COURSE GUIDE

ANP 505
MONOGASTRIC NUTRTION
(2 UNITS)

Course Team:

Prof. T. S. Olugbemi – ABU, Zaria (Course Writer)
Prof. Grace E. Jokthan – NOUN (Programme Leader)
Prof. G. S. Bawa - ABU, Zaria (Course Editor)
Dr. Ahmed A. Njidda – NOUN (Course Coordinator)

NATIONAL OPEN UNIVERSITY OF NIGERIA

TABLE OF CONTENTS

INTRODUCTION

Monogastric Nutrition is a two-credit unit course. This course seeks to explain the science governing the ingestion, mastication, digestion, absorption and excretion of feed ingredients that results in the maintenance, growth, reproduction and production of the monogastric animal. It also encompasses other science disciplines such as chemistry, microbiology, physics, mathematics, physiology, biochemistry. The nutrition of the monogastric animal has its peculiarities as these animals which include poultry, swine and the rabbit are single stomached. A proper understanding of the composition, availability and utilization of the nutrients contained in feedstuffs utilized in monogastric animal feeds is vital in adopting the correct design and formulation of rations. Cognizance of these peculiarities influences their nutritional requirements as well as the feed ingredients that can be utilized in the formulation of their feeds. Proper feeding is also vital as feed along with its utilization constitutes the bedrock of production and if disregarded could result in sub-optimal efficiency and nutritional disorders.

COURSE AIM

This course aims to provide you with information on the principles involved in the nourishment of monogastric animals, feeding standards and their limitations, nutrient requirements for the different classes of livestock, substances that are added to feeds to achieve various production purposes, water in relation to nutrition and water metabolic computation, the appraisal of feeds, feed industry, feed mixing and manufacture on a large scale.

COURSE OBJECTIVES

- To define what a monogastric animal is
- To illustrate what the animal's digestive tract looks like and function of its various components

- To identify the classes of feed ingredients, their potentials, limitations, methods of preparation and combination in feed formulation
- To recognize the basis for which substances are added in monogastric animal feeds
- To know the effect of added substances in feeds on the final product

At the end of the course, it is expected that you would be able to:

- State what a monogastric animal is
- Draw the digestive tracts
- State the peculiarities of the monogastric animal's digestive system as compared to other classes of animals
- Identify the parts of monogastric animals's digestive system and know their functions
- Point out the role of nutrient types and feed additives in monogastric animal feeds along with the consequences of their inadequacies
- Identify the types of feedstuffs utilized in the formulation of feeds for these animals
- Formulate feeds for these classes of animals

COURSE MATERIALS

The course material consists of the following:

1.0 INTRODUCTION
2.0 OBJECTIVES
3.0 MAIN CONTENT
4.0 CONCLUSION
SELF ASSESSMENT EXERCISE
5.0 SUMMARY
6.0 TUTOR-MARKED ASSIGNMENT
7.0 REFERENCES/FURTHER READINGS

MODULE 1: PRINCIPLES OF MONOGASTRIC NUTRITION

UNIT 1: Basic definitions and nutritional limitations of Monogastric animals

1.0 INTRODUCTION

Certain terminologies are linked to monogastric nutrition and their understanding by way of definition and differentiation from similar terminologies is important to get a good grasp of this course. The modality of feeding monogastric animals has its peculiarities due to the structure of the digestive tract of the animal. The simple stomached nature of the gastro intestinal tract imposes certain nutritional limitations that must be appreciated if the best is to be obtained from monogastric animals. These include the need for readily digestible feeds arising from their inability to utilize complex carbohydrates, cellulose and hemicelluloses. They also require essential amino acids as they cannot synthesize amino acids. The appropriate processing of feed ingredients to be used in feed formulation is also vital in ensuring that the animals are able to readily digest the feeds.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- Define basic terminologies associated with monogastric nutrition
- Differentiate between similar terminologies
- Highlight the nutritional limitations associated with the monogastric animal

3.0 MAIN CONTENT

3.1 Basic Definitions

Listed below are some basic definitions related to monogastric nutrition.

Ad libitum (ad lib) - a diet offered free-choice, allowing animals to eat as much as they desire; typically allows for 10% leftover from a daily allotment.

Amino acids - a class of nitrogen-containing molecules that are the building blocks from which protein is made in the body.

Antibiotic - a class of drug usually produced by living organisms (moulds, bacteria or green plants) that can inhibit or kill undesirable bacteria (e.g., penicillin).

Antioxidant - a compound added to feeds to prevent the oxidative rancidity of fats.

As fed - an expression of feed nutrient content with moisture included. Nutrient content on an "as fed" basis is always lower than on a "dry matter" basis.

Available protein - the portion of the crude protein that can be digested by the animal; it can represent the proportion of total protein after deducting the ADF-N fraction of a feed.

Balanced ration - a 24-hour feed allowance that provides an animal with appropriate amounts and proportions of all nutrients required for a given level of performance.

Blended - two or more feed ingredients combined; blending does not imply a uniformity of dispersion.

Bran - coarse outer grain coating, separated during processing.

Byproduct - feed ingredients produced as a result of industrial manufacturing, plant or animal processing (e.g., distillers' grains, beet pulp, fish meal).

Cake - residue remaining after pressing seeds, meat or fish to remove oil, fat or other liquid.

Carbohydrate - energy-providing substrate, including starches, sugars, cellulose and hemicellulose. All carbohydrates contain carbon, hydrogen and oxygen, and are usually divided into two fractions: structural (fibre from plant cell wall) and non-structural (sugars and starches from plant cell contents).

Chaff - husks or other seed coverings and other plant parts separated from seed during harvest or processing.

Chemical analysis - the use of standard chemical analytical procedures to determine the composition of a feed.

Coccidiostat - drug used to control coccidial infections. Coccidia are microscopic protozoa that live in the intestinal lining of livestock and poultry, causing severe diarrhea or unthriftiness.

Colostrum - the first milk secreted by mammals after giving birth, particularly rich in nutrients and antibodies essential for newborn survival through passive transfer of immunity to the calf from the mother.

Complete feed - a thoroughly blended mixture of different feed ingredients formulated to meet specific nutrient requirements that allows for greater efficiency in feeding and provides better control of nutrient intake. A complete feed may or may not include the roughage portion of the ration.

Concentrate - a classification of feedstuffs high in energy and low in fibre, usually further divided into energy and protein concentrates. Often used interchangeably with supplement (e.g., corn, barley, soybeans).

Condensed - reduced to a denser form by removing moisture.

Crude fibre (CF) - chemical analysis that involves extraction of a ground feed sample with diethyl ether followed by sequential boiling in dilute acid and dilute base. Residue is then burned in a furnace; CF is calculated as the difference in weight of the sample before and after burning.

Crude protein - an estimate of the total protein content of a feed determined by analyzing the nitrogen content of the feed and multiplying the result by 6.25. Crude protein includes true protein and other nitrogen-containing substances such as ammonia, amino acids, nitrates.

Dehydrated - dried by removing moisture.

Digestibility - a measure of the apparent extent that a feed or nutrient is digested, usually expressed as a percentage of the amount consumed.

Digestible energy (DE) - the apparent energy that is available to the animal by digestion, measured as the difference between gross energy content of a feed and the energy contained in the animal's feces (gross energy minus fecal energy).

Digestion - the process of mechanical, chemical and enzymatic breakdown of consumed feeds into smaller components for absorption in the intestine of the animal.

Dry matter - feed residue left after all moisture has been removed by drying (e.g., 100% dry matter).

Dry-matter basis - used to compare nutrient composition or animal intake of feeds in a standardized fashion by eliminating differences in moisture content.

Dry-matter intake - amount of moisture-free feed or diet consumed.

Emulsifier - a substance added to products to enable fat or oil to remain in liquid suspension;

Enzyme - a complex protein produced by living cells that speeds up chemical reactions without being changed or destroyed itself. Enzymes are added to animal feeds to supplement low enzyme production or to improve utilization of poorer quality feeds.

Essential amino acid - amino acids that must be supplied in the diet, as the animal either cannot synthesize them at all or cannot synthesize them in sufficient quantities to meet its requirements.

Essential fatty acid - fatty acid that cannot be synthesized by an animal from other sources.

Ether extract - laboratory test to approximate the total fat content of a feed; includes some waxes, pigments and other lipids to a minor degree.

Extracted - fat or oil removed from a feed or byproduct by heat and mechanical pressure (mechanically extracted) or by organic solvent (solvent extracted).

Extruded - feed forced through narrow openings under pressure.

Fat-soluble vitamins - includes vitamins A, D, E and K. Fat-soluble vitamins are stored in body fat reserves. Vitamins A, D and E are supplemented in many livestock rations.

Fatty acid - a major component of fat that is used for energy by the animal. Molecules are composed of carbon and hydrogen in chain-like formation.

Feed efficiency - a ratio describing the amount of feed consumed per unit of production (e.g. gain, milk, eggs).

Feed processing - physical or chemical changes in feedstuffs, which influence their nutritional value.

Flour - soft, finely ground meal consisting mainly of starch and gluten obtained during grain milling.

Grain - seed from cereal plant (e.g., oats, corn, wheat).

Grits - coarsely ground grain from which the bran and germ have been removed.

Ground - particle size reduced by mechanical shearing, wearing or impact.

Heat damage - reduction in nutrient content of a feed because of chemical reactions induced by high temperatures.

Heat-damaged protein - reduction in protein content of feedstuff that is available to the animal because of chemical reactions that occur at high temperatures.

Lignin - a complex polymer bound to cellulose that strengthens plant cell walls but is indigestible to animals.

Lipids - substances found in plant and animal tissues that are insoluble in water, but soluble in benzene or ether; includes glycolipids, phosphoglycerides, fats, oils, waxes and steroids.

Lysine - an essential amino acid for protein synthesis. It is the first limiting amino acid in maize-soybean-based monogastric diets.

Macrominerals - minerals required in relatively large amounts by livestock. Includes calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), chlorine (CI), sulfur (S) and sodium (Na).

Maillard reaction refers to loss of amino acid availability as it complexes with carbohydrates.

Mash - a mixture of ingredients in meal form.

Meal - a feed ingredient having a particle size similar to flour.

Medicated feed - any feed that contains drug ingredients intended for the cure, treatment or prevention of animal disease, enhancement of feed efficiency or promotion of growth.

Metabolizable energy (ME) - a measure of the useful energy in a feed, representing that portion of the feed gross energy not lost in the feces, urine and eructated gas.

Methionine - a sulfur-containing essential amino acid for protein synthesis; a limiting amino acid in many ruminant diets. Protected-methionine means resistant to rumen digestion.

Micro-ingredient - a vitamin, mineral, antibiotic, drug or other compound normally required in small amounts and added to diets in milligrams or micrograms.

Micromineral - minor mineral elements required fed in very small amounts in the ration of animals; includes manganese (Mn), copper (Cu), zinc (Zn), selenium (Se), iron (Fe), cobalt (Co), iodine (I) and fluorine (Fl).

Mineral supplement - a rich source of one or more mineral elements.

Minerals - inorganic feed elements essential for life.

Mycotoxin - a substance produced on plants by fungi, particularly during weather stress during the growing or harvest seasons, that is toxic to animals (e.g., vomitoxin, zearalenone, aflatoxin and T-2).

Non-essential amino acids - amino acids that can be synthesized by the animal.

Non-protein nitrogen (NPN) - nitrogen not derived from true protein, but usable by rumen microbes to build microbial protein, (e.g., urea).

Non-structural carbohydrate (NSC) - simple carbohydrates, such as starches and sugars, stored inside the cell that serve as a cellular energy source. Non-structural carbohydrates are rapidly and easily digested by the animal.

Nutrition - Nutrition is the science that studies the intake of feed, breaking down into smaller pieces, mixture with substances that would facilitate further breakdown,

Nutrient allowances - recommendations for the nutrient amounts necessary for maintenance, growth, gestation, lactation or performance that include a safety margin to account for variability in feeds and animals (e.g., environment, health, storage losses).

Nutrient requirements - the minimum amounts of nutrients (energy, protein, minerals and vitamins) necessary to meet an animal's needs for maintenance, growth, reproduction, lactation or work; does not include a margin of error in ration formulation.

Organic matter - total weight of the feed minus the mineral content.

Palatability - the appeal and acceptability of feedstuffs, including the taste, odour, texture of the feed.

Particle size - the diameter of granular feed materials (e.g., grains, pellets, mineral particles) and/or the length of roughage fragments.

Pelleted - feed compressed into a circular or cubic mass, forced through die openings by a mechanical process and cut at predetermined lengths.

Premix - a uniform mixture of one or more microingredients and a carrier, used to facilitate uniform dispersion of micronutrients into a larger mixture. A mineral premix contains higher fortification of trace minerals and vitamins than a mineral supplement.

Preservative - a substance added to protect, prevent or retard decay, discolouration or spoilage of a substance during storage or use.

Protein - naturally occurring compounds containing nitrogen, carbon, hydrogen and oxygen, and sometimes sulfur or phosphorus. Proteins are made up of complex combinations of amino acids and are essential for animal growth, production and reproduction.

Protein supplement - a feed or mixture of feeds containing 20% or more protein or protein equivalent (e.g., soybean meal, canola meal).

Ration - the 24-hour feed allowance for an individual animal.

Saturated fat - a completely hydrogenated fat, solid at room temperature (e.g., animal tallow).

Supplement - feed or feed mixtures used to improve the nutritional value of basal feeds. A supplement is rich in one or more of protein, energy, vitamins, minerals or antibiotics, and is combined with other feeds to produce a more complete feed. Often used interchangeably with concentrate.

Toxicity - the extent to which a substance is poisonous to animals.

Unsaturated fat - any fat that is not completely hydrogenated. Unsaturated fats are liquid at room temperature (e.g., corn oil, vegetable oil).

Water-soluble vitamins - sub-class of vitamins that includes B complex vitamins and vitamin C. Not normally supplemented for ruminants after 2 months of age because

rumen microbes are thought to be able to manufacture enough to meet the animal's requirements.

Nutritional Limitations of Monogastric Animals

Monogastric as compared to ruminant animals are simple and single stomached animals with less efficient digestive system in breaking down feed and absorbing nutrients from a wide variety of feed materials especially fibrous ones. They do not on their own produce enzymes that can digest cellulose which is contained in most fibrous feeds and there is an absence of a fully functional caecum. There is also very limited symbiotic relationship between the animal and microflora in the gut resulting in the reduced capacity of these animals to make use of feed ingredients that are high in lignocelluloses thereby necessitating the provision of well compounded feeds containing all the essential amino acids and vitamins with the end result of a more expensive feed. The rabbit however fares better in this regards as they possess a ceacum which houses microbes as is therefore able to utilize more fibrous material than the other monogastric animal species. Monogastric animals also have relatively shorter digestive tracts hence reducing the available time for digestion and absorption of nutrients hence nutrients contained in their feeds should be easily digestible and biologically available.

4.0 CONCLUSION

Being conversant with basic terminologies associated with monogastric nutrition is important in understanding the concepts of this course. Monogastric animals have nutritional limitations imposed on them due to the nature of their gastro intestinal tracts thereby influencing the type and form of ingredients used in compounding their feeds as well as creating a necessity for adding synthetic amino acids.

5.0 SUMMARY

A good understanding of some basic terminologies you will come across during the course of your studying monogastric nutrition is vital in appreciating this course. Also important is the ability to avoid mixing up similar terminologies. Monogastric animals cannot generally be fed like other animals due to peculiarities in their gastro intestinal tract. These peculiarities must be known and appreciated in order to provide for the needs of the animal with a view of getting the best from them in terms of growth and products as well as reducing diseases incidences. Due to their inability to utilize complex carbohydrates, cellulose and hemicelluloses as well as synthesize amino acids, they must be given feeds that are easily digestible and supplemented with synthetic forms of amino

acids. The feed ingredients used in compounding the feeds must also be processed into a form that would enhance easy digestibility of the feeds.

SELF ASSESSMENT EXERCISE

1. Define *ad lib*, complete feed, nutrition, amino acid
2. Non-structural carbohydrates can be rapidly and easily digested by the animal. True or False
3. Which is the first limiting amino acid in maize -soybean-based monogastric diets?
4. Taste, odour and texture influence palatability of feeds. True or False?
5. List some of the nutritional limitations of the monogastric animal

6.0 TUTOR-MARKED ASSIGNMENT

1. Differentiate between mash and meal, balanced ration and ration, nutrient allowances and nutrient requirements, protein and amino-acids.
2. Write short notes on the nutritional limitations of monogastric animals

7.0 REFERENCES/FURTHER READINGS

Atteh, J.O.(2018). Principles and practice of livestock feed manufacturing. Niyi printing and publishing company, Ilorin. 205pp

McDonald, P., Edwards, R.A. and Greenhaigh, J.F.D. (1994). Animal Nutrition, 4th Edition. Longman Publishers ltd, England.

