COURSE GUIDE

ANP 508
FEED FORMULATION
(2 UNITS)

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Introduction

Feed formulation is a two-credit unit course. Feed formulation is the process of quantifying the amounts of feed ingredients that need to be combined to form a single uniform mixture (diet) for poultry that supplies all of their nutrient requirements. Since feed accounts for 65-75% of total live production costs for most types of poultry throughout the world, a simple mistake in diet formulation can be extremely expensive for a poultry producer.

Feed formulation requires thorough understanding of the:

(a) nutrient requirements of the class of poultry (e.g., egg layers, meat chickens or breeders);

(b) feed ingredients in terms of nutrient composition and constraints in terms of nutrition and processing, and

(c) cost and availability of the ingredients.

Most large-scale poultry farmers have their own nutritionists and feed mills, whereas small operations usually depend on consultant nutritionists and commercial feed mills for their feeds. It is therefore essential that formulations are accurate because once feeds are formulated and manufactured, it is often too late to remedy any mistakes or inaccuracies without incurring significant expenses.

Course Aim

Feed formulation is designed to provide you with the knowledge of animal feedstuffs, handling and processing. It also enlighten the students on the different types of milling machines and there mode of operation.

Course Objectives

On successful completion of the course, you should be able to:

- Explain the rumen environment, physiology and metabolic pathways
- Explain the different systems of energy and protein partitioning

- Formulate rations for ruminant and carry out proximate analysis
- Mention the different food additives, nutritional disorders and how to manage them.

Working through this Course

You are expected to study and understand the content of this course. Each unit must be properly studied for good comprehension of the contents. By the end of each unit, you are expected to answer the questions therein and submit as appropriate when directed by the administration of the University. These questions are like continuous assessment. You are expected to sit for an examination on completion of the course. The course duration shall take about 17 weeks of learning. Therefore, you must be able to organize your time to achieve this successfully. Tutorial session will be available and it is advisable for you to attend in order to be able to assess and compared yourself with your peers and clarify any area that you do not properly understand.

The Course Material

Major components of the course material are:

- The Course Guide
- Study Units
- The References/Further Reading, that will be provided at the end of each unit are necessary supplements to the course material.

MODULE 1: Classification of feeds, feedstuffs and supplements

Unit 1: Classification of feedstuffs

1.1 Energy Concentrate
1.2 Protein Concