oxide (sulphite pulp), with sugar. Depending on the antinutritional factors present in the raw materials, pectin may or may not be added. Jam is a general name for all such products.

Marmalade is synonymous to Jam in some parts of the world. In other parts, notably is a name used specifically for jams made from citrus fruits.

Most jams contain about 65-70% sugar, 0.5% protein. It also has Ca (0.02 – 0.04%), iron (1.2 mg), Vitamin A (2-10 mg/100g) and Vitamin C 10-45 mg/100g. Jams are pleasant, attractive and sweet foods.

CEREALS

Cereals are mostly used in the tropical countries are maize, rice and guinea corn and to a less extent millet and wheat.

In temperate or dry climate, whet is the, barley, oat and rye may be available for use in the diets of farm animals and human beings. Cereals are high in starches that are readily digested by animals. They are relatively low in protein content. Cereal energy constitute below 45 - 70% of the energy in poultry, swine and rabbit diets. Cereals contain fair amount of Ca, P and Fe, although the absorption of these minerals. Whole cereals contain useful amounts of B vitamins although most of these B vitamins are lost in the milling process to which the grains are subjected in the preparation of various foods from them.

They are however totally devoid of vitamin B_{12} and ascorbic acid Vitamin A activity in cereals is low except for yellow maize cereals are also deficient in the amino acid such as lysine and tryptophan.

MAIZE (Zea mays)

It is grown extensively in the country for human food as well as livestock feed. It is used for all classes of livestock. Essentially maize supply energy which is as high as 14.2 MJ/kg. It is low in protein (8-10%) depend on the variety. Its protein content is low in lysine and tryptophan. The fat content is about 4% and high in linoleic acid an essential

fatty acid (about 50%) yellow maize contain Xanthophyll which gives yellow colouration to the shank, skin, egg yolk of birds and carcass of pig fed diet containing yellow maize.

Yellow maize contains carotenoids which have pro vitamin A activity 100 – 800 mlg/100g. white maize is low in xanthophylls and lacking in vitamin A activity.

Green leaves, palm oil or synthetic colourant can be added to white maize. Niacin in maize is in bound forin and is not easily available. However, treatment with home water makes the niacin more available. Maize is used up to 60% in livestock feed. It is sometimes difficult to do 100% replacement of maize.

SORGHUM (GUINEA CORN) Sorghum guiness

It is widely grown in several parts of the world. In Nigeria, it is grown in the Northern part. Sorghum can be grown successfully on poorer soils and in drier conditions than maize. Its energy content is comparable to that from maize up to 13.79MJ/kg. Its protein content is slightly higher than that of maize. It contains low levels of xanthophylls, linoleic acid, lysine, methionine, tryptophan and fibre. It is also low in calcium but high in phosphorus. It is used to substitute maize to a reasonable extent in livestock feeding. It is also used in human food in various forms especially in the Northern part of the country.

The use of sorghum in livestock feeding is limited by its content of tannin. Although low tannin sorghum has been bred to improved its utilization in poultry. Tannins are a group of compounds that bind proteins, thus impairing protein digestion. Tannins also reduces palatability.

Guinea corn leaves are used as feed for ruminant animals. However, it must be noted that young sorghum contains cyanogenic. The glycoside occurs in the germinated plant and its contents increases as the plant matures and disappears completely when grain appears glycoside hydrolysis yield hydrocyanic acid (HCN).

RICE (*Oryza sativa*)

Rice is grown locally but principally as human food, though it is useful in livestock feeding. By products obtainable from rice includes rice husk, rice bran, broken rice, rice polishing and rice mill by products.

Rice bran consists of the pericarp or bran layer and germ. The fat and linoleic acid contents of rice bran are relatively high. The protein content is between 12 and 13%.

Rice polishing is obtained in the operation of brushing the grain to polish the rice. The protein content and linoleic content of rice polishing are higher than those of maize. The crude fibre content is low (4.1%). Its energy value is higher than rice bran.

Rice mill by-products consist of rice husk, rice bran, rice polishing and broken rice grains. Its CF may be higher than 32%. Its CP is low and fat content 5 – 6 %. Its high CF ad its low ME values discourage its use in poultry and swine diets.