Olomu, J.M. (2011). Monogastric Animal Nutrition: Principles and Practices. St. Jackson Publishong, Benin City, Nigeria. 478pp

www.http://chestofbooks.com/animals/Composition-of-The-Animal-Body.html. Retrieved 15th April, 2017.

www.http://List of nutrition terms. www.poultyryhub.org/nutrition/nutrient-requirements/list-of-nutrition-terms. Retrieved 5th December, 2018.

UNIT 2: FEEDING BEHAVIOURS OF MONOGASTRIC ANIMAL

1.0 INTRODUCTION

Feeding behaviour refers to any action of an animal that is directed toward the procurement of nutrients. The variety of means of procuring food reflects the diversity of foods used and the myriad of animal types. Major areas of interest in the study of feeding behavior are voluntary feed intake and diet selection as the quality of feed and the amount eaten are major constraints affecting animal productivity. Feed quality and quantity are vital aspects relating to the overall productivity and well being of the animal. Voluntary feed intake is influenced by a number of factors which should be well understood.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- State what feeding behaviour is
- Identify the factors which influence feeding behavior of monogastric animals

3.0 MAIN CONTENT

3.1 Feeding Behaviour

Pigs are able to consume a wide range of feeds consisting of both animal and plant origin due to their omnivorous nature. Their feeding habits tend to be opportunistic and when left to freely roam under the free range system of management, they tend to spend a greater part of their time foraging with rooting behaviour being a vital part. Under intensive systems of management where the floors are solid with no bedding coupled with the provision of a feeding trough containing their ration, pigs are hindered from performing their natural behavioural patterns. This can lead to behavioural abnormalities like tail biting. Pigs tend to engage more in eating activities during the early morning when the environmental temperatures are lower.

Poultry under natural conditions (free ranging) scratch at the ground to forage thereby gaining access to feed items such as seeds, insects, fruits and herbage. Under these conditions, poultry equally spend a major portion of their time foraging; an activity debarred under the intensive system and which could result in feather pecking. Poultry intensively raised engage more in eating activities during the early morning and evening when the environmental temperatures are lower. Other behavioual patterns include them not feeding during dark periods provided daylengths last for six to eight hours. In dark periods, the crop serves as a feed reservoir to supply nutrients overnight.

3.2 Factors affecting feeding behaviour

3.2.1 Diet selection

Pigs when allowed to select their diets from a variety of comparatively palatable diets are able to select the best diets. Poultry likewise especially under free range conditions

are also able to choose a diet that would meet their nutritional needs. They equally have appetites for protein, thiamine, calcium, zinc and phosphorus.

3.2.2 Temperature

The range of ambient temperatures that provides a sense of comfort, maximizes performance and minimizes stress for an animal is called the thermoneutral zone. High ambient temperatures reduces feed intake generally though more with highly producing animals. Very young animals have higher thermo neutral zones (TNZ) than adults and when animals are kept at temperatures below their TNZ, the heat produced will be exclusively for warmth at the expense of weight gain and growth. Higher ambient temperatures also result in reduced feed intake. It is therefore important to ensure monogastric animals are adequately protected from temperature extremes especially heat by the provision of wallows in the case of pigs, shade around houses, utilization of appropriate housing materials.

3.2.3 Water availability

There is a close relationship between dry matter intake and amount of water consumed. Animals drink more water when more feed is eaten. Although the exact water requirements of animals are dependent on feed type, physiological condition and climatic factors, when water is scarce, the tendency is for a reduction in feed intake. Feeds with higher salt contents cause increases in water consumption however in events of low water availability, the animal will reduce their feed intake. In addition to the adequate provision of water, care should be taken to ensure /the water is clean and not warm.

3.2.4 Physiological state

Feed intake generally reduces during oestrus. Sows however eat more when pregnant and lactating due to increased nutrient requirements.

3.2.5 Health status

Monogastric animals just like others reduce their feed intake when there is a rise in body temperature due to disease conditions. Worm and ectoparasite (ticks, lice, mites) infestation affect the feeding behaviour of these animals resulting in a decline in feed intake.

3.2.6 Stress

Stressed animals due to any management practice will eat less.

4.0 CONCLUSION

The feeding behavior of monogastric animals which highlights the actions that enable it acquire the nutrients required for its growth, production and reproduction are generally related to all factors that affect the ability to eat quantitatively and qualitatively. It is therefore important that any factor that debars the animal from feeding maximally be addressed.

5.0 SUMMARY

Any action of an animal that is directed toward the procurement of nutrients is known as feeding behaviour. The behaviour is mostly associated with the ability to feed free choice and *ad lib*. For efficient production, both the quantity and quality of feed presented to the animal are vital. Factors affecting feeding behaviour include diet selection by the animal, temperature, water availability to the animal, physiological state of the animal, health status of the animal.

SELF ASSESSMENT EXCERCISES

1. What is feeding behavior
2. List 5 factors that influence feeding behavior of monogastric animals

6.0 TUTOR-MARKED ASSIGNMENT

1. Clearly explain the concept of feeding behavior

2. Write notes on 5 factors influencing feeding behavior.

7.0 REFERENCES/FURTHER READINGS

Vilanova, X.M. and Smith, A.J. (2004). Livestock Behaviour, Management and Welfare. Technical Centre for Agricultural and Rural Cooperation. Macmillan Publishers Limited. 136pp.

Leendert de Ruiter. Feeding behaviour. https://www.britannica.com/science/ feeding-behaviour. Retrieved 5th January, 2019

UNIT 3: DIGESTIVE SYSTEMS AND ADAPTATION OF MODE OF FEEDING

1.0 INTRODUCTION

Monogastric animals are animals with simple and single stomachs unlike ruminant animals with four chambered stomachs. Monogastrics have nutritional limitations in that they do not on their own produce enzymes that can digest cellulose which is contained in most fibrous feeds. They include poultry, swine, rabbits, dogs, cats and a number of others.

Poultry have a short digestive tract and require well compounded concentrate feeds In order to perform well. The short tract also results in a fast passage of the feed. The absence of a fully functional caecum limits its utilization of high fibre feed materials.

Swine also known as the pig has its own unique digestive tract. They are omnivores and can handle feed from both animal and plant origin. The rabbit though a monogastric animal has certain features that distinguish them from poultry and swine hence giving them a comparative nutritional advantage. These features are similar to what is obtained in ruminants hence rabbits are called pseudo-ruminants. These include the possession of a diastema and caecum as well as the practice of caecotrophy; eating of soft faeces by the rabbit. As a result of these features and practice, the rabbit is able to utilize more fibrous material than the other monogastric animal species.

This unit highlights the various components of the digestive tract as well as the various pathways taken.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- State the functions of the poultry digestive system
- Recognize the role of fibre in poultry nutrition
- State the nutritional limitations of monogastric animals
- Be acquainted with the digestive tract parts and the feed pathway of poultry
- Be familiar with the digestive tract parts and the feed pathway of swine
- Recognize the digestive tract parts of a rabbit and its feed pathway

3.0 MAIN CONTENT

3.1 Digestive tract of poultry

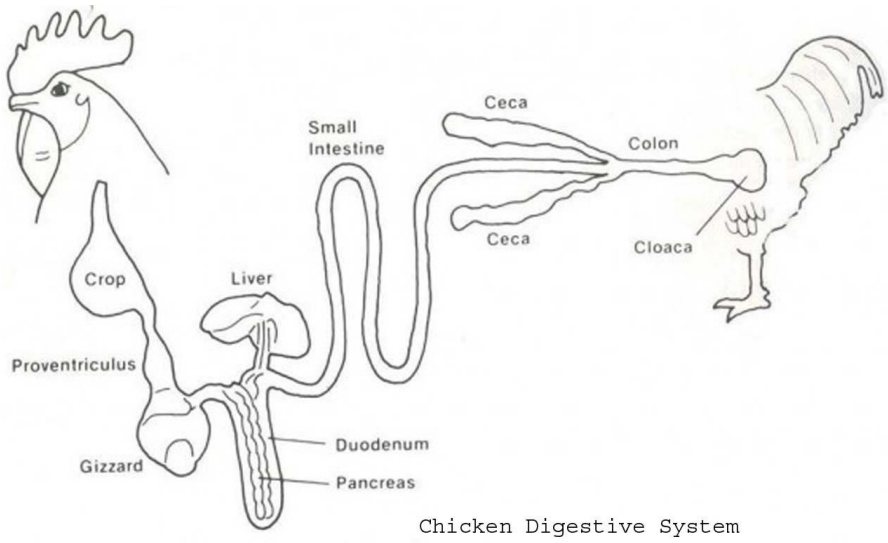


Figure 1: Digestive System of the Chicken

The digestive system of the chicken as shown in Figure 1 is simple but efficient. It mechanically and chemically breaks down feed and allows nutrients to be absorbed ready for use in the body. The basic functions of the digestive system of poultry are as follows:

i. It collects and makes small pieces from large particles or pieces
ii. It softens feed so that the enzymes may readily react
iii. It provides a desirable environment for microorganisms
iv. It promotes or brings about synthesis in the gut
v. It allows for absorption and water balance
vi. It absorbs, excretes and recycles substances
vii. It produces and disposes of faeces

The process of feeds digestion by poultry is:

- Feed is picked up by the beak and selected on the basis of feel and appearance. The beak is the perfect tool for pecking feed in crumble or pellet form, small grains, grass or insects.
- The beak moistens feed which is swallowed whole with Saliva.
- The oesophagus takes the feed down to the crop to be stored. A small bit of saliva and digestive enzymes are added as the feed moves from the mouth into the esophagus.
- After a chicken has eaten, the crop will feel full and bulge. The crop is an expandable storage compartment pouch in the esophagus used to store feed (ingesta) temporarily for up to 12 hours before it moves on to the stomach. It is located at the base of the chicken's neck,
- Ingesta from the crop slowly passes down to the proventriculus. The ingesta trickles from the crop into the bird's stomach (proventriculus or gizzard) where digestive enzymes are added to the mix and physical grinding of the food occurs.
- Ingesta is then passed through to the gizzard where insoluble (flint) grit has accumulated. The gizzard is a muscular part of the stomach that uses grit to grind grains and fiber into smaller particles. Feed is ground down by strong muscular action in the gizzard.
- From the gizzard, ingesta is passed through to the small intestine and is reduced further in particle size with enzymes from the pancreas. The ingesta is moved theough the small intestine by regular peristaltic contraction. The small intestine aids in digestion and nutrient absorption and is composed of the duodenum, jejunum and ileum.
- Bile produced by the liver and stored in the gall bladder helps to break down fat. The liver is the largest glandular organ in the body. It aids in the metabolism of carbohydrates, fats and proteins.
- The intestines digest the feed, taking nutrients from it.
- Water and the remaining undigested feed is absorbed in the large intestine.
- The residue then passes through the ceaca, a blind sack along the lower intestinal tract, where bacteria help break down undigested feed. The caeca are a pair of tubes that allow fermentation of undigested feed to take place
- The ceaca turns into the large intestine, which absorbs water and dries out indigestible feeds. It connects to the cloaca which is where the digestive, urinary and reproductive systems meet. This is emptied every 24 hours or so and is a light brown (mustard colour) froth.
- The cloaca / vent is the external opening and passes a combination of faeces and urine, together with eggs from the oviduct.

3.2 Role of Fibre in Poultry Nutrition

Fibre is the component of a plant material consisting mainly of cellulosic and non-cellulosic polysaccharides, and a non-carbohydrate component, lignin which are highly resistant to hydrolysis by alimentary enzymes and cannot, therefore, be digested or absorbed in the blood stream. Fibre content of feedstuffs are also wrongly believed to be always bulky. Wheat bran for instance which is a major feed ingredient in many poultry feeds is one of the bulkiest feedstuffs yet contains only about one third as much fibre as does sunflower seeds which are one of the less bulky feeds (9% crude fibre in wheat bran compared with 26% in sunflower seeds).

Fibre is required in poultry though at lower levels than ruminant animals and if appropriately applied in poultry nutrition could be of benefit. Benefits can be derived if the type, handling, processing and enzyme supplementation of fiber in poultry diets are adequately planned to suit the requirement of the specified age and class of bird to be fed.

Some of the benefits include:

3.2.1 Reduced cannibalism

Cannibalism (area of body part pecked as well as severity) has been reported to be reduced with moderate increases in fibre levels in poultry feeds probably due to increased feeding time as birds would spend more time feediung top meet their energy requiedments. It may also be due to increased utilisation of sodium and potassium with high fibre diets.

3.2.2 Decreased ammonia emission

Fibre helps to reduce health problems such as gastrointestinal irritation, respiratory diseases, contact dermatitis, and foot burns by decreasing the amount of ammonia emmitted. Ammonia emission in laying hens manure decreases with the inclusion of fibre ingredients in the feed. This has been attributed to fibre providing energy to bacteria in the lower gastrointestinal tract where the bacteria uses nitrogen that would otherwise be excreted as uric acid for bacterial protein synthesis. Another reason is that the bacterial metabolism produces short-chain fatty acids that lower manure pH, thereby shifting ammonia (NH_3) to ammonium (NH_4+), which is less volatile.

3.2.3 Reduced yolk and plasma cholesterol

Plasma and yolk cholesterol levels in poultry blood and eggs greatly reduce with increasing fibre levels in the diet. The inclusion of ingredients such as whole oats or

alfalfa meal in layer hen diets have been shown to result in lower cholesterol levels thereby minimising the health hazards associated with consumption of poultry eggs and meat. This cholesterol lowering (hypocholesterolemic) attributes can be linked to bile acids being bound by fibre in the intestines thereby causing more of such acids to be excreted in the faeces. This reduces the amount of bile acids returning to the liver and forces the liver to produce more bile acids to replace those lost in the faeces. In order to produce more bile acids, the liver converts more cholesterol into bile acids which lowers egg yolk and plasma cholesterol levels.

3.2.4 Fibre and mineral balance

varied fibre sources enhance the utilization and retention of certain minerals. For example, long-term feeding of rations having oat hulls increases the retention of sodium and potassium while copper retention is enhanced with soybean hulls usage. These three fibre sources increases retention of iron hence fibre incorporation could be an effective means of satisfying requirements for a specific mineral and correcting deficiency.

3.2.5 Fibre and nitrogen balance

Amino acids in fibrous feed ingredients are typically less digestible than those in low-fibre ingredients, requiring consumption of larger amounts of amino acids to satisfy the requirement for digestible amino acids. Hence, nitrogen balance will be higher in birds fed wheat middling compared to hens fed diets devoid of such fibre source.

3.2.6 Pigmentation of egg and meat

Distiller's dried grains from maize or sorghum when fed to chickens enhances yolk colour by imparting a reddish appearance. This is prefered by most customers in Africa and Asia. The colouration effect is a result of the high xanthophylls contents which are the primary contributors of yolk pigmentation the in these ingredients. Meat colour is also postively affected as they can effectively be absorbed and deposited in the abdominal fat pad and skin.

3.2.7 Digestibility in Poultry

Digestibility of feed is the ability of the animal to breakdown and utilize the feed taken in to provide the nutrients required to facilitate growth. The consumption of feed is not a guarantee that it would translate into growth or enhanced yield of products as it merely attests to the palatability of the feed. Proper digestibility of feed alone guarantees the release of nutrients and is the indices that ascertain that the nutrients released will nourish the animal. Utilization depends on the digestibility and is influenced by:

- Feed composition – poultry by their digestive system cannot effectively handle fibre hence feeds containing higher fibre would be less digestible and hence less productive.
- Ration composition – the provision of a balanced feed suitable for the purpose of the poultry and in adequate amounts for a specified period is vital for enhanced digestibility.
- Form of feed – nutrients denatured or reduced in value during processing reduces the nutrient available thereby affecting the digestibility. Appropriate particle sizes also make digestibility better as feeding younger birds with larger feed particles would result in poorer digestibility.
- Physiological state of the animal – unhealthy birds are unable to properly digest feeds.
- Age of poultry – younger birds are able to digest feeds more efficiently compared to older ones due to the immaturity of their digestive systems.