Cereal grain By-products

Cereals grain by- products are obtained during the processing of grains into food and drinks for human. The by-products are used mostly for feeding livestock. Some are now processed into human foods e,g oat bran breakfast cereals. Examples of cereal by-products include:

- Wheat Bran
- Wheat Shorts
- Wheat middling
- Wheat mill run
- Rice Bran
- Rice Polishings
- Rice mill by - products
- maize Gluten meal
- Maize gluten feed
- Maize Distillers Dried grains
- Hominy feed.
- Brewer's dried grains
- Sorghum distillers grain

- Breweries dried yeast
- Torula dried yeast
- Dried Bakery products

1. Wheat Bran: wheat bran consists of the coarse, outer covering of the wheat in the usual process of commercial milling of wheat. Although of low energy value, wheat bran is useful when low calorie diets are required. It is also cheap. The crude fibre level is above 9.5%
2. Wheat Shorts: Wheat shorts consist of fine particles of wheat bran, wheat germs. Wheat flour and the offal from the tail of the mill, in the usual process of milling wheat. Because of the endosperm fraction, wheat shorts contain more energy and less crude fibre than wheat bran. It has not more than 7% Crude fibre.
3. Wheat Middling: wheat middling are essentially similar to wheat shorts except for the differences in crude fibre content. Wheat middling consist of fine particles of wheat bran, wheat shorts wheat germ, wheat flour and some of the offal from the tail of the mill. Has not more than 9.5% crude fibre.
4. Wheat mill Run: This consists of coarse wheat bran, fine particles of wheat bran, wheat flour and the offal from. The tail of the mill. The chemical content of wheat mill run are similar to those to those of wheat shorts. Not more than 9.5% crude fibre.

   Wheat mill run and the other wheat by-products are ingredients that can be used but in restricted amount in poultry and swine diets.
5. Rice bran: Rice bran is the by-product of the milling of rice to produce edible rice. Rice bran consists of the pericarp or bran layer and germ of the rice, along with small quantities of hull fragments, and some chipped, broken rice and perharps $CaCO_3$ as is unavoidable in the rice milling process but which should usually not exceed 5%. The fat and linoleic acid contents of rice bran are relatively high. The protein content is below 12 – 13%.

   The oil gram rice bran is used largely in human diets. Rice bran is relatively high. The protein content is below 12 – 13%. The oil grain rice bran is used largely in

human diets. Rice bran can be used successfully to replace some part of the grain portion of some poultry and swine diets. As much as possible, rice bran should be avoided in the diets of younger poultry and pigs.

6. Rice Polishing: this is a by – products of rice obtained in the milling operation of brushing the grain to polish the rice. The protein content and linoleic acid content of rice polishing are higher than those of maize. The product is characterized by relatively low crude fibre content 4.1%. Its energy value is higher than rice brain.

   There are no special limitations to the use of rice polishing in poultry and swine diets. It is however not as available as rice brain.

7. Rice mill by – product: this consist of rice hulls, rice polishing, and broken rice grains. Rice mill by-product is in actual fact the total offal obtained in the milling of rice. Its crude fibre content should normally not exceed 32%. Its protein content is low, with fat content of 5.6%.

   Maize gluten meal: Maize gluten meal is the dried residue from maize after the removal of the larger part of the starch and germ, and the separation of the bran by the process employed in the wet willing manufacture of corn starch or syrup or by enzymatic treatment of the endosperm it may contain fermented corn extractive and/or maize germ meal.

   The energy amino acid contents of maize gluten meal are much content of maize gluten meal are much higher than those of maize gluten feed. Like maize the maize by-products are deficient in lysine and tryptophan.

8. Maize Gluten feed: This is that part of the commercial shelled maize that remains after extraction of the larger portion of the starch, gluten and germ by the processes employed in the wet milling manufacture of maize starch or syrup it may or may not contain fermented Maize extractives and or maize. Contain about 21 – 23% crude protein and 9 -10% crude fibre.

9. Maize Distillers Dried Grains: These are derived from the fermentation industry particularly the alcohol industry. There are 2 types of maize distillers dried grains, with soluble and maize distiller's dried grains, both containing 27% Crude protein. The crude fibre (12%) is high and energy value relatively.

Generally the distillers dried Grains and the distiller dried soluble are by-products obtained after removal of ethyl alcohol by distillation from the yeast fermentation of grains and the distillers dried soluble are by products obtained after removal of ethyl alcohol by distillation from the yeast fermentation of a grain or grain mixture.

10. Homing feed: this is a mixture of maize bran, maize germ and part of the starchy portion of the maize grain as produced in the manufacture. There have at least 5% Crude fat (ether extract). The fat of homing feed is high in linoleic acid (3.2%) and the energy content is fairly high.
11. Brewers dried grains: this is the dried extracted residue of barley alone or in mixture with other cereal grain or grain products resulting from manufacture of beer and may contain pulverized dried spent hops in an amount not exceeding 3% evenly distributed. Because of its low energy content and high fiber content (over 18%). BDG is more suitable as cattle feed. It is also used extensively in swine production.

Other cereal by products includes sorghum distillers' grain, brewers dried yeast, torula dried yeast and dried bakery by product.

FATS AND OILS

The term fat general, referred to a group of food or feed ingredients including animal fats, vegetable oils and related compounds. Technically, fats refer to those that are

- Solid at room temperature e.g butter, fallow and land while oil is the term used to describe fats that exist as liquid at room temperature e.g. groundnut oil, corn oil etc.
- Fats and oils are concentrated sources of linoleic acid and linolenic acid (two essential fatty acids). Fats and oils may be a source of fat soluble vitamins. Most vegetable oils contain significant amounts of vitamin E. Red palm oil is a rich source of beta carotene and hence a good source of vitamin A. corn oil contain small ants of carotene. Fish liver oils, milk fat (and thus butter and milk) and

animal fats generally contain vitamins A, and D. Most vegetable oils do not contain vitamins A and D.

- Fat commonly included in livestock feeds (for poultry and pigs) can be divided into 6 general groups

1. **Animal fats:-** these are rendered fats from beef or pork by-products.
2. **Blended feed grains animal fats:** these may include mixtures of beef, tallow, pork lard, poultry grease and possibly restaurant grease
3. **Poultry fat or grease: T**his is rendered fat from poultry offal.
4. **Vegetable oil:** these are oils derived from vegetable materials e.g groundnut, soybean, palm nut etc.
5. **Blended animal and vegetable fats:** these may include proportions of animal and plant fats
6. **Soapstocks:** This is also used in the manufacture of soap: these contain products not wanted in oil meant for human consumption including free fatty acids.

The use fats and oils in poultry and pig diets would depend on their price and availability relative to other energy source. Fats should be used in diets where higher energy levels are required such as those for broiler chickens and turkey poults, weaning pigs, fast growing market hogs and lactating sows.

It is not economical to add any fat at levels above 5% in poultry and swine diets. It is however possible to use levels between 5-8% if prices are favourable. Animal tallow and restaurant greases are the most used animal fat.

All fat supplements used in animal diet should contain an anti oxidant to prevent rancidity. Contain raw oil seeds such as groundnut and soybean may deteriorate under certain circumstances. It is wise to use artificial antioxidants to preserve butylated hydroxyl toluence (BHT), butylated hydroxyl anisole (BHA), ethoxyquin, propyl galate and octylgallate.

ANIMAL PROTEIN SOURCE

It is made from dried ground, whole fish, or fish cuts, offals with or without oil extraction. There are various brands of fish meal but the commonest are those with high oil including herring, menhaden, salmon and low white fish.

FISH MEAL

It is a very common animal protein feed ingredient in use. It is a by-product of fish industry. It is usually made from whole fish. However, fish offal of high quality could also be used. Local fish meal is lower in its protein content than the imported fish meal. Crude protein content of fish meal may vary from 55 and 77% depending on the fish type use and extent of oil extraction. Calcium (3-6%) and phosphorus (1.5 – 3%) contents and micro mineral are in high content are high (i.e 3-6% and 1.5 – 3%) respectively.