3.3 Digestive tract of swine

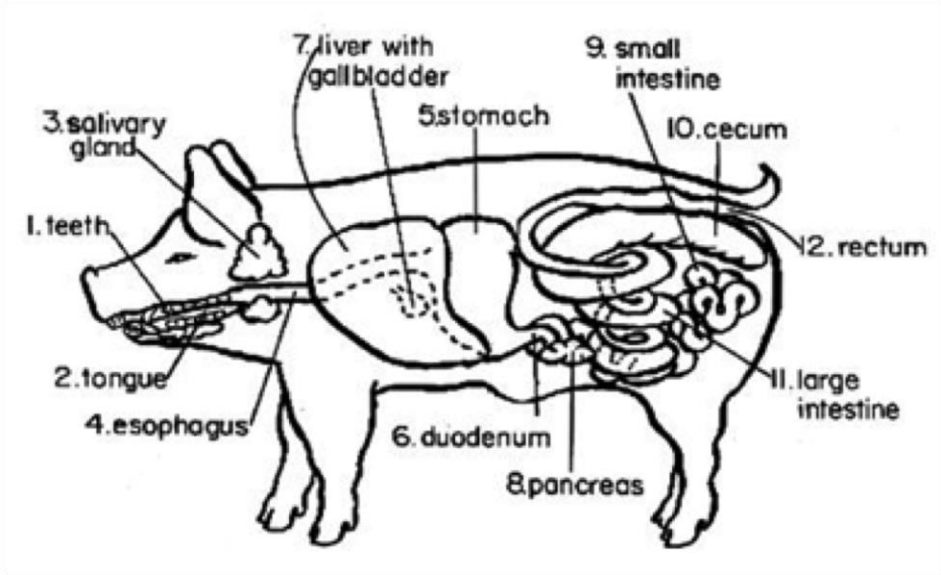


Figure 2: Gut of the Swine

As shown in figure 2, the feed is taken in through the mouth and this is where mechanical breakdown of feed begins. The teeth chew and grind the feed into smaller pieces. Saliva is produced in the mouth and acts to soften and moisten the small food particles. Saliva also contains an enzyme Ptyalin which starts the digestion of starch. The tongue helps by pushing the food toward the esophagus. The tongue has taste buds which has implications in feed palatability and voluntary feed intake.

The esophagus is a tube which carries the food from the mouth to the stomach. A series of muscle contractions push the food toward the stomach. Swallowing is the first of these contractions. At the end of the esophagus is the cardiac valve, which prevents food from passing from the stomach back into the esophagus.

The next part of the digestive tract is the stomach. It is a reaction chamber where chemicals are added to the feed. Certain cells along the stomach wall secrete hydrochloric acid and enzymes. These chemicals help break down feed into small particles of carbohydrates , protein and fats . Some particles are absorbed from the stomach into the bloodstream. Other particles which the stomach cannot absorb pass on to the small intestine through the pyloric valve.

The small intestine is a complex tube which is spiral, allowing it to fit into a small space. Its wall has many tiny finger-like projections known as villi, which increase the absorptive area of the intestine. The cells along the small intestine's wall produce enzymes that aid digestion and absorb digested foods. At the first section of the small intestine (duodenum), secretions from the liver and pancreas are added. Secretions from the liver are stored in the gall bladder and pass into the intestine through the bile duct. These bile secretions aid in the digestion of fats. Digestive juices from the pancreas pass through the pancreatic duct into the small intestine. These secretions contain enzymes that are vital to the digestion of fats, carbohydrates, and proteins.

Most feed nutrients are absorbed in the second and third parts of the small intestine, called the jejunum and the ileum. Undigested feed materials and secretions pass on to the large intestine through the ileocaecal valve.

A "blind gut" or ceacum is located at the beginning of the large intestine. In most monogastric animals, the ceacum has little function. However, in animals such as the horse and rabbit, the cecum is very important in the digestion of fibrous feeds.

The last major part of the digestive tract, the large intestine, is shorter, but larger in diameter than the small intestine. Its main function is the absorption of water. The large intestine is a reservoir for waste materials that make up the faeces. Some digestion takes place in the large intestine. Mucous is added to the remaining feed in the large intestine, which acts as a lubricant to make passage easier. Muscle contractions push feed through the intestines. The terminal portion of the large intestine is called the rectum.

The anus is an opening through which undigested feed passes out of the body. Feed that enters the mouth and is not digested or absorbed as it passes down the digestive tract is excreted through the anus as faeces.

3.4 Digestive tract of the rabbit

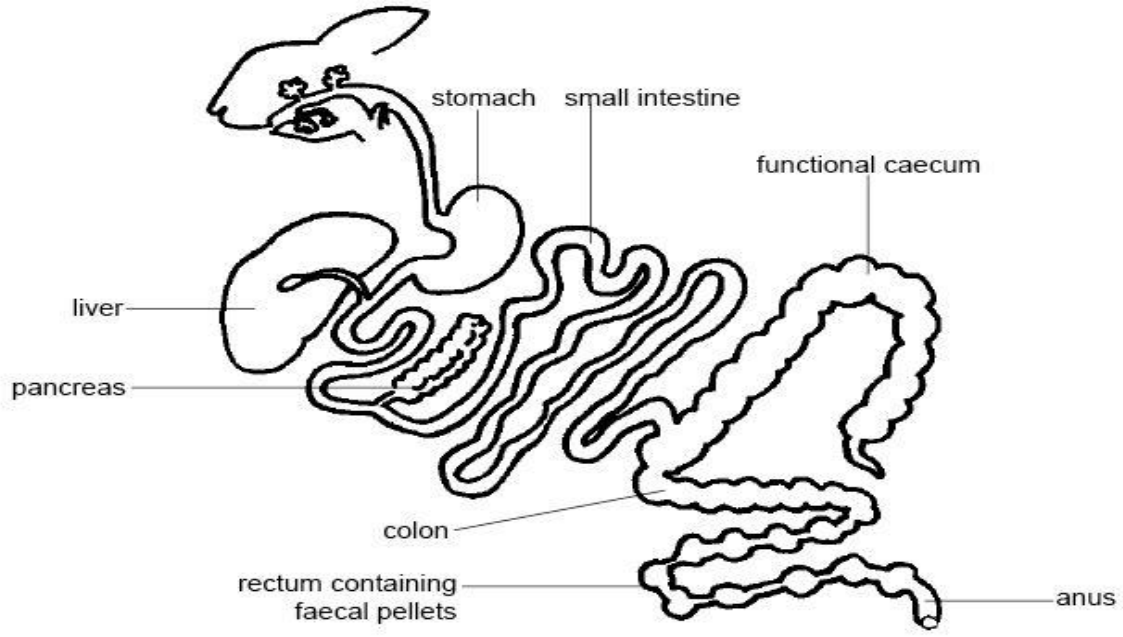


Figure 3: Gut of a rabbit

A rabbit's digestive tract (Figure 3) is a bit more complicated than that of poultry and swine and makes up 10 to 20% of its bodyweight.

As feed travels down the rabbit's oesophagus, it passes through a junction between the esophagus and the stomach called the cardia. The cardia is a region that contains a valve called the cardiac sphincter. In rabbits this valve is well developed, and makes the rabbit unable to vomit. After passing through the cardia the feed enters the stomach. The stomach is a thin-walled large organ, that almost always contains feed, hair, caecal pellets, and fluid even after 24 hours of fasting. After being mixed with stomach acid the feed moves through a junction called the pylorus. This junction joins the stomach to the duodenum, which is the first of three parts that make up the small intestine. The small intestine is where most of the nutrient extraction occurs. After the duodenum, the feed passes through the second part of the small intestine, the jejunum. The last third of the small intestine is called the ileum. At the end of the ileum is the sacculus rotundus where the small intestine widens and its walls thicken. This dilated globule of the small intestine is rich in lymphoid follicles, and opens into a saucer shaped thickening of the walls of the large intestine or colon. As the feed passes into the colon it passes by the ileo-caecal valve, which leads to the caecum. Colonic contractions (also known as peristaltic waves)

move fibrous particles rapidly through the colon, which extracts most its water content before excretion at the anus. At the same time, these waves separate out non-fibrous particles. Then anti-peristaltic (reverse) waves move fluid and non-fibrous particles back up the colon and through the ileo-caecal valve into the caecum for fermentation.

Three to eight hours after eating, soft mucus-covered caecal pellets, looking very much like small clusters of grapes, appear at the anus. Instinctually, the rabbit will eat these without chewing, thus keeping the mucous coating intact. This coating protects the vitamin and nutrient rich bacteria from stomach acid, until it reaches the small intestine where the nutrients can be absorbed.

The rabbit digestive system is unique in that it has an enlarged colon and large intestine. The rabbit is referred to as pseudo ruminants as they possess some features/practice activities similar to those of ruminants. Rabbits possess a caecum containing some microbial population just like the rumen. This allows for the intake and utilization of high quality leafy hays, grasses and green vegetables. These items are broken down by bacteria in the lower digestive tract.

They also possess a diastema (gap in dentition due to absence of canine teeth) and can do well on forage. In addition they practice caecotrophy, an act of eating their soft faeces.. In this regards, rabbits eat their faeces (caecotroph) and is based on their digestive tract construction. Rabbits pass out two kinds of faeces; hard and soft. The hard faeces is seen while the soft which is eaten is light green and hardly seen. Caecotrophy starts at about 4 weeks of age. This normally takes place in the night or early in the morn. Faeces passed out during the day are brown, hard and not eaten. After the ingestion of feed, it passes into the stomach for digestion but not all is assimulated into the body. Some passes on through the system to the caecum where bacteria act on it and important amino acids and vitamins of the B complex are synthesized. It then passes along the colon and out through the rectum as soft pellets that are re-eaten and mix with the new feed intake. The pellets also contain bacterial enzymes which further help in the breakdown of undigested feed material especially those of cellulose origin. This allows the rabbit to make full use of the bacterial digestion in the hind gut – that is conversion of forage protein to high quality bacteria protein, synthesis of B vitamins and breakdown of cellulose or fibre into energy.

Caecotrophs contribute about 20% of the protein and 10% of the energy needs for maintenance as well as needed vitamins and minerals. Older rabbits may have problems reaching around to ingest their soft caecal pellets. Soft caecal pellets contain 3.0-3.5 and half times the amount of protein and fibre as in normal faeces respectively.

SELF ASSESSMENT EXERCISE

1. List three monogastic animals
2. List 5 differences between monogastric and ruminant digestive tract
3. List 5 benefits of fibre in poultry diets
4. What is the function of the Pyloric Valve?
5. What is the name of the terminal portion of the large intestine?

4.0 CONCLUSION

The rabbit is a monogastric animal with some ruminant features giving it a comparative advantage over other monogastric animals.
The process of feed passage in poultry begins from the feed intake through the beak to the exit via the vent after passing through several functional apparatus.
Swine have a similar digestive apparatus like poultry though with some differences. Feed is taken in through the mouth which posses teeth and after a series of processes involving chewing, enzyme action and metabolic processes ends up being passed out from the anus in the form of faeces.

5.0 SUMMARY

Monogastric animals which include poultry, swine and rabbits are animals with simple and single stomachs unlike ruminant animals with four chambered stomachs. They have nutritional limitations in that they do not on their own produce enzymes that can digest cellulose which is contained in most fibrous feeds. They have shorter digestive tracts compared to ruminants. Poultry require well compounded concentrate feeds In order to perform well and the absence of a fully functional caecum limits its utilization of high fibre feed materials. Swine have a unique system in that they are omnivores and can handle feed from both animal and plant origin. The rabbit though a monogastric animal has certain features that distinguish them from poultry and swine hence giving them a comparative nutritional advantage. These include the possession of a diastema and caecum as well as the practice of caecotrophy; eating of soft faeces by the rabbit. As a result of these features and practice, the rabbit is able to utilize more fibrous material than the other monogastric animal species.
Fibre is the component of a plant material consisting mainly of cellulosic and non-cellulosic polysaccharides, and a non-carbohydrate component, lignin which are highly resistant to hydrolysis by alimentary enzymes and cannot, therefore, be digested or absorbed in the blood stream. Fibre is however required in poultry rations though at lower levels than ruminant animals and if appropriately applied in poultry nutrition could be of benefit in reducing cannibalism, reducing ammonia emission, reducing yolk and plasma cholesterol, enhancing mineral and nitrogen balance, improving pigmentation of egg and meat

Digestibility of feed is the ability of the animal to breakdown and utilize the feed taken in to provide the nutrients required to facilitate growth. Proper digestibility of feed is necessary to ensure required nutrients are released for the animal nourishment and is influenced by the composition of the feed, form of the feed, ration, age of poultry.

6.0 Tutor-Marked Assignment

1. Describe the attributes of monogastric animals
2. Compare and contrast the digestive tracts of poultry, swine and rabbit
3. Elucidate on possible benefits of fibre in poultry diets.
4. List the path that feed moves from the first point of entry to the point of exit in poultry
5. What role does saliva play in swine nutrition?
6. How does the rabbit digestive tract differ from other monogastric animals?
7. Summarise the process of caecotrophy in the rabbit
8. What are the outstanding attributes of caecotrophy?

7.0 References/Further Readings

Akinola, L. A. F. and Onunkwo, D. N. (2009). A review on the role of fiber in poultry nutrition. *Environment and Ecology* , 27(4): 1689-1691.

Advanced Livestock Science Manual, University of Illinois at Urbana, Champaign Cooperative Extension Service.

Babayemi, O.J., Abu, O.A. and Opakunbi, A. (2014). Integrated Animal Husbandry. Positive Press, Ibadan.

DeRouchey, J. (2009). An overview of the pig's digestive system - mouth, stomach, small and large intestines. Proceedings of the Swine Profitability Conference 2009, held at Kansas State University on 3rd February 2009.

Esmail, S.H. (2012). PoultryWorld - Fibre plays a supporting role in poultry . https://www.poultryworld.net/Breeders/Nutrition/2012/2/Fibre-plays. Retrieved 12th December, 2018.

Obioha, F.C. (1992). A guide to poultry production in the tropics. ACENA publishers Ltd, Enugu

Omole, A.J., Ajasin, F.O., Oluokun, J.A. and Tiamiyu, A.K. (2007). Rabbit Farming without tears. Green Choice Agricultural Publications.

Smith, A.J. (2001). Poultry. Macmillan Education Ltd., Oxford.

http://fohn.net/rabbit-pictures-facts/bibliography.html#93. Retrieved 20th July, 2015

http://www.justrabbits.com/rabbit-anatomy.html. Retrieved 14th May, 2015

https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/The_Gut_and_Digestion. Retrieved 12th May, 2014

MODULE 2: FEEDSTUFFS AND FEEDING STANDARDS

UNIT 1: DEFINITIONS AND CLASSIFICATIONS OF FEEDSTUFFS

1.0 INTRODUCTION

Feedstuffs are ingredients of nutritional value that when combined in certain manners and fed to animals facilitate their survival, growth and productivity. The quality of feedstuffs used in compounding animal feeds determines to a large extent the level of attainment of the animal's productive potential. There are benchmarks that feedstuffs and their combinations must meet in order to satisfy the standards set for feeding different classes of animals at different productive stages and for animals to remain healthy and highly productive. These standards have been developed over time and are the results of painstaking researches. Though they serve very useful purposes, feeding

standards have their limits as not all factors influencing nutrient requirements could be adequately captured hence they sometimes serve best as guidelines.

2.0 OBJECTIVES

By the end of this unit, you should be able to state clearly the:

- Definition and classes of feedstuffs
- Importance and limitations of feedstuff
- Nutritive value of feedstuffs
- Basis of determining the nutritive worth of feedstuff
- Criteria in determining if a feed meet the needs of an animal
- Effect of certain substances included in feeds on the product quality

3.0 MAIN CONTENT

3.1 Definition

Feedstuffs refer to any feed ingredient or constituent material which can be consumed by animals or which is used in the formulation of diets for animals. A feedstuff usually serves some useful purpose and provides a source of one or more nutrients. As a general rule, medicinal compounds are usually excluded from lists of feedstuffs.

3.2 Classification of feedstuffs in monogastric feeding

For practical purposes, feedstuffs can conveniently be grouped into Roughages (include forages), Energy and basal, Protein supplements or concentrates, Vitamin and mineral supplements, non-nutritive feed additives.

3.2.1 Roughages

In simple terms can be defined as bulky feed that has low weight per unit volume and sometimes the terms herbage, forage, fodder and roughage are used interchangeably. Most feedstuff under this classification contains more than 18% crude fibre and are relatively low in energy and protein yielding nutrients. Most roughage have a high content of cellulose, hemicellulose, pectin, lignin and silica which are all cell wall materials. Roughages have lower readily available carbohydrate than cereal grains and other basal feeds. They include legumes, grass/legume mixtures, non-legume such as straw and chaff, corn cobs, cotton seed hulls, groundnut shells, groundnut hulls, sugar cane peelings, silages from maize, guinea corn and a number of others. Forages include pasture, range plants, grazed plants and plants fed green to livestock (green chop).

3.2.2 Energy and basal

Feeds also referred to as energy concentrates are feeds with less than 20 crude protein and less than 18% crude fiber. They constitute bulk of the energy source for monogatrics. They are highly digestible, low in protein, fibre, vitamins and minerals.

Examples are cereal grains like maize, sorghum, rice, wheat as well as milling by-products from most cereal grains, molasses, seed and mill screenings, vegetable and marine fats.