Fish meal is low in fat soluble vitamin because they are extracted along with the oil. It is however, high in vitamin B complex vitamins especially vitamin B_{12}. Its biological value is very high and usually varies from 60-80%. It is a good source of sulphur amino acid i.e methionine is about 1.8%. Its lysine content is about 4.5%. Fish meal must be properly stored because of its residual oil causing rancidity.

Limitation of fish meal

1. It is usually used at a level between 0 – 5% for economic reasons.
2. High levels of inclusion may make animal go off feed.
3. Fish meal flavor may also be imparted to the carcass at higher level of inclusion.
4. Fish meal must be properly stored because of its residual oil.

BLOOD MEAL

It is a slaughter's house by products. It is prepared from fresh and clean animal blood free of all extraneous materials such as stomach content, hair and urine. The water in the blood is usually removed by parboiling. It is parboiled or mechanically dewatered the resulted semi solid blood mass is rapidly dried and ground to obtain meal.

It is high in protein (80-88%). It is an excellent source of lysine if properly prepared. It is also rich in leucine but is low in isoleucine, ash calcium and phosphorous. It can partly replace fish meal in starter diets for broiler chicks and turkey but can replace all the fish meal in broiler finisher.

Limitation

1. Badly processed blood meal may expose animal to the attack of salmonella organisms create problems of flies.

2. Its amino acid content is not well balanced. It is low in sulphur containing amino acids. Its biological value is low (i.e about 19%.
3. It is not usually utilize beyond 5% level. Higher levels make animal go off feed.
4. Over heating reduces lysine availability of protein is less digestible.

MEAT AND BONE MEAL

It is the rendered product from animal (especially mammal) tissues including bone. It excludes blood hair, hoof horn, hide trimmings, manure, stomach and rumen content.

It contains about 50% CP and it is high in fat and ash. The protein quality is variable depending on the quality of meat and amount of extraneous material. It is a good source of lysine, calcium and phosphorous but it is deficient in methionine, cystine and tryptophan.

Limitations

-Excessive processing temperature may reduce lysine availability.

-Too high levels of inclusion may result in undesirably high levels of calcium and phosphorous.

MEAT AND BONE MEAL TANKAGE

It is similar to meat and some meal except that it may contain blood or blood meal.

MEAT MEAL (MEAT SCRAP)

It is the rendered products from animal (especially mammal) tissue. It excludes bone, blood, hair, hoof, horn, hide trimmings, manure stomach and rumen content. It is similar to meat and bone meal except that it is low by calcium and phosphorous unit than 4.4%, it is classified as meat and bone meal.

It is used at about 7-10 % dietary inclusion level. Meat meal is virtually nonexistent in Nigerian as virtually all parts of the animals are consumed

MEAT MAEL TANKAGE

It is similar to meat meal except that it contains blood or blood meal.

POULTRY BY-PRODUCT MEAL

It consists of the ground, dried, rendered parts of the carcass of slaughtered poultry such as heads, feet offals, undeveloped eggs and intestine. Feathers are not included.

It is an excellent source of protein (i.e 55% CP). It is rich in lysine tryptophan, calcium and phosphorous. The level of inclusion is as discussed for meat and bone meal.

FEATHER AND HAIR MEALS

Feather and hair are not digestible commercially available feather and hair meals are often referred to as hydrolysed feather and hair meal. This is obtained by pressure streaming undecomposed clean feathers from slaughtered poultry. Excessive heat may destroy cysteine and lysine. They are about 75% digestible.

Hydrolysed feather meal is high in cystine and threonine but deficient in lysine, methionine, histidine and tryptophan.

DRIED POULTRY MANURE

It is dried poultry excreta. Its chemical contents may vary depending on the source and age of the birds from which manure is obtained. The protein content is between 25 and 29%%, fat content 1.5 – 2.5% and fibre 14 – 20%. Lysine content 0.3 – 0.5%, methionine 0.10 and 0.15%. Dried poultry manure is used in ruminant and mongastric animal feeding.