3.2.3 Protein supplements or concentrates

Can be either of plant or animal origin and are of high protein constituents that provide readymade protein but possess less than 18% crude fibre. They are high in protein, low in carbohydrate and fats, low in minerals and highly digestible. Protein content ranges from about 40-72% and are available from a wide variety of animal, marine, milk by products. Animal protein concentrate include blood meal, avian hatchery waste, meat meal, dried skimmed meal, whey and fish meal.. Plant protein concentrates include soyabeans, cotton seed meal, groundnut cake, palm kernel cake, Sunflower meal, Copra cake and others.

3.2.4 Vitamin and mineral supplements

Are high in vitamins and minerals. They are required in small quantities in feed to supplement basal and protein concentrate in order to form a complete balanced ration. They are low in energy, protein and fibre. They largely aid digestion and resistance to diseases. They are also necessary for growth and development. They are intended to be fed undiluted as a supplement to other feeds or be further diluted and mixed to produce a complete feed. They include vitamin and mineral premixes, bone meal, oyster shell and limestone.

3.2.5 Non-nutritive

Feed additives improve the feed when added but do not constitute a nutrient deficiency if not added. They stimulate growth rate or other types of performance, improve efficiency of feed utilization and /or help to promote good health. Feed additives include drugs and other compounds which are non-nutritive in nature such as coccidiostats, synthetic enzymes, growth stimulants, disease preventing compounds such as antibiotics, antiprotozoans, antihelminths, acaricides.

3.3 Nutritive value of feedstuffs

The nutritive value of any feedstuff is normally assessed based on the energy available, protein content, fats, water, minerals and to a lesser extent vitamins and the absence of toxins. The nutritive value of a feed is determined by finding out the quantity of the targeted nutrient present in a feedstuff which could be available to the animals for maintenance, growth and or production. We can say therefore that the quantity of carbohydrate (energy), fats, proteins and minerals contained in any feedstuff helps in measuring the usefulness of the feed.

3.3.1 Determination of Nutritive Value

The simplest and the earliest method of determining the nutritive value of feeds was to estimate the nutrient composition of the feed with respect to the various nutrients present

through what we call proximate analysis(chemical analysis of feeds) but it is known that the chemical composition only gives the potential value of the feed but does not give the actual nutritive value of the feed stuff until the loses of the nutrients in the feaces, urine and gases from the animal during digestion, absorption and metabolism in general are taken into consideration. The nutritive value of feeds thus depends on the chemical composition, digestibility and other factors. It also depends upon the amounts of these nutrients that the animal can digest and use. The feed which is more digestible has the higher nutritive value.

SELF ASSESSMENT EXERCISE

1. Define feedstuffs
2. List the categories of feedstuffs
3. What factors limit the usage of feedstuffs
4. What methods can be adopted to evaluate the potential of feedstuffs

4.0 CONCLUSION

The monogastric animal and its products are a function of what is fed to it both in feedstuff type and feedstuff quality. Appropriate feeding can only be achieved if the needs of the animal are known and these are indicated in feed standards obtained from published materials which though might have limitations, serve a very useful role as a sure guide.

5.0 SUMMARY

Feeding is the bedrock of animal survival and productivity in general and monogastric production success in particular. Feedstuffs are classed according to what they have to offer nutritionally in quantity, quality and form. Understanding the nutritional limitations of monogastric animals because of their digestive system is vital in efficient management of these animals. In addition, a knowledge of their nutritional needs in vital in order to ensure that the quantity of feedstuffs combined together to constitute the feed is nutritionally adequate. Ultimately, the physical appearance, weight gained and chemical composition of the monogastric animal and its products are indicators of the nutritive worth of a feedstuff or feed. The feed Standards set to serve as a guideline in these regards while providing a baseline for feed formulation sometimes requires amendments depending on factors which are mostly environmental related. The consumer determines the quality of the final product hence additives are sometimes added to produce a desired result that suits the market.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are feedstuffs
2. How can feedstuffs be categorized
3. What is the role of non-nutritive material added in feeds
4. What factors determine the nutritive potential of a feedstuff
5. Why is the potential of a feedstuff not a reliable indices

7.0 REFERENCES/FURTHER READINGS

Atteh, J.O. (2002). Principles and practice of livestock feed manufacturing. Printed by Adlek Printers, Ilorin.

Olomu, J.M. (2011). Monogastric Animal Nutrition. Principle and practices. Printed by St Jackson Publishing, Benin City.

UNIT 2: FEED ADDITIVES AND FEED TOXINS

1.0 INTRODUCTION

Feed additives are substances that do not occur naturally in feeds but are added to animal feeds during processing or storage for specialized functions. They also include substances present in low concentrations and require topping up. They include amongst others antioxidants, preservatives, colouring and flavouring agents, and anti-infective agents. These are natural organic substances which retard or prevent the growth of organisms. It is also used generally to designate substances formed by microorganisms which prevent growth or other micro-organisms. These are substances that prevent fat from becoming rancid through oxidation. They can also be defined as man-made or natural substances that may prevent or delay some types of cell damage. Colouring agents may be added to feeds to enhance the appearance of the feed and make it more palatable. Growth promoters are the substances that are added to a nutritionally balanced diet which provoke response towards the exploitation of maximum genetic potential of the host, in terms of growth as well as improvement in feed conversion efficiency.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- Understand what feed additives are
- Identify the different types and functions

3.0 MAIN CONTENT

3.1 Feed additives

3.1.1 What are feed additives

Feed additives are substances that do not occur naturally in feeds but are added to animal feeds during processing or storage for specialized functions in order to enhance feed intake and utlization. They also include substances present in low concentrations and require topping up. They include amongst others antioxidants, preservatives, colouring and flavouring agents, and anti-infective agents. While very few feed additives may have nutritional value and are sometimes referred to as nutritional additives, most have little or no nutritional value and could be processing agents, preservatives, drugs and sensory agents. Approval of standardized feed additives involves extensive and expensive testing for efficacy in animals, safety in animals and tissue residues. Some common examples of feed additives used in animal feeds include prebiotics, probiotics, enzymes, antioxidants, antibiotics and organic acids.

3.1.2 Functions of feed additives

These substances improve feed palatability and intake, improve feed utilization, improve health and reduce the incidence of mortality, enhance good health, reduce length of finishing time during the production process, add flavors in order to enhance the palatability of animal feeds or provide variation in the colour of meat or egg products, feed firmers or softners, reaction hasteners or retards, feed acidifiers or alkaliners, oxidifyers or reducing agents.

3.1.3 Types of feed additives

3.1.3.1Pellet binder

These are materials that are used to aid the binding of pellet ingredients together.
Molasses, brewers' yeast, starch are commonly used.

3.1.3.2Anticoccidials

These are drugs which are administered for the control of coccidiosis and includes Amprolium, Nitrofurazone, Sulphaquinoxaline, Furazolidone, Clopidol.

3.1.3.3 Antibiotics and growth promoters

These are natural organic substances which retard or prevent the growth of organisms. It is also used generally to designate substances formed by microorganisms which prevent growth or other micro-organisms.
Antibiotic growth promoters (AGP) are any medicine that destroys or inhibits bacteria and is administered at a low, subtherapeutic dose.
Antibiotic growth promoters are used to help growing animals digest their food more efficiently, improve daily growth rates, reduced mortality, better meat quality with less fat and increased protein content.
Growth promoters are the substances that are added to a nutritionally balanced diet which provoke response towards the exploitation of maximum genetic potential of the host, in terms of growth as well as improvement in feed conversion efficiency. Some act by controlling clinical and subclinical infectious diseases. Growth promoters include Antibiotics, Probiotics, prebiotics, exogenous enzymes, antioxidants, coccidiostats etc.

3.1.3.4 Antifungal agents

These are also known as mold inhibitors and they destroy fungi or prevent harmful molds from developing in feeds or in the digestive tracts of poultry and pigs. It is not desired for fungi to grow as they have negative effects on feeds and eventually on the animals that feed on contaminated feeds. The negative effects include the production of mycotoxins as well as interference and modification of nutrient composition of the feed ingredients. They include sorbic acid, sodium propionate, nystatin, gentian violet and propionic acid.

3.1.3.5 Prebiotics and Probiotics

Probiotics: Probiotics are the live microbial feed supplements which are used for balancing the microbial population in the intestine through the production of various compounds, competitive exclusion and displacement of pathogens from enterocytes, as well as maintenance of gut pH thereby improving the health and immune status of animals. These improve the overall health of an animal by improving the microbial balance in its gut.

3.1.3.6 Yeasts and Enzyme

These are routinely added to feeds and work by helping to break down certain components of the feed especially the fibrous parts but also include components like glucans, proteins and phytates, that the animal may have problems digesting. They are produced as fermentation products from fungi and bacteria and seem to have positive effects on the animal. Feed enzymes are very effective at maximising feed conversion efficiency. Eg Nutrase, Avizyme, Mazigrain, Allzyme, Biofeed.

3.1.3.7 Colouring and Flavouring Agents

Colouring agents are added to enhance the appearance of the feed. These include a range of naturally occurring food colours, food dyes or mineral based colours such as iron oxide or titanium dioxide. They are added to increase the palatability of the diet. These are useful when the animal is under stress, less palatable feedstuffs are incorporated into the diet, unpatable medication is given in feed. Examples are molasses and saccharin.
Flavouring agents are included in feeds to add flavoiur eg Benzaldehyde (almond), n propyl acetate (pear), diethyl sulphate (peppermint).

3.1.3.8 Phytobiotics

Natural medicinal products originating from herbs, spices and their products including essential oils have been used as feed additives in poultry production. Garlic (*Allium sativum*), Turmeric (*Curcuma longa*), Thyme (*Thymus vulgaris* L.) Aloe vera, onion (*Allium sepa*), Ginger (*Zingiber officinale*, Rosc.), *Astragalus membranaceus*, Noni (*Morinda citrifolia*) etc., are some of the major plant additives which are used in poultry feeds for enhanced growth effect in broiler and better egg production in laying hens.

3.1.3.9 Organic Acids

They act by regulating the lower gut pH to limits the activity of some pathogenic bacteria. They may act directly against bacteria, besides antimicrobial effects and stimulation of the immune system.

3.2 Feed Toxins

Mycotoxins are a group of chemicals produced by certain fungi when they have a suitable environment. These substances which affect performance of birds can be bind and voided out of the system through the inclusion of toxin binders in poultry feeds. Mycotoxin-adsorbing agents are compounds with a high molecular weight, which are able to bind mycotoxins after ingestion. Ideally, this complex does not dissociate in the gastrointestinal tract of the animal, resulting in an efficient elimination via faeces and hereby preventing or minimizing exposure of animals to mycotoxins. These mycotoxin-adsorbing agents include aluminosilicates (bentonite, montmorillonite, zeolite, phyllosilicates), activated carbon, complex indigestiblecarbohydrates (cellulose, polysaccharides from the cell walls of yeast and bacteria such asglucomannans and peptidoglycans) and synthetic polymers (cholestyramine and polyvinylpyrrolidone)

SELF ASSESSMENT EXERCISE

1. What are feed additives?
2. List 5 types of feed additives and write short notes on each of the type you listed
3. What are the functions of feed additives?
4. Explain what you understand by Feed Toxins.

4.0 CONCLUSION

Feed additives are important in monogastric nutrition and play vital roles.

5.0 SUMMARY

Feed additives are substances that do not occur naturally in feeds but are added to animal feeds during processing or storage for specialized functions.. They also include substances present in low concentrations and require topping up. They include amongst others antioxidants, preservatives, colouring and flavouring agents, and anti-infective agents. They could be Sensory additive, nutritive or zootechnical in nature and include antibiotics, antioxidants, colourants etc.

Antibiotics are natural organic substances which retard or prevent the growth of organisms. It is also used generally to designate substances formed by microorganisms which prevent growth or other micro-organisms. The positive outcome of antibiotic none the less, there have been concerns which have built up over the decade on the negative consequences on antibiotic use in animal feeds. These are substances that prevent fat from becoming rancid through oxidation. Monogastric feeds generally contain fats and oils which require stabilization by adding anti-oxidants in order to prevent fats from reacting with oxygen in the air; a process known as oxidization. If this occurs, the feed would become rancid which could result in reduced nutritional quality, unpleasant smells

and toxicity. Colouring agents are added to to enhance the appearance of the feed. These include a range of naturally occurring food colours , food dyes or mineral based colours such as iron oxide or titanium dioxide. They are added to increase the palatability of the diet. These are useful when the animal is under stress, less palatable feedstuffs are incorporated into the diet, unpatable medication is given in feed. Growth promoters are the substances that are added to a nutritionally balanced diet which provoke response towards the exploitation of maximum genetic potential of the host, in terms of growth as well as improvement in feed conversion efficiency. Growth promoters include Antibiotics, Probiotics, prebiotics, exogenous enzymes, antioxidants, coccidiostats etc

6.0 TUTOR-MARKED ASSIGNMENT

1. Define feed additives
2. List the type of feed additives
3. Discuss any two of them
3. Which growth promoter is the most controversial and why?

7.0 REFERENCES/FURTHER READINGS

Atteh, J.O.(2018). Principles and practice of livestock feed manufacturing. Niyi printing and publishing company, Ilorin. 205pp

Castanon, J. I. R. (2007). History of the Use of Antibiotic as Growth Promoters in European Poultry Feeds. *Poultry Science* 86 (11): 2466-2471.

Dhama, K., M. Mahendran and S. Tomar (2007). Probiotics and prebiotics: A safer way towards improving health and productivity in poultry. Poultry World, 2: 28-32.

Olomu, J.M. (2011). Monogastric Animal Nutrition. St. Jackson Publishing, Benin City.

www. http://www.fao.org/docrep/article/agrippa/555_en.htm. Retrieved 15th March, 2018.

www. https://en.wikipedia.org/wiki/Antioxidant. Retrieved 12th March, 2018

UNIT 3: FEEDING STANDARDS AND LIMITATIONS

1.0 Introduction

Feeding standards are statements or quantitative descriptions or tables listing the amounts of 1 or more nutrients needed by different species of animals for specific productive functions. They are usually expressed in either quantities of nutrients required per day or concentrations of percentage of a diet. The first expression is used for animals which are given exact quantities of a feed during a 24hr period e.g. cattle and sheep while the second expression is used where rations are fed *ad libitum* i.e. without limitation on the time at which the feed is consumed.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- Understand what Feeding Standards are.
- Role of the standards in feed formulation.
- Limitations to the use of these standards.

3.0 MAIN CONTENT

3.1 Development of feeding standards

Quantitatively, energy is the most important item in an animal's diets and all feeding standards and rations formulations are based on some measure of energy with additional inputs on proteins, vitamins and minerals. The National Research Council (NRC) under the auspices of the National Academy of Science in America came up with their first feeding standards in 1945. Other countries also evolved their feeding standard based on digestible crude protein and total digestible nutrients. Separates reports for poultry, swine, dairy cattle, beef cattle, sheep and horses were made available and the statements were described as allowances of the various species. These allowances included safety margins for ration formulation. The British Agricultural Research Council (ARC) also came up with their tables based on their metabolizable energy contents of feeds. Three separates reports with extensive summaries of literature dealings with poultry, ruminants and pigs were prepared and these have been revised from time to time. Feeding standards are subject to the environment hence feeding standards in one place may not be adequate for another. There are current moves in producing an updated feed standards table for Nigerian poultry. Economics of livestock feeding must be taken into consideration when these tables are used.

3.2 Terminologies Used in Feeding standards

Marginal safety and nutrient allowance are terms associated with feeding standards. Marginal Safety refers to the extra ration given to animals to cater for possible additional feeding needs. Animals are generally given feed *ad lib* thereby giving them a free choice to eat to their capacity instead of under feeding them and this is of greater importance especially when animals are group fed as not all animals eat at the same time or the same quantity. Nutrient allowance otherwise known as feed allowance is the sum total of an animal's nutrient requirement plus marginal safety.

3.3 Uses of feeding standards

Feedings standards are statements of nutritional requirements of animals. They provide a useful base from which rations could be formulated or estimate feed requirements of animals. They are also useful in farm budgeting. They should not, however, be considered as the final answer on nutrient needs but should be used as a guide.

3.4 Limitations of Feeding Standards

Feeding standards may provide a useful base from which the rations are formulated or estimation of feed requirements are made for animals. They should not however be considered as the final answer on nutrient needs as NRC and ARC recommendations were made for the temperate zones. Since NRC tables recommended values known as requirements figures and not necessarily the recommended allowances, it is sometimes necessary to adjust values to contain margins of safety in order to maximize production and ensure good health and profitability.

Limitations associated with feeding standards are:

1. The current NRC and ARC recommendations provide no basis for increasing intake in harsh weather conditions or reduction in mild climates. It does not also take into consideration other stress effects like disease conditions, surgery and others.
2. Feeding standards does not also take into consideration also the beneficial effects of feed additives.
3. It also excludes what management feeds preparatory methods and feeding procedures to animal's needs or efficiency of food utilization.
4. Feeding standards do not take into consideration the effect of variation within and between species of animals. It is well known that animal requirements vary considerably even within a relatively uniform herd, e.g. a protein intake that may be satisfactory for most animals in a given situation will probably not be sufficient for a few of the rapid gainers or high producers on the other hand some of the herd will probably be overfed.
5. Cognizance is not taken of breed effect. Breeds nutrients metabolism and requirements differ.
6. The many variables that may alter nutrient needs and nutrient utilization in animals are usually difficult to include quantitatively in feeding standards even when feed quality is well known.

SELF ASSESSMENT EXERCISE

1. What did you understand by feeding standards and their uses?
2. List five (5) limitations of feeding standards
3. How can nutrient needs be estimated
4. List 2 terms associated with feeding standards

4.0 CONCLUSION

Feeding standards provide a guideline for feed formulation. Caution should however be exercised in using the values absolutely without taking cognizance of variations between the locations where the standards were set and the place of use. Heat for instance produced in animal bodies in the tropics generally have to be dissipated whereas it

requires conservation in the temperate zone. The energy requirement of the temperate and tropical areas would therefore not be the same.

5.0 SUMMARY

Feedings standards remain vital instruments in ration however, should not be considered as the final answer on nutrient needs but rather used as a guide. Allowances should be included for safety margins for ration formulation. Economics of livestock feeding must be taken into consideration when these tables are used. Some of the limitations in its use are its inconsideration for climatic and stress variations, effect of feed additives and breed effect. It is challenging to factor in all possible variations when setting feeding standards.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are feeding standards?
2. How are feeding standard expressed?
3. What is/are the main use(s) of feeding standards?
4. List 5 limitations of feeding standard.
5. What is marginal safety?
6. What is feed allowance?

7.0 REFERENCES/FURTHER READINGS

Esonu, B.O. (2006). Animal Nutrition and feeding; a functional approach. 2nd Edition. Rukzeal and Ruksons Associates, Owerri.

Payne, W.J.A. (1990). An introduction to Animal husbandry in the tropics. 4th edition. Longman Singapore Publishers.

MODULE 4: NUTRITIONAL DISORDERS IN MONOGASTRIC ANIMALS

UNIT 1: NUTRITIONAL DEFICIENCY AND TOXICITY SYMPTOMS IN POULTRY

1.0 INTRODUCTION

A nutritional deficiency occurs when the body doesn't absorb or get from feed the necessary amount of a nutrient. Deficiencies can lead to a variety of health problems. These can include digestion problems, skin disorders, stunted or defective bone growth, and even dementia. A nutritional deficiency may be due to a nutrient being omitted from the diet, adverse interaction between nutrients in otherwise apparently well-fortified diets, or the overriding effect of specific antinutrients. Micronutrients such as vitamins and trace minerals are usually added to diets in the form of stand-alone micro premixes, so it is rare to see classic symptoms of deficiency of individual nutrients. A diet by

analysis appears to contain just enough of one or more nutrients may actually be deficient to some degree in those nutrients. Stress (bacterial, parasitic, or viral infections; high or low temperatures; etc) may either interfere with absorption of a nutrient or increase the quantity required. Thus, a toxin or microorganism, for example, may destroy or render unavailable to the bird a particular nutrient that is present in the diet at apparently adequate levels according to conventional chemical or physical assay procedures.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- Explain nutritional deficiencies in poultry
- Identify the causes of nutritional deficiencies in poultry
- Identify means of preventing nutritional disorders in poultry

3.0 MAIN CONTENT

3.1 Nutritional Deficiency

Nutritional deficiency is an inadequate supply of essential nutrients (as vitamins and minerals) in the diet resulting in malnutrition or disease. There are different types of nutritional deficiencies in poultry which includes:

1. Protein, Amino acid and Energy deficiencies
2. Minerals deficiencies
3. Vitamin deficiencies

3.1.1 Protein, Amino acid and Energy deficiencies

There are signs associated with a deficiency of the various amino acids, except for a peculiar, cup-shaped appearance of the feathers in chickens with arginine deficiency and loss of pigment in some of the wing feathers in bronze turkeys with lysine deficiency. All deficiencies of essential amino acids result in retarded growth or reduced egg size or egg production. If a diet is deficient in protein or certain amino acids, the bird may initially consume more feed in an attempt to resolve the deficiency. After a few days, this transient increase in feed intake shifts to a situation of reduced feed intake. Consequently, there will be inferior feed efficiency, and the birds are invariably fatter as a consequence of over consuming energy.
A deficiency of energy can therefore occur only if the diet is so low in energy concentration that the bird physically cannot eat a sufficient quantity of feed to normalize energy intake. With a deficiency of energy, the bird will grow slowly or stop ovulating. As sources of energy, protein and amino acids will be deaminated, and any lipids will undergo β-oxidation. The latter condition can lead to ketosis, which more commonly occurs in mammals, yet the classic signs are similar.

3.1.2 Mineral Deficiencies

The deficiencies of mineral are imbalances of calcium and phosphorus in the diet of young growing birds results in abnormal bone development, even when the diet contains adequate vitamin D_3. A deficiency of either calcium or phosphorus results in lack of normal skeletal calcification. Calcium deficiency in laying hens results in reduced shell quality and subsequently osteoporosis. This depletion of bone structure causes a disorder commonly referred to as "cage layer fatigue." Others disorder includes:

3.1.2.1 Rickets

Rickets is inadequate bone mineralization which occur mostly in young birds meat. Calcium deficiency at the cellular level is the main cause, although feeding a diet deficient or imbalanced in calcium, phosphorus, or vitamin D_3 can also induce this problem. Young broilers and turkey poults can exhibit lameness at about 10–14 days of age. Although rickets is not caused by a failure in the initiation of bone mineralization but rather by impairment of the early maturation of this process. There is often an enlargement of the ends of the long bones, with a widening of the epiphyseal plate. An analysis of blood phosphorus levels and investigation of parathyroid activity may be necessary in determination of whether rickets is due to deficiencies of calcium, phosphorus, or vitamin D_3, or to an excess of calcium (which induces a phosphorus deficiency).

Rickets can be prevented, by providing adequate levels and potency of vitamin D_3 supplements, and by ensuring that the diet is formulated to ensure optimal utilization of all fat-soluble compounds. Young birds have limited ability to digest saturated fats, and these undigested compounds can complex with calcium to form insoluble soaps, leading to an induced deficiency of calcium. Diets must also provide a correct balance of calcium to available phosphorus.

3.1.2.2 Tibial Dyschondroplasia (Osteochondrosis)

Tibial dyschondroplasia is an abnormal cartilage mass in the proximal head of the tibiotarsus. It has been seen in all fast-growing types of meat birds but is most common in broiler chickens. Signs can occur early but more usually are not initially seen until 14–25 days of age. Birds are reluctant to move, and when forced to walk, do so with a swaying motion or stiff gait. Tibial dyschondroplasia results from disruption of the normal metaphyseal blood supply in the proximal tibiotarsal growth plate, where the disruption in nutrient supply means the normal process of ossification does not occur. The abnormal cartilage is composed of severely degenerated cells, with cytoplasm and nuclei appearing shrunken. Affected cartilage contains less protein and less DNA.

More tibial dyschondroplasia is also seen when the level of dietary calcium is low relative to that of available phosphorus, or more commonly when diet phosphorus is high relative to calcium. Tibial dyschondroplasia can be prevented by tempering growth rate; however, programs of light or feed restriction must be considered in relation to economic consequences of reduced growth rate.

3.1.2.3 Magnesium Deficiency

Magnesium is rich in natural feed ingredients; thus, deficiency is rare and magnesium is never specifically used as a supplement to poultry diets. Newly hatched chicks fed a diet totally devoid of magnesium live only a few days. They grow slowly, are lethargic, and often pant and gasp. When disturbed, they exhibit brief convulsions and become comatose, which is sometimes temporary but often fatal. Mortality is quite high on diets only marginally deficient in magnesium, even though growth of survivors may approach that of control birds.

A magnesium deficiency in laying hens results in a rapid decline in egg production, hypomagnesemia, and a marked withdrawal of magnesium from bones. Egg size, shell weight, and the magnesium content of yolk and shell are decreased. Increasing the dietary calcium of laying hens accentuates these effects. Magnesium requirements for most classes of chickens seem to be ~500–600 ppm, a level that is usually achieved with contributions by natural feed ingredients.

3.1.2.4 Potassium, Sodium, and Chloride Deficiencies

Potassium, sodium, and chloride are important to maintain a balance of these and all other electrolytes in the body. Often termed electrolyte balance or acid-base balance, the effects of deficiency of any one element are often a consequence of alteration to this important balance as it affects osmoregulation.

- A deficiency of sodium : This leads to a lowering of osmotic pressure and a change in acid-base balance in the body. Cardiac output and blood pressure both decrease, PCV increases, elasticity of subcutaneous tissues decreases, and adrenal function is impaired. This leads to an increase in blood uric acid levels, which can result in shock and death. A less severe sodium deficiency in chicks can result in retarded growth, soft bones, corneal keratinization, impaired food utilization, and a decrease in plasma volume. In layers, reduced egg production, poor growth, and cannibalism may be noted. A number of diseases can result in sodium depletion from the body, such as GI losses from diarrhea or urinary losses due to renal or adrenal damage.
- A deficiency of chloride: This causes ataxia with classic signs of nervousness, often induced by sudden noise or fright. The main sign of hypokalemia is an overall muscle weakness characterized by weak extremities, poor intestinal tone with intestinal distention, cardiac weakness, and weakness and ultimately failure of the respiratory muscles. Hypokalemia is apt to occur during severe stress. Plasma protein is increased, causing the kidney, under the influence of adrenocortical hormone, to discharge potassium into the urine. During adaptation to the stress, blood flow to the muscle gradually improves and the muscle begins uptake of potassium. As liver glycogen is restored, potassium returns to the liver. Birds fed a diet low in both protein and potassium or that are starving grow slowly but do not show a potassium deficiency.

- Electrolyte balance: Electrolyte imbalance causes tibial dyschondroplasia and respiratory alkalosis in layers. To prevent electrolyte imbalance, the buffering systems in the body must maintain the normal physiologic pH,. The primary role of electrolytes is in maintenance of body water and ionic balance. Thus, requirements for elements such as sodium, potassium, and chloride cannot be considered individually, because it is the overall balance. Electrolyte balance, also referred to as acid-base balance, is affected by three factors: the balance and proportion of these electrolytes in the diet, endogenous acid production, and the rate of renal clearance

3.1.2.5 Selenium deficiency

This causes exudative diathesis in growing chickens. Early signs of unthriftiness and ruffled feathers usually occur at 3–6 wk of age, depending on the degree of deficiency. The edema results in weeping of the skin, which is often seen on the inner surface of the thighs and wings. The birds bruise easily, and large scabs often form on old bruises. In laying hens, such tissue damage is unusual, but egg production, hatchability, and feed conversion are adversely affected. This can be treated with either the mineral or the vitamin. Vitamin E can spare selenium in its role as an antioxidant, and so some selenium-responsive conditions can also be treated by supplemental vitamin E.

3.1.2.6 Zinc Deficiency

Signs of zinc deficiency in young chicks include retarded growth, shortening and thickening of leg bones and enlargement of the hock joint, scaling of the skin (especially on the feet), very poor feathering, loss of appetite, and in severe cases, mortality. Although zinc deficiency can reduce egg production in aging hens, the most striking effects are seen in developing embryos. Chicks hatched from zinc-deficient hens are weak and cannot stand, eat, or drink. They have accelerated respiratory rates and labored breathing. If the chicks are disturbed, the signs are aggravated and the chicks often die. Retarded feathering and frizzled feathers are also found. However, the major defect is grossly impaired skeletal development. Zinc-deficient embryos show micromelia, curvature of the spine, and shortened, fused thoracic and lumbar vertebrae. Zinc requirements and signs of deficiency are influenced by dietary ingredients. In semipurified diets, it is difficult to show a response to zinc levels much above 25–30 mg/kg diet, whereas in practical corn-soybean meal diets, requirement values are increased to 60–80 mg/kg. Such variable zinc needs likely relate to phytic acid content of the diet, because this ligand is a potent zinc chelator. If phytase enzyme is used in diets, the need for supplemental zinc is reduced by up to 10 mg/kg diet.

3.1.3 Vitamin deficiencies

Vitamin deficiencies occur due to inadvertent omission of a complete vitamin premix from the birds' diet. Multiple signs: signs of B vitamin deficiencies appear first. Because there are some stores of fat-soluble vitamins in the body, it often takes longer for these deficiencies to affect the bird, and it may take months for vitamin A deficiency to affect adult birds.

Treatment and prevention rely on an adequate dietary supply, usually microencapsulated in gelatin or starch along with an antioxidant. Vitamin destruction in feeds is a factor of time, temperature, and humidity. For most feeds, efficacy of vitamins is little affected over 2-mo storage within mixed feed.

3.1.3.1Vitamin A

Adult birds could be fed with vitamin A–deficient diet for 2–5 months before signs of deficiency develop depending on liver stores. Eventually, birds become emaciated and weak with ruffled feathers. Egg production drops markedly, hatchability decreases, and embryonic mortality increases. As egg production declines, there will likely be only small follicles in the ovary, some of which show signs of hemorrhage. A watery discharge from the eyes may also be noted. As the deficiency continues, milky white, cheesy material accumulates in the eyes, making it impossible for birds to see (xerophthalmia). The eye, in many cases, may be destroyed.

a) The first lesion usually noted in adult birds is in the mucous glands of the upper alimentary tract. The normal epithelium is replaced by a stratified squamous, keratinized layer. This blocks the ducts of the mucous glands, resulting in necrotic secretions. Small, white pustules may be found in the nasal passages, mouth, esophagus, and pharynx, and these may extend into the crop. Breakdown of the mucous membrane usually allows pathogenic microorganisms to invade these tissues and cause secondary infections.
b) Day-old chicks reared on a vitamin A–deficient diet may show signs within 7 days, depending on the quantity of vitamin A passed on from the breeder hen, However, chicks with a good reserve of maternal vitamin A may not show signs of a deficiency for up to 7 wk. Gross signs in chicks include anorexia, growth retardation, drowsiness, weakness, incoordination, emaciation, and ruffled feathers. If the deficiency is severe, the chicks may become ataxic, which is also seen with vitamin E deficiency. The yellow pigment in the shanks and beaks is usually lost, and the comb and wattles are pale. A cheesy material may be noted in the eyes, but xerophthalmia is seldom seen because chicks usually die before the eyes become affected. Secondary infection may play a role in many of the deaths noted with acute vitamin A deficiency.

3.1.3.2 Vitamin D_3

This required for the normal absorption and metabolism of calcium and phosphorus. A deficiency can result in rickets in young growing chickens or in osteoporosis and/or poor

eggshell quality in laying hens, even though the diet may be well supplied with calcium and phosphorus. Symptom : a) Laying hens fed a vitamin D_3–deficient diet show loss of egg production within 2–3 wk, and depending on the degree of deficiency, shell quality deteriorates almost instantly. Using a corn-soybean meal diet with no supplemental vitamin D_3, shell weight will decrease dramatically by ~150 mg/day throughout the first 7 days of deficiency.
b) Retarded growth and severe leg weakness are the first signs noted when chicks are deficient in vitamin D_3. Beaks and claws become soft and pliable.
c) Chicks may have trouble walking and will take a few steps before squatting on their hocks. While resting, they often sway from side to side, suggesting loss of equilibrium. Feathering is usually poor, and an abnormal banding of feathers may be seen in colored breeds. With chronic vitamin D_3 deficiency, marked skeletal disorders are noted.
d) The spinal column may bend downward and the sternum may deviate to one side. These structural changes reduce the size of the thorax, with subsequent crowding of the internal organs, especially the air sacs.
e) A characteristic finding in chicks is a beading of the ribs at the junction of the spinal column along with a downward and posterior bending. Poor calcification can also be seen at the epiphysis of the tibia and femur.

3.1.3.3 Vitamin E

This contains three main disorders in chicks which are encephalomalacia, exudative diathesis, and muscular dystrophy. The occurrence of these conditions depends on various other dietary and environmental factors.

Encephalomalacia is seen in commercial flocks if diets are very low in vitamin E, if an antioxidant is either omitted or is not present in sufficient quantities, or if the diet contains a reasonably high level of an unstable and unsaturated fat.

For exudative diathesis to occur, the diet must be deficient in both vitamin E and selenium. Signs of muscular dystrophy are rare in chicks, because the diet must be deficient in both sulfur amino acids and vitamin E. Because the sulfur amino acids are necessary for growth, a deficiency severe enough to induce muscular dystrophy is unlikely to occur under commercial conditions.

Muscular dystrophy can be reversed in chicks by supplementing the diet with liberal amounts of vitamin E, assuming the deficiency is not too advanced. Encephalomalacia may respond to vitamin E supplementation, depending on the extent of the damage to the cerebellum.