MISCELLANEOUS SOURCES OF PROTEIN

LEAF PROTEIN

Plant protein contains fair amounts of protein. The protein can be concentrated by crushing and disintegrating the leaves or by precipitating protein concentrate from the leaf juice with the aid of heat or acid. The concentrate so formed may contain up to 60% protein.

SINGLE CELL PROTEIN refers to bacteria, yeast, fungi and algae are microorganisms. Biomass containing up to 50% or more can be produced from each of these micro organisms are termed single cell protein. (SCP).

Hatching waste: It is a mixture of egg shells; infertile and unhatched eggs called chicken that are cooked, dried and ground prior to use.

INSECT MEALS

They include larva of insects, whole insects and earthworm. They can replace plant protein or parts of the fish used in the diet.

Milk and milk by product: they include skimmed milk, condensed butter milk, dried whole milk. They are excellent source of protein but are usually too expensive to be included in the feed.

PROCESSING OF FEEDS

There are several ways of processing feed stuffs. This can be classified into dry and wet processing or cold and hot processing.

COLD PROCESSING METHODS

GRINDING: The particles may be finely, moderately or coarsely ground. However, fine ground may lead to wind loss, tends to form ball in the GIT when mixed with saliva, reduces palatability in cattle, and reduces digestibility and absorption due to faster rate of passage in GIT. May cause ulcer in pig, feed bloat in cattle. Moderately ground is good for pig and poultry. Grinding of grains for cattle may probably not necessary but sorghum has to be crushed coarsely because its waxy coats may prevent digestions. Fine ground grains for dairy cattle will result in low butter, fats and milk.

ROLLERMILL GRINDING

Rollermills act on grain by compressing it between two corrugated rolls that can be screwed together to produce smaller and smaller particles. Rollermils are not used with roughages.

HAMMER MILLS

A hammer mill processes feed with the aid of rotating metal bars (hammers) that blow the ground product through a metal screen. The size of the product is controlled by changing the screen size. These mills will grind anything from coarse roughage to any type of grain. The products size will vary from particles similar to cracked grain to a fine powder.

SOAKED GRAIN

Grain is soaked for 12-24 hours. The soaking, sometimes with heat, softens the grain which swells during the process making a palatable product that should be rolled before using in finishing rations.

RECONSTITUTION

It is similar to soaking and involves adding water to mature dry grain to raise the moisture content to 25-30. It is stored in oxygen, limiting silo for 14-21days prior to feeding. This procedure works well with sorghum.

HIGH MOISTURE GRAIN

Grain is harvested at a high moisture content of (25-35%) and stored in a silo or treated with chemical to avoid spoilage. It may be ground before ensiling or ground or rolled before feeding. This is an important method when weather conditions do not allow sun drying.

ACID PRESERVATION OF HIGH MOISTURE GRAINS

Thorough mixing of 1.1.5% propionic acid, mixture of acetic propionic acids or formic and propionic acids into high moisture (20-30%) whole corn or other cereal grains retards molding and spoilage.

HOT PROCESSIGN METHODS

Most of these methods are associated with high cost and maintenance problem of equipment.

STEAM ROLLING

The steaming is accomplished by passing steam through a tower above the roller mill. The grains are subjected to steam for only a short time (3-5minutes) prior to rolling. Most results had only little or no improvement on animal performance as compared to dry rolling but use of steam does allow production of larger particles and fewer fines.

STEAM FLAKING

Grain is subjected to high moisture steam for a sufficient time to raise the water content to 18-20%, and the grain then rolled to produce a flat flake. This process is beneficial in term of weight gain efficiency.

PELLETING

Pelleting is accomplished by grinding the feed and then forcing it through a thick die. Feedstuffs are usually but not always steamed to some extent prior to pelleting. Pellets can be made in different diameters, lengths and hardness and are commercially available. It is good for pig and poultry.