In prevention of encephalomalacia, vitamin E functions as a biologic antioxidant. The quantitative need for vitamin E for this function depends on the amount of linoleic acid and polyunsaturated fatty acids in the diet.

3.1.3.4 Vitamin K

This results in impairment of blood coagulation or prolonged blood clotting hence severely deficient chicks may bleed to death from a slight bruise or other injury. Borderline deficiencies often cause small hemorrhagic blemishes. Because the prothrombin content of newly hatched chicks is only about 40% that of adult birds, young chicks are readily affected by a vitamin K–deficient diet. A number of stress factors (eg, coccidiosis and other intestinal parasitic diseases) increase the requirements for vitamin K. Dicumarol, sulfaquinoxaline, and warfarin are antimetabolites of vitamin K.

3.1.3.5 Vitamin B_{12}

This results in reduced weight gain and feed intake, along with poor feathering and nervous disorders in growing chickens. Vitamin B_{12} may alleviate perosis because of its effect on the synthesis of methyl groups. Other signs in poultry are anemia, gizzard erosion, and fatty infiltration of the heart, liver, and kidneys. Laying hens initially appear to be able to maintain body weight and egg production; however, egg size is reduced. In breeders, hatchability can be markedly reduced, although several weeks may be needed for signs of deficiency to appear. Changes noted in embryos from B_{12}-deficient breeders include a general hemorrhagic condition, fatty liver, fewer myelinated fibers in the spinal cord, and high incidence of mid-term embryo deaths. Treatment involves feeding up to 20 mcg/g feed for 1–2 wk.

3.1.3.6 Choline

In chicks and poult, perosis is the classic sign of choline deficiency. Perosis is first characterized by pinpoint hemorrhages and a slight puffiness about the hock joint, followed by an apparent flattening of the tibiometatarsal joint caused by a rotation of the metatarsus. The metatarsus continues to twist and may become bent or bowed so that it is out of alignment with the tibia. When this condition exists, the leg cannot adequately support the weight of the bird. The articular cartilage is displaced, and the Achilles tendon slips from its condyles. Perosis is not a specific deficiency sign; it appears with several nutrient deficiencies. Diets that contain appreciable quantities of soybean meal, wheat bran, wheat shorts, distiller's grains, fishmeal, liver meal, meat meals and yeast are unlikely to be deficient in choline. Commercial choline supplements are also available.

3.1.3.7 Niacin (Nicotinic Acid)

This can be synthesized by chick and turkey embryos, but at a rate too slow for optimal growth. A marked deficiency of niacin cannot occur in chickens unless there is a concomitant deficiency of the amino acid tryptophan, which is a niacin precursor.

Niacin deficiency is characterized by severe disorders in the skin and digestive organs. The first signs are usually loss of appetite, retarded growth, general weakness, and diarrhea. Deficiency produces enlargement of the tibiotarsal joint, valgus-varus bowing of the legs, poor feathering, and dermatitis on the head and feet.
Niacin deficiency in chicks can also result in "black tongue." At about 2 weeks of age, the tongue, oral cavity, and esophagus become distinctly inflamed. In niacin-deficient hens, weight loss, reduced egg production, and a marked decrease in hatchability can result, Turkeys, ducks, pheasants, and goslings are much more severely affected by niacin deficiency than are chickens. Niacin deficiency in chickens may be prevented by feeding a diet that contains niacin at ≥30 mg/kg. An allowance of 55–70 mg/kg of feed appears to be satisfactory for ducks, geese, and turkeys. Ample niacin should be provided in poultry diets so as to spare the utilization of tryptophan.

3.1.3.8 *Pantothenic* Acid

This is an important coenzyme involved in many reversible acetylation reactions in carbohydrate, fat, and amino acid metabolism. Signs of deficiency therefore relate to general avian metabolism and it involve the nervous system, the adrenal cortex, and the skin.
In chicks, the first signs are reduced growth and feed consumption, poor feathering with feathers becoming ruffled and brittle, and a rapidly developing dermatitis. The corners of the beak and the area below the beak are usually the worst affected regions for dermatitis, but the condition is also noted on the feet.
Treatment with both calcium pantothenate (2 g) and riboflavin (0.5 g) in the drinking water (50 gal [190 L]) for a few days has been reported to be successful in some instances. Diets usually contain supplemental pantothenic acid at 12 mg/kg.

3.1.3.9 *Riboflavin*

When chicks are fed a diet deficient in riboflavin, their appetite is fairly good but they grow slowly, become weak and emaciated, and develop diarrhea between the first and second weeks. The leg muscles are atrophied and flabby, and the skin is dry and harsh, In hens egg production decrease, increased embryonic mortality, and an increase in size and fat content of the liver. Treatment can be given as two sequential daily 100-mcg doses for chicks or poults, followed by an adequate amount of riboflavin in feed.

3.1.3.10 Folic Acid (Folacin)

Results in anemia and leukopenia. Tissues with a rapid turnover, such as epithelial linings, GI tract, epidermis, and bone marrow, as well as cell growth and tissue regeneration, are principally affected. Deficiency results in poor feathering, slow growth, an anemic appearance,and sometimes perosis. As anemia develops, the comb becomes a waxy-white color, and pale mucous membranes in the mouth are noted. Increasing the

protein content of the diet has been shown to increase the severity of perosis in chicks receiving diets low in folic acid, because there is an increased folacin demand for uric acid synthesis. Signs of folic acid deficiency in poultry can be prevented by ensuring diets contain supplements of up to 1 mg/kg.

3.1.3.11 Biotin

This results in dermatitis of the feet and the skin around the beak and eyes in poultry. Perosis and footpad dermatitis are also characteristic signs. Signs of classic biotin deficiency are rare but occurrence of fatty liver and kidney syndrome (FLKS) is important to commercial poultry producers. Chicks of about 3 weeks old become lethargic and unable to stand, then die within hours. Mortality is usually quite low at 1%–2% but can reach 20%–30%. Postmortem examination reveals pale liver and kidney with accumulation of fat. It is good practice to add 150 mg biotin/tonne of feed, especially when significant amounts of wheat or wheat byproducts are used in the diet.

3.1.3.12 Pyridoxine (Vitamin B_6)

This causes retarded growth, dermatitis, and anemia. Reduced nitrogen retention can occur as it plays a major role in protein metabolism. In adult birds, pyridoxine deficiency results in reduced appetite, leading to reduced egg production and a decline in hatchability. Severe deficiency can cause rapid involution of the ovary, oviduct, comb, and wattles, and of the testis in cockerels. Deficiency can be prevented by adding pyridoxine at 3–4 mg/kg feed.

3.1.3.14Thiamine

A marked decrease in appetite is seen in birds fed a thiamine-deficient diet. As the deficiency progresses, birds may sit on flexed legs and draw back their heads in a star-gazing position. Retraction of the head is due to paralysis of the anterior neck muscles. Soon after this stage, chickens lose the ability to stand or sit upright and topple to the floor, where they may lie with heads still retracted. Thiamine deficiency may also lead to a decrease in body temperature and respiratory rate. Testicular degeneration may be noted, and the heart may show slight atrophy. Birds consuming a thiamine-deficient diet soon show severe anorexia. They lose all interest in feed and will not resume eating unless given thiamine. If a severe deficiency has developed, thiamine must be force-fed or injected to induce the chickens to resume eating.

3.2 Toxicity Symptoms

3.2.1 Ammonia Toxicity

Ammonia toxicity refers to an inflammatory eye condition in chickens, caused by exposure to prolonged or high amounts of ammonia fumes. Ammonia concentrations above 25 ppm is toxic to chickens. Ammonia toxicity usually occurs in both of the chicken's eyes. The main clinical symptom is the inflammation of the cornea and conjunctiva of the eye (conjunctivitis). Young, growing chicks are more susceptible to ammonia damage then adult chickens. Chickens are more prone to developing ammonia toxicity during the winter season, due to increased time spent indoors, with reduced ventilation and accumulated manure.
Prevention: Add 100 g/kg of natural zeolites (clinoptilolite) to the bedding litter, to help reduce litter moisture and ammonia levels. Ensure proper ventilation and provide dry, clean bedding that is regularly changed. Do not overcrowd birds

3.2.2 Aflatoxin

Aflatoxin-induced symptoms are decreases in performance - reduced weight gain and feed conversion rate (FCR) -, as well as weight and size variation of the organs such as the liver, spleen, kidneys, bursa of Fabricius and thymus. Birth hatch defects induced by aflatoxins cause an increase in the number of chicks that are rejected at the beginning of the production cycle. In addition, aflatoxins are immune suppressive; they affect innate, cell-mediated and humoral responses, causing symptoms such as abnormal behavior (birds standing together in groups), and other nervous syndrome related signs. Intoxication with aflatoxin B_1 (AfB_1) affects cell-mediated immunity by decreasing the concentration of albumin and globulin, and therefore it exerts an important role in the inhibition of protein synthesis.

3.2.3 Fumonisin

Main symptoms include decreased body weight and average daily weight gain due to modulation of intestinal function and disruption of gut integrity as well as increased liver and gizzard weights, followed by increased sphinganine to sphingosine (Sa/So) ratios. It also have effects on the immune system, such as a reduction in white blood cell counts in chicks fed fumonisin B_1 contaminated diets. Treatment depends on the age of birds but an intravenous (2 mg/kg BW) or an oral dose (2 mg/kg BW) of C-FB_1 (mixture of Clostridium perfringens and fumonisins B_1) can be given to laying hens.

SELF ASSESSMENT EXERCISE

1. What are the nutritional deficiencies in poultry production
2. Explain in details the vitamin deficiencies in poultry

4.0 CONCLUSION

Nutritional deficiency and toxicity symptoms have more effect on poultry production. Stress (bacterial, parasitic, or viral infections; high or low temperatures; etc) may either interfere with absorption of a nutrient or increase the quantity required. However, programs of light or feed restriction must be considered in relation to economic consequences of reduced growth rate. Cleaning or changing coop litter/bedding more often or if necessary switching to a different type of material enhances reduction of ammonia levels.

5.0 SUMMARY

In this unit we were able to list and explain some deficiencies of nutrition in poultry and preventive measures in order to promote growth rate and productivity. We also explained the symptoms of toxicity.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is nutritional deficiency?
2. Explain vitamin deficiencies in details
3. List and explain toxicity symptoms in poultry production

7.0 REFERENCES/FURTHER READINGS

Cilievici, O., Cordos, I., Ghidus, E. and Moldovan, A. (1980). The toxic and teratogenic effect of aflatoxin B1 on the chick embryo development. Morphol. Embryol. (Bucur.): 309-314.

www.msdvetmanual.com/poultry/nutrition-and-management-poultry/nutritional-deficiencies-in-poultry. Retrieved 15th September, 2018

www.poultrydvm.com/condition/ammonia-burn. Retrieved 15th September, 2018

UNIT 2: NUTRITIONAL DEFICIENCY AND TOXICITY SYMTOMS IN SWINE

CONTENTS

1.0 INTRODUCTION

Nutritional deficiencies could be as a result of mismanagement as well as malnutrition and the signs may not be specific but include poor appetite, reduced growth, and unthriftiness. A nutritional deficiency may exist without the appearance of definite signs.

2.0 OBJECTIVES

At the end of this course, you should be able to:

- Explain the nutritional deficiency in swine
- List the causes of nutritional deficiency in swine
- Know how to prevent nutritional disorders in swine

3.0 MAIN CONTENT

3.1 Nutritional Deficiencies

A nutritional deficiency is ideally diagnosed positively only after observance of several of the expected clinical signs and a careful review of the dietary, disease, and management history of the animals.

3.1.1 Protein

This results from suboptimal feed intake or a deficiency of one or more of the essential amino acids, causes reduced gains, poor feed conversion, and fatter carcasses in growing and finishing pigs. In lactating sows, milk production is reduced, excess weight loss occurs, and sows may fail to exhibit post-weaning estrus or have delayed return to estrus. Treatment: protein supplements (35%–50%) should be mixed with the grain or be available at all times with grain on a free-choice basis.

3.1.2 Fat

Linoleic acid is essential in the diet and is used to produce longer-chain fatty acids that are probably also essential. A linoleic acid deficiency induces hair loss, scaly dermatitis, skin necrosis on the neck and shoulders, and an unthrifty appearance in growing pigs. Conventional swine diets generally contain adequate fat from the natural ingredients to furnish ample amounts of essential fatty acids.

3.1.3 Mineral

a) Deficiencies of calcium or phosphorus result in rickets in growing pigs and osteomalacia in mature pigs. Signs include deformity and bending of long bones and lameness in young pigs, and fractures and posterior paralysis in older pigs. Sows that produce high levels of milk and nurse large litters are particularly susceptible to posterior paralysis toward the end of lactation or after weaning if dietary calcium or phosphorus is deficient. These signs can also result from a deficiency of vitamin D, but phosphorus deficiency is the most common cause.

b) Pigs fed diets low in salt (NaCl) grow poorly and inefficiently, largely because of a marked reduction in feed intake. Although not specific for salt deficiency, poor hair and skin condition may also develop.

c) Sows fed diets deficient in iodine produce hairless pigs that are weak or stillborn. With a borderline deficiency, the newborn pigs may be weak only at birth, but their thyroids are enlarged and have histologic abnormalities.

d) A deficiency of zinc results in parakeratosis in growing pigs, particularly when fed diets high in phytic acid and more than the recommended amount of calcium. The exact mode of action of zinc in the prevention of parakeratosis is not known.

e) Deficiencies of selenium and/or vitamin E can cause sudden death of young, rapidly growing pigs. In addition, selenium/vitamin E deficiency in nursing pigs makes them more susceptible to iron toxicosis from iron injections.

3.1.4 Vitamin

a) Vitamin A deficiency results in disturbances of the eyes and the epithelial tissues of the respiratory, reproductive, nervous, urinary, and digestive systems. Reproduction is impaired in sows, and they may farrow blind, eyeless, weak, or malformed pigs. Herniation of the spinal cord in fetal pigs is a unique sign of vitamin A deficiency in pregnant sows. Growing pigs deficient in vitamin A show incoordination and develop night blindness and respiratory disorders. Vitamin A deficiency is rare because of the ability of the liver to store this vitamin.

b) Vitamin D deficiency result in rickets, stiffness, weak and bent bones, and posterior paralysis. These signs are indistinguishable from those of a calcium or phosphorus deficiency

c) Vitamin E deficiency can result in poor reproduction and impaired immune system. Many of the signs of vitamin E deficiency are similar to those of selenium deficiency.

d) Vitamin K deficiency causes prolonged blood clotting time and may animal may die from hemorrhages. Certain components in moldy feed can interfere with vitamin K synthesis. Also, excessive levels of dietary calcium interfere with vitamin K activity, causing these signs.

e) Deficient in riboflavin; reproduction is impaired; postpubertal gilts fail to cycle but show no other clinical signs. Deficient sows are anorectic and farrow dead pigs 4–16 days prematurely. The stillborn pigs have very little hair, often are partially resorbed, and may have enlarged forelegs. Growing pigs fed diets low in

riboflavin gain weight slowly and have a poor appetite, a rough coat, an exudate on the skin, and possibly cataracts.

f) Deficient in niacin have inflammatory lesions of the digestive tract and exhibit diarrhoea, weight loss, rough skin and coat, and dermatitis on the ears. Intestinal conditions can be due to niacin deficiency or bacterial infection. Deficient pigs respond readily to niacin therapy and, although not a cure for infectious enteritis, adequate dietary niacin probably allows the pig to maintain its resistance to bacterial invasion.

g) Pigs with choline deficiency exhibit incoordination and an abnormal shoulder conformation. At necropsy, they may have fatty livers and usually show kidney damage. Sows deficient in choline have reduced litter size and may give birth to spraddle-legged pigs.

h) Biotin deficiency includes excessive hair loss, skin ulcerations and dermatitis, exudates around the eyes, inflammation of the mucous membranes of the mouth, transverse cracking of the hooves, and cracking or bleeding of the footpads.

3.1.5 Iodine Deficiency (Goiter)

Goiter usually occurs in iodine deficient regions where iodized salt has not been included in the dam's feed. Deficiency of iodine leads to the birth of weak or dead pigs that are largely devoid of hair. Many of the pigs have a mucinous edema, especially over enlarged foreparts of the body. The skin in these areas is thick and doughy. The tongue is often edematous and may protrude from the oral cavity. In mature swine, iodine deficiency is not usually a significant disease although gestation may be prolonged by as much as seven days. Iodine deficiency is easily avoided by using iodized salt in the ration of gestating sows.

3.1.6 Parakeratosis

Parakeratosis is a zinc-responsive dermatosis usually observed in 2- to 4-month-old swine. The disease is caused by a relative deficiency of zinc. The deficiency is usually caused by feeding an unbalanced diet that has one or more of the following features:

excessive calcium; excessive phytic acid (sometimes present in soybean protein); or a low concentration of essential fatty acids.

3.2 Toxicity Symptoms

3.2.1 Zearalenone Toxicity in Swine

The presence of zearalenone in feed is unavoidable and zearalenone toxicosis is hard to treat however, the only way is to use an enterosorbent to prevent the initial dietary absorption by the gut and subsequent conjugated zearalenone compounds from being reabsorbed via enterohepatic circulation. Due to its rapid absorption in the small intestine, the inactivation of zearalenone after ingestion becomes extremely critical in stopping toxicity.

SELF ASSESSMENT EXERCISE

1. List nutritional deficiencies in swine
2. Explain mineral deficiency in details

4.0 CONCLUSION

Nutritional deficiencies in swine occur due to lack of some supplementation in the diet, excess minerals such as calcium which can cause loss of appetite, poor production and low growth rate. In this case the farmer must have knowledge of nutrients needed at particular stages.

5.0 SUMMARY

In this unit, we have been able to explain the causes of nutrient deficiencies in swine and to know proper supplements to mix with their diets at each stage, in order to increase production, reduce disease incidents and mortality rates.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain nutritional deficiency in swine

2. How can nutr itional deficiencies affect swine production?
3. Discuss Zearalenone Toxicity in Swine.

7.0 REFERENCE

Glenn (2007). Anim. Feed Sci. Technol., 137: 213-240

Rotter (1996). J. Toxicol. Environ. Health, 48:1-34

www.https//msdvetmanual.com/management-and-nutrition/nutrition-pigs/feeding-leve. Retrieved 17th September, 2018

UNIT 3: NUTRITIONAL DEFICIENCY AND TOXICITY SYMPTOMS IN RABBIT

CONTENTS

1.0 INTRODUCTION

Nutritional deficiencies in rabbit occur due to imbalance of nutrients or lack of supplementation in diet given to the animals. This are however not very common.

2.0 OBJECTIVES

At the end this unit course, you should be able to:

- Mention the nutritional deficiencies in rabbit

- List the symptoms of nutritional deficiencies
- Explain how the deficiencies affects rabbit production

3.0 MAIN CONTENT

3.1 The Nutritional Deficiencies of Rabbit

This affects the survivability of the animal, especially during their early stage of the pregnancy and also day old to maturity stage.

3.1.1 Protein Deficiency

Protein deficiency in rabbits can lead to the following symptoms:

- poor tissue regeneration
- restricted absorption of micronutrients
- changes in appearance and amount of hair - often seen as reddish and thin fur in malnourished rabbits
- reduced body ability to eliminate some drugs and their metabolites

Excessive protein in a rabbit's diet can cause the following issues

- strain on liver and kidneys
- increased urine production
- alteration of microflora and increased pH in the cecum
- increased urea production
- reduced gastrointestinal motility

3.1.2 Methionine deficiency

This can cause:

- creatinuria or an increased concentration of creatine in the urine
- muscle degeneration
- weight loss
- paralysis
- death

3.1.3 Lysine deficiency

Signs include:

- reduced growth
- weight loss

3.1.4 Fat Deficiency

A deficiency of fat in rabbit diets can lead to:

- gut motility problems
- poor coats and loss of hair
- deficiencies of fat-soluble vitamins
- immune deficiencies
- slower repair after injury
- retarded growth in young rabbits
- brain and nerve problems with a severe deficiency

Also the excessive fat levels in a rabbit's diet can lead to the following problems:

- obesity
- harm to the immune system
- increased risk of hepatic lipidosis if a rabbit becomes anorexic
- atherosclerosis or deposition of fat in the arteries, particularly in magnesium-deficient diets

The recommended fat levels in a rabbit's diet:

- 2-5% for the general rabbits
- 3-6% for pregnant or lactating does
- 4-8% for long-haired, wool-producing rabbits (e.g. American Fuzzy Lop, Jersey Wooly, Angora)

3.1.5 Calcium deficiency

This can be a contributory factor to poor tooth and bone quality and dental disease in rabbits. Excessive calcium in rabbits is excreted in the urine in the form of calcium carbonate, which gives the urine a thick creamy appearance.

A minimum of 0.22% is required to support normal growth, but a level of 0.44% is required for bone calcification. A level of 0.6-1.0% or 5 to 10 g/kg is recommended for pet rabbits.

3.1.6 Vitamin A Deficiency

Deficient animals are susceptible to disease and infection, and a high incidence of enteritis occurs in vitamin A-deficient in rabbits.

3.1.7 Vitamin E Deficiency

This classically results in nutritional muscular dystrophy, damage to the heart muscles, exudative diathesis, liver disorders, increased incidence of lactation problems, and reproductive failure.

3.2 Toxicity Symptoms

3.2.1 Lead Toxicity in Rabbits

- Decreased appetite or complete loss of appetite (anorexia)
- Gastrointestinal hypomotility or stasis (slowing or inactivity of the intestinal contents)
- Blindness.
- Weakness, lethargy, ataxia (loss of muscle coordination)
- Seizures.
- Anemia and low blood cell count.
- Diarrhoea (rare)

SELF ASSESSMENT EXERCISE

1. Explain the causes of vitamin deficiencies in rabbit production
2. What leads to protein deficiency?
3. Identify 3 deficiencies and indicate list the signs.

4.0 CONCLUSION

In this lesson we have realized that nutritional deficiencies and toxicity symptoms have more effect on rabbit production due to incomplete nutrients or excess. This may actually occur if there is lack of knowledge or understanding as well as mismanagement Programs of good management must be considered to promote the growth of rabbit production and their survivability.

5.0 SUMMARY

In this unit, we have been able to examine nutritional deficiencies and toxicity symptoms in rabbit production. We have also examined the proper recommendation for the management of rabbit production.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are the symptoms of protein deficiency in rabbit
2. Explain vitamin deficiencies in details in rabbit
3. List the symptoms of excess fat in rabbit diet

7.0 REFERENCE/FURTHER READINGS

Blas, C. D. and Wiseman, J. (2010). Nutrition of the rabbit. (2nd ed.).

Deborah A. McWilliams, MSc, Nutritional Pathology in Rabbits: Current and Future Perspectives

Lebas, F. (2000). Vitamins in Rabbit Nutrition: Literature Review and Recommendations. World Rabbit Science.

MODULE 5: FEED PREPARATION AND ITS FORMULATION

UNIT 1: FEED TYPES AND PROCESSING METHODS

1.0 INTRODUCTION

Feed preparation involves a number of processes one of which is the processing of the feedstuff to enable them be in a form that would be utilizable. It involves processes that could be mechanical, chemical, thermal/heating or microbial fermentation in nature. These are done to alter the physical form or particle size in order to prevent spoilage, improve palatability, detoxify poisons or improve the capability of machinery to handle it. Sometimes, animals reject feed if the physical texture is not to their liking or engage in selective eating if the feed is not homogenous.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- Understand what Feed preparation is all about.
- Identify the appropriate processing method for feedstuffs

3.0 MAIN CONTENT

3.1 Processing methods

3.1.1 Heating

This may be used to dry plant animal materials to a point which would allow storage without refrigeration, preservatives or ensiling, to sterilize some products, to alter the

chemistry of proteins or carbohydrates or to detoxify some plant toxins. It could be either dry (toasting, drying) or wet (cooking, soaking and cooking).

Care must however be taken as excessive heating denatures protein. In the presence of carbohydrates such as sugars, excessive heating also results in browning; a reaction that occurs between lysine and sugars causes lysine to be partially unavailable to the animal. This is however more of a problem in plant proteins or milk by products as carbohydrate is limited in animal proteins. Generally, heating of fish or animal proteins make makes them less efficient in promoting growth. Heating of cereal grains to a moderate degree and for shofrt periods of time may result in slight improvement in protein utilization. With legume grains, heating results in an improvement in protein quality partly by degrading toxic factors which are present.

Prolonged heat treatment results in some deterioration of most of the vitamins with fat soluble vitamins, Vitamin B_1, folic acid and biotin being the most susceptible to destruction. Some trace minerals availability is also compromised.

3.1.2 Grinding

This is the most common processing method. Reduction in particle size and exposure of much more surface area to action of chemical as well as to digestive juices is achieved through grinding thereby increasing digestibility. The pas sage of undigested kernels is prevented thereby increasing the utilization of the product. It facilitates uniform mixing of various feedstuffs. Palatability is increased. Storage of ground grains or other feedstuffs results in destruction of those nutrients which are readily oxidized eg vitamins in the presence of trace minerals such as iron and manganese or unsaturated fats. Appropriate grinding is important in monogastric nutrition and depends on the age of the animal and the digestibility of the particular grain by the animal to be fed. For poultry, maize is finely ground during the first three days after hatching to prevent the development of sticky droppings. This is replaced by medium-fine ground mash. Broilers can be fed relatively finely ground grains while hens can be fed whole scratch grains of maize, sorghum or millet with a ground mash. Larger particle sizes can be accommodated by swine than poultry.

3.1.3 Pelleting

This is quite advantageous for monogastric animals due to increased density of the diet thus allowing greater consumption as each mouthful is a balanced diet. A pellet is ground feed compacted by steaming and forcing them through openings by mechanical means. Pelleting has the advantages of preventing selective eating, lessens storage and transportation costs, alleviates wastage of relatively unpalatable feeds, reduces bulkiness, eliminates dust and losses from wind blowing.

3.1.4 Extrusion

This involves applying heat and pressure to a feedstuff or feed. This is of use in destruction of anti- nutritional factors, gelatinization of starches. This is achieved using an extrusion cooker.

4.0 CONCLUSION

Processing of feedstuffs in one form or the other are required before they can be used to formulate feeds. The type of processing is dependent on the aim for which the processing is being carried out.

5.0 SUMMARY

Feed preparation involves a number of processes one of which is the processing of the feedstuff to enable them be in a form that would be utilizable. It involves processes that could be mechanical, chemical, thermal/heating or microbial fermentation in nature. These are done to alter the physical form or particle size in order to prevent spoilage, improve palatability, detoxify poisons or improve the capability of machinery to handle it. Sometimes, animals reject feed if the physical texture is not to their liking or engage in selective eating if the feed is not homogenous. Processing methods include amongst others heating which could be dry or wet, grinding, pelleting, extrusion.

6.0 TUTOR-MARKED ASSIGNMENT

1. List the reasons for which feedstuffs are processed.
2. List the various types of processing methods.
3. Which processing method is the most common?
4. What is browning?

7.0 REFERENCES/FURTHER READINGS

Atteh, J.O. (2002). Principles and practice of Livestock feed manufacturing. ADLEK Printers, Ilorin.

UNIT 2: RATION FORMULATION

1.0 INTRODUCTION

Ration formulation is the addition of various feed ingredients in proportions that provide adequate nutrients to meet maintenance, growth, production and reproductive needs of animals.

In order to effectively formulate rations, the nutrient requirements of the animal(s) for which the ration is to be formulated must be known. The nutrient content as well as availability of feedstuff to be used must be ascertained. Also vital is the determination of the proportion of ingredients to be mixed in order to provide the required nutrients.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- Understand the importance of ration formulation
- Identify the factors governing ration formulation
- State the methods of ration formulation.
- Identify the appropriate processing method for feedstuffs

3.0 MAIN CONTENT

3.1 Factors governing ration formulation

The process of assembling various ingredients together in order to supply the required nutrients for maintenance, growth, reproduction and production is influenced by a number of factors which include economic, chemical, biological and mathematical factors.

3.2 Considerations for feed compounding

These include:

- the class of animal eg broiler, layer grower, weaner
- Age of animal
- Chemical composition of feedstuff
- Nutrient class eg protein, carbohydrate
- Availability of nutrients due to inhibiters eg trypsin inhibitors
- Toxic elements
- Cost of ingredients

3.3 Types of feed formulation

There are several types of feed formulation but the most common are least cost feed formulation, Pearson square, algebraic, trial and error.

3.3.1 Least Cost feed formulation

This is sometimes also referred to as computer method and is based on using linear programming via computers to work out the least cost of a feed taking into consideration the stipulations which are of value to the person compounding the feed. The ingredients to be used, their nutrient composition as well as their prices are normally imputed into the programme. The nutrient requirements for the specific diet(s) are also imputed and limits set on the level of particular ingredients. These are mathematical computations hence can't guarantee that the feed produced would be the best in terms of ensuring animal productivity or acceptability and palatability of the feed. It also implies that the person must be familiar with animal nutrition and the limitations of each ingredient used in order to set limits eg a limit on bloodmeal can be set at 5 or 10% as beyond these levels, palatability issues set in.

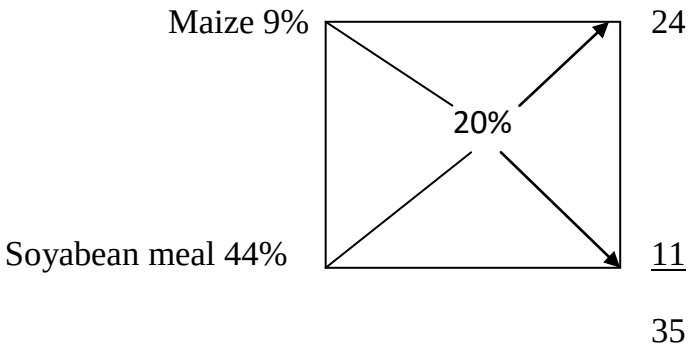
3.3.2 Pearson square method

It is designed for simple rations with few ingredients and of greatest value when only two ingredients are to be mixed. Used to mix two classes of feed ingredients such as a protein and energy source in proportions to achieve a specified protein content of the mixture. Considerations are exclusively on protein and energy, or one of these alone.

Example 1: Assume that you intend to formulate a broiler finisher diet using maize and soyabean meal, information needed are the required protein content of the finisher diet (20%) as well as the crude protein contents of the maize and soyabean meal which are 9% and 44% respectively.

The procedure is as follows:

i. Draw a square and place in the middle, the required protein content of the diet.



ii. Place the maize with 9% crude protein at the upper left side of the square and soyabean meal with 44% crude protein at the lower left side as shown above. Take note that the value in the middle must be intermediate between the two values positioned on the left of the square.
iii. Subtract the values diagonally across the square and place the answers at the right but disregard any negative numbers that result from the subtraction (9-20 = 11; 44-20=24). The upper right (24) and lower (11) values represent the proportion of maize and soyabean meal in the diet.
iv. Sum up the maize and soyabean meal proportions to get 35 which represents the total constituents of the diet.
v. Express the figures at the right as a proportion or percentage of the total constituent

$$\text{Maize} = \frac{24}{35} \times 100 = 68.57\%$$

Soya bean meal $\frac{11}{35} \times 100 = 31.43\%$

vi. It is important to double check calculations to ensure that the protein requirement is met as shown below:

Maize	68.57(quantity of maize) X 0.09(crude protein)	= 6.17
Soyabean meal	31.43(quantity of soyabean) X 0.44(crude protein) = 100.00	13.83 20.00% CP

This formulation focuses on protein as the some nutrient.

Example 2

Multiple ingredients can be used if the proportions/ratios of inclusion are predetermined. For example, Formulate a broiler finisher diet (23%) using Soyabean full fat (38%) plus Groundnut cake (44%) in the ratio 60:40, and Maize (8.9%) plus Sorgum (11%) in the ratio 50:50.

- The protein and energy sources must be combined since only two components can be used in the person square.
- $\frac{60}{100}$ Soyabean X 38% crude protein = 22.8

  $\frac{40}{100}$ Groundnut cake X 44% crude protein = 17.6

Protein in this mixture = 22.8 + 17.7 = 40.4

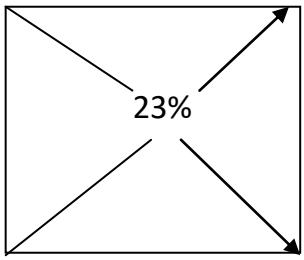
$\frac{50}{100}$ Maize X 8.9% crude protein = 4.45

$\frac{50}{100}$ Sorghum X 11% crude protein = 5.5

Protein in this mixture = 4.45 + 5.5 = 9.95

- Draw a square and place in the middle, the required protein content of the diet. Place the maize and sorghum with 5.5% crude protein at the upper left side of the square and soyabean and groundnut cake with 9.95% crude protein at the lower left side

Maize + Sorghum 9.95% 17.40



Soyabean + G/nut 40.40% 13.05

30.45

- Subtract the values diagonally across the square and place the answers at the right disregarding any negative numbers that result from the subtraction (9.95 - 23 = 13.05; 40.4 - 23 = 17.40). The upper right and lower values represent the proportion of maize plus sorghum and soyabean plus groundnut in the diet.

- Express the figures at the right as a proportion or percentage of the total constituent

  Maize + Sorghum = $\frac{17.4}{30.45}$ X 100 = 57.14%

  Soyabean + G/nut $\frac{13.05}{30.45}$ X 100 = 42.86%

- The proportion of each ingredient is determined as follows:

  Soyabean 60/100 X 42.86 = 25.72

  Groundnut 40/100 X 42.86 = 17.14

  Maize 50/100 X 57.14 = 28.57

  Sorghum 50/100 X 57.14 = 28.57

  100.00

- Check calculations to ensure that the protein requirement is met as shown below:

Soyabean	25.72 X 0.38 = 9.77	
Groundnut	17.14 X 0.44 = 7.54	
Maize	28.57 X 0.089 = 2.54	
Sorghum	28.57 X 0.11 = 3.14	
	100.00	23.00% CP

Maize	68.57(quantity of maize) X 0.09(crude protein)	= 6.17
Soyabean	31.43(quantity of soyabean) X 0.44(crude protein)	= 13.83
meal	100.00	20.00% CP

In practical diets, other supplements such as vitamin and mineral premixes, salt, limestone, bone meal etc are included. These are non protein contributing but must be factored in when working out the calculations as shown in example 3 below:

Example 3: Formulate a broiler starter diet (20%) using Soyabean full fat (38%) and Maize (8.9%). Other ingredients included are 3.0% bonemeal, 0.3% limestone, 0.25% vitamin mineral premix, 0.3% salt, 0.2% methionine, 0.1 lysine.

The total proportion of non protein containing ingredients (bonemeal, limestone, vitamin mineral premix, salt, methionine, lysine) is 4.15 obtained by adding them up (3.0 + 0.3 + 0.25 + 0.3 + 0.2 + 0.1)

100 – 4.15 = 95.85

3.3.3 Algebraic method

Simultaneous equations can be used to formulate diets and is more flexible than the Pearson square method.

Example 1: Assume that you intend to formulate a broiler finisher diet with a protein requirement of 20% using maize (9% crude protein) and soyabean meal (44%).

Let X represent the percentage of soyabean meal and Y the percentage of Maize in the feed

X + Y = 100 (Equation 1 for total amount of X and Y constituting feed)

0.44X + 0.09Y = 20(Equation 2 for total protein from X and Y)

Multiply equation 1 by 0.44 in order to eliminate one of the variables in equation 2

0.44X + 0.44Y = 44 equation 1

$$\underline{0.44X + 0.09Y = 20} \quad \text{equation 3}$$
$$0.35Y = 24$$

$$Y = \frac{24}{0.35} = 68.57$$

X = 100 – 68.57 = 31.43

Verify that protein requirement is met as done under the pearson square method

Example 2:

$\frac{60}{100}$ Soyabean X 38% crude protein = 22.8

$\frac{40}{100}$ Groundnut cake X 44% crude protein = 17.6

Protein in this mixture = 22.8 + 17.7 = 40.4

$\frac{50}{100}$ Maize X 8.9% crude protein = 4.45

$\frac{50}{100}$ Sorghum X 11% crude protein = 5.5

Protein in this mixture = 4.45 + 5.5 = 9.95

$X + Y = 100$ equation 1

$0.0995X + 0.404Y = 23$ equation 2

$\underline{0.0995X + 0.0995Y = 9.95}$ equation 3 (equation 1 X 0.0995)

$0.3045Y = 13.05$

$Y = \frac{13.05}{0.3045} = 42.86$

$X = 100 - 42.86 = 57.14$

Verify that protein requirement is met as done under the pearson square method

Example 3: Formulate a broiler starter diet (20%) using Soyabean full fat (38%) and Maize (8.9%). Other ingredients included are 3.0% bonemeal, 0.3% limestone, 0.25% vitamin mineral premix, 0.3% salt, 0.2% methionine, 0.1% lysine.

The total proportion of non protein containing ingredients is 4.15

Proportion of soyabean and maize is 100 – 4.15 = 95.85

$X + Y = 95.85$ equation 1

$0.089X + 0.38Y = 20$ equation 2

$\underline{0.089X + 0.089Y = 8.53}$ equation 3 (equation 1 multiplied by 0.089)

$0.291Y = 11.47$

$Y = \frac{11.47}{0.291} = 39.42$

$X = 95.85 – 39.42 = 56.43$

Diet would therefore comprise of Maize 56.43%, Soyabean 39.42%, Bonemeal 3.0%, Limestone 0.3%, Vitamin mineral premix 0.25%, Salt, 0.3%, Methionine 0.2% and Lysine 0.1%.

Verify that protein requirement is met as done previously

3.3.3.4 Trial and Error

This method is a bit complex as it takes into consideration the entire needed nutrients and cannot be used by novice as a good knowledge of animal nutrition is required. It involves adopting the following steps:

i.Identify which nutrients you desire to consider in the formulation eg protein, energy, calcium, lysine etc

ii. Consult nutrient requirement table(s) and write out the nutrient requirement for the type and class of animal

iii. Select feed ingredients that can supply the required nutrients at appropriate levels and cost

iv. Outline the ingredients that you desire to use and assign the proportions ensuring it adds up to 100

v. Calculate the nutrients contributed by each ingredient using feed composition table(s)

vi. Keep adjusting the proportions until the diet conforms to the nutrient requirement for the type and class of animal

Let us hypothetically assume for instance you desire to formulate a broiler starter diet using 53% maize, 30% soyabean meal, 14% wheat offal, 1.5% Oyster shell, 1% bonemeal, 0.25% salt and 0.25% vitamin mineral premix

Maize:

Protein 0.53 X 9 = 4.77%
Energy 0.53 X 3450 = 1828kcal/kg
Phosphorus 0.53 X 0.12 = 0.06%
Calcium 0.53 X 0.15 = 0.08%

Soyabean meal

Protein 0.3 X 40 = 12%
Energy 0.3 X 2450 = 735kcal/kg
Phosphorus 0.3 X 0.2 = 0.06%
Calcium 0.3 X 0.03 = 0.009%

Bonemeal

Protein 0.01 X 0 = 0
Energy 0.01 X 0 = 0
Phosphorus 0.01 X 13 = 0.13%
Calcium 0.01 X 0.30 = 0.003%

Wheat Offal

Protein 0.14 X 15.6 = 2.184%

Energy 0.14 X 1250 = 175kcal/kg

Phosphorus 0.14 X 0.40 = 0.056%
Calcium 0.14 X 0.14 = 0.0196%

Oyster Shell

Protein =0
Energy = 0
Phosphorus = 0
Calcium 0.015 X 0.38 = 0.0057%

Total protein in the feed is 4.77 (maize) + 12(soyabean) + 2.184(wheat offal) = 18.95%

Energy will be 1828 + 735 + 175 = 2738kcal/kg

The same as above is to be done for phosphorus and calcium then the total values obtained matched with the nutrient requirement (obtained from nutrient requirement tables) for broiler starter birds.

SELF ASSESSMENT QUESTION

i. Outline the importance of ration formulation
ii. List the factors governing ration formulation
iii. List the methods of ration formulation.

TUTOR MARKED ASSIGNMENT

1. Using the pearson square method, formulate a broiler finisher diet (22%) using Soyabean full fat (38%) and Maize (10%).
2. Formulate a broiler starter diet (21%) using Soyabean full fat (40%) and Maize (9%). Other ingredients included are 3.0% bonemeal, 0.3% limestone, 0.25% vitamin mineral premix, 0.3% salt, 0.2% methionine, 0.1 lysine. Use any method of your choice.

REFERENCES/FURTHER READINGS

Atteh, J.O. (2018). Principles and Practice of Lives stock Feed Manufacturing. Niyi Printing and Publishing Company, Ilorin. 205pp

Olomu, J.M. (2011). Monogastric Animal Nutrition: principles and practice. St Jackson Publishing, Benin City. 478pp

MODULE 6: WATER IN MONOGASTRIC NUTRITION
UNIT 1: Water requirements and management in Monogastric feeding

1.0 INTRODUCTION

In this unit, you will be shown the role water plays in the life of monogastric animals and the places where different water types originate from. You will also be informed on the basis for water consumption, factors that influence its uptake and the needs of various monogastric animals. The student will gain an understanding of the mechanisms through which water is discharged from the body and the need as well as mechanisms adopted to ensure equilibrium in order to avoid dehydration. The importance of optimum water temperatures in animal productivity and the implications of water restriction will be brought to the fore. In addition, the attributes qualifying water to be drinkable and agents of contamination are highlighted.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- Appreciate the vital role of water in the life and processes of the monogastric animal
- Realize that the water available to the animal comes from varied sources each with their own peculiarities
- Understand that though all animals require water, the extent of water demand is subject to several factors which are mostly out of the control of the animal
- Comprehend the essence of water balance in relation to water loss and dehydration
- Understand that water quality rather than quantity is key to the optimum performance and productivity of animals

3.0 MAIN CONTENT

3.1Importance of water

Water is an essential component of an animal's body comprising of about 50 - 80% of the live weight depending on age and degree of fatness and though it is the simplest of feed nutrients, it is the most fundamental as it plays an important role in almost all life processes. An animal can survive for only few days without water and a loss of 10% water can result in death in contrast to survival of even weeks when other nutrients are deficient. An animal can lose 50% of its fat and half of the body protein. It is chemically made up of hydrogen and oxygen in the ratio 2:1. Water is needed for the regulation of body temperature and homeostasis as well as is the medium of chemical reactions such as digestion, enzymatic, hormonal activities and several other metabolic processes. It serves as the solvent for many substances which are conveyed from one part of the animal body to the other. Turgidity of cells and muscles are facilitated by water and it is an important constituent of most body fluids. Water helps to lubricate joints and prevent friction in addition to acting as a cushion for the nervous system, it is also a constituent of milk, egg and meat.

3.2 Water sources and forms

There are 3 main sources of water available to monogastric animals and they come in various forms:

i. Direct drinking water: this accounts for the main source of water available to animals accounting for up to 75% of their water supply. Its presentation can be in the form of ponds, lakes, rivers, taps, boreholes, wells, rainwater, spring, and ocean
ii. Metabolic water: this is also known as oxidation water and is less than that obtained from direct sources but constitutes the next main source of water accounting for about 19%. The proportion of oxygen and hydrogen in the feed nutrients taken in by the animal determines the amount of metabolic water produced from oxidation. The metabolic water yield is influenced by the feed type with fat yielding the most. One hundred grams of fat, carbohydrate and protein produces 107-120g, 55-60g and 42-50g of water respectively.
   It also includes that of direct from tissue respiration
   eg $C_{6o12}O_6 + 6O_2 \rightleftharpoons$ Energy + $6H_2O + 6CO_2$
iii. Components of feeds: this accounts for the least (3-6%) water but is an integral component of feed materials. Though the amount contained is varied depending on feed type, fodder, forages, roots and tubers, silage, fresh grasses all contain water in varied amounts and hence offer these amounts to the animals that consume them. Meals can have up to 12% moisture content, dry grains and hay 5-7%, fruits up to 75% and lush green grass 90%.

3.3 Water intake and requirements of monogastric animals

3.3.1 Water Intake

The intake of water of water by animals is influenced by a variety of factors:

i. Water content of the feed – animals will drink more water when fed on low water
ii. containing feeds and drink less if the feed contains more water.
iii. Composition of the feed – animals on high salt and protein feeds would drink more than others.
iv. Health Status of the animal – Disease conditions like diarrhea and fever can cause increase in water consumption.
v. Climatic conditions- High ambient temperatures and dry environmental conditions predispose animals to requiring and drinking more water than wet conditions and low ambient temperatures.
vi. Age of animals – Though older animals have the capacity to take in larger quantities of water at any given time, young animals are in greater need of water.
vii. Physiological status of animal – The physiological status of an animal has a direct bearing on the animal's water intake as water is a vital constituent of animal products. Lactating animals would require more water than non-lactating, laying birds more than non laying.
viii. Feed quantity: on a general note, the more feed an animal eats especially if dry, the more water it would require.
ix. Environmental temperature: under hot conditions, the intake of water increases when the water temperature is lower than that of the ambient temperature.
x. Water quality: High levels of salt in drinking water results in high levels of water consumption.
xi. Health of the birds: A health condition like diarrhea causes an increased demand for water.

3.4 Water loss, water balance and dehydration

Water is lost through four primary routes: sweating, urination, respiration and faeces.

3.5 Water restriction

It is not generally desirable to restrict water.

3.6 Water quality and contamination

Water quality though sometimes neglected is vital to the wellbeing and ultimate productivity of animals. Water quality also affects the quantity of the water consumed.

Good drinking water should be clean, colourless, tasteless, free of harmful sediments, fresh and cool. Extremes in bacteria, nitrogen levels, pH, hardness, low or high naturally occurring elements all compromise water quality. It is ideal and advisable to determine its quality by analyzing for pH, total salt content, minerals, and bacterial contents. Levels of nitrates and various minerals such as, potassium, magnesium, sodium and calcium present in the water can also be determined.

Contaminations include amongst others bacterial, chemical, chlorination, mineral content, nitrates and nitrites, hard water, pH and salinity.

Water may contain a variety of micro-organisms, such as bacteria, viruses, protozoa and parasite eggs. High number of microorganisms in water is an indication of contamination and could imply seepage of surface water into the water supply. Even low bacteria counts can be termed as contamination as some bacteria grow in water and count consequently cause the animal to be exposed to high levels.

Chemical contaminants pose a serious challenge when present in high concentrations as they can affect performance. Water chlorination removes harmful bacteria and other micro-organisms. Protozoa and enteroviruses are more resistant to chlorination than bacteria. Chlorination though a vital process of purifying water can be harmful if the chlorine residual levels are high apart from lowering water consumption.

Salinity is measured as the concentration of dissolved salts of various kinds as all water contains dissolved substances of which most are ions of inorganic salts. The most predominant of these are calcium, magnesium, sodium chloride, sulfate and bicarbonate. Where the levels of salts are high enough to cause harmful osmotic effects it results in poor performance, illness or even death in animals forced to drink them. An increase in water consumption can result from increased salinity although animals may initially refuse to drink the water due to the salty taste which can even span for few days at very high concentrations. The subsequent large consumption can result in animals becoming sick or even death. Younger animals are more prone to harm from salinity than are older animals.

Toxic Elements though not a common incidence sometimes are contained in natural waters which become contaminated with toxic elements such as arsenic, mercury, strontium, cadmium or radioactive substances. Major concerns apart from harm to the animals consuming the water are possible accumulation in animal products used for human consumption.

Nitrates and nitrites presence in water often indicates contamination of the water supply with fecal material or seepage from a septic field. Nitrates are produced during the final stage of organic matter decomposition. Nitrates themselves are not very toxic, but when reduced to nitrites, problems can develop. Nitrites that get into the blood stream convert the red pigment, haemoglobin, to a dark brown pigment, methemoglobin thereby preventing the carrying of oxygen as it cannot be carried in the methemoglobin form. Respiratory distress arising from a shortage of breath and death can result.

Alkalinity or acidity is expressed as pH. Alkaline water has pH higher than 7 while acid has below 7. Many and perhaps most waters are alkaline with only few instances of

water samples been found to be too alkaline for livestock resulting in physiological and digestive upsets. Acid water can affect digestion, corrode equipment and incompatible with vaccines and some medicines.
Algae especially the blue-green algae which are free floating and green, blue-green or brown in colour generally appear as small specks in the water can under certain circumstances be toxic. Large consumption of infected waters results in paralysis and respiratory failure leading to suffocate and death. Heavy algae growth occasionally, occurs in stagnant or slow flowing bodies of water that is high in nitrogen and phosphorus.

SELF ASSESSMENT EXERCISE

iv. What is the importance of water in monogastric nutrition?
v. List 3 main sources of water available to monogastric animals
vi. List some water quality indices
vii. List 8 factors that influence water quality and contamination.

4.0 CONCLUSION

Water though many atimes neglected is the most essential nutrient to ensure the survivability and productivity of monogastric animals. Though the requirements of the animals largely governs the desired supplied volume, Its consumption and efficiency of utilization is influenced by varied factors that must be understood if the full productive potential of the animals are to be met.

5.0 SUMMARY

Water available for animal use abounds in several forms originating from different sources. Of the three major sources, drinking water constitutes the most abundant. The amount of water an animal requires can be generalized but its specific need is not static but dependent on various factors that are climatic, physiological, health, physical in nature.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain in details the importance of water in monogastric nutrition
2. Why is water quality an issue of importance
3. Explain water quality
4. What factors influence water intake

7.0 REFERENCES/FURTHER READINGS

Kleyn, R. (2013). Chicken Nutrition. A guide for nutritionists and poultry professionals. Context Products Ltd. 347pg.sss

Olomu. J.M. (2011). Monogastric Animal Nutrition. Principles and practice. 2nd Edition. St. Jackson Publishing Benin City. 478pg

Water Requirements for livestock.

http://www1.agric.gov.ab.ca/department/deptdocs.nsf/all/agdex801

Smith, A.J. (2001). Poultry. Technical Centre for Agriculture and Rural Co-operation. Macmillan Publishers Limited. 242pg