ADVANTAGES

1. It reduces dustiness
2. It reduces loss in the fine particles ingredients during transportation.
3. It reduces feed wastage particularly in fish, pig, poultry
4. Bulking reduction
5. It increases the utilization of fibrous feed component of the ration
6. Partial cooking of starch results in making it more susceptible to enzymatic action and improves digestibility of starch

DISADVANTAGES

1. It increases cost of production
2. Improper pelleting procedure may cause feed spoilage
3. Ration high in fat are not good in pelleting

TOASTING

Maize is usually the target. The maize is passed through a roaster. The moisture constant will be reduced to about 5% but the bulkiness is increased by 15%.

Results of livestock feeding trials with roasted maize used for pigs, consistently shown an improvement in the rate of grain to about 8-12% and improvement in feed efficiency to about 9-10%.

COOKING

It is usually done for two reasons:

1. To destroy the antinutritional factors in feed stuffs
2. To increase the utilization of starch granules present.

PROTEIN QUALITY AND EVALUATION OF FEED STUFFS

BIOLOGICAL EFFICIENCY OF A DIETARY PROTEIN

It depends not only on the balance of available amino acids but also in the nitrogen and energy intake nutrient digestibility, the species and physiological stage of the animals.

The biological efficiency is also affected by the presence or absence of bacteria or fungi toxins, the rancidity of the associated fat, the content of vitamins, minerals and other essential nutrients that accompany it in a diet. Effect of physiological status of animals on protein utilization;

Animal in a growing phase are able to utilize protein better than adult animals. Pregnancy and lactation also improve protein utilization while infection, emotion and injury reduce the utilization efficiency of protein.

METHODS OF EVALUATION OF PROTIEN QUALITY

PROTEIN EFFICIENCY RATIO (PER)

It expresses numerically the growth promoting value of protein. It involves using weight of protein intake in a test diet to divide the weight gain by animal on the test diet. It is assumed that the primary function of a dietary protein is to furnish a mixture of amino acid in a proper pattern for the synthesis of tissue protein.

PER have a high correlation (r = 0.736) with biological value. However, despite its long history and wide usage, PER may not be a very good assay procedure based on the following facts;

i. the results are influenced by the level of protein consumed.
ii. no allowance is made for the quantity of protein used for maintenance
iii. gain in body weight does not necessarily correspond to gain protein

NET PROTEIN RETENTION (NPR)

Some improvements can be made to some of the short coming of PER by including a group of animals consuming a non protein diet (basal diet).

$$\textbf{NPR} \quad \frac{\text{weight gain on a test diet - weight loss on a basal diet}}{\text{protein intake on a test diet}}$$

The basal diet is made up of a purified diet and it contains no any other nutrient than a principal one.

BIOLOGICAL VALUE (BV)

It is the percentage of nitrogen absorbed from the GI tract which is available for productive body functions.

$$BV = \frac{\text{N intake – feacal nitrogen - urinary N}}{\text{N intake – feacal N}} \times 100$$

The Thomas Mitchell method of determining BV takes the metabolic and endogenous N losses into account

$$BV = \frac{DNI - (FN - MFN) - (UN-EN)}{DNI - (FN – MFN)}$$

DNI - Dietary Nitrogen Intake

FN - Faecal Nitrogen

MFN - Metabolic Faecal Nitrogen

UN - Urinary Nitrogen

EN - Endogenous Nitrogen

NET PROTEIN UTILIZATION (NPU)

It measures efficiency of growth by comparing body nitrogen resulting from animals fed a test protein with that of animal fed protein free diets for the same length of time.

There are two methods for this;

1. The carcass analysis technique

The nitrogen content of the animals on test diet and those of protein free diets are obtained and the formular below is applied;

$$NPU = \frac{\text{carcass N on test diet - carcass N on … diet}}{\text{Total N intake on test diet}}$$

It is only suitable for small animals like rat.

2. Nitrogen depletion method

Animals are fed on protein free diet for a period of time sufficient to deplete the labile protein reserve. Animal are then placed on test diets and the response of the animals are measured. It is good for growing animals e.g. chicken and piglet.

ADVANTAGES

i. homogeneity and sensitivity

ii. linear response even at high protein intake

iii. ease of execution

iv. rapid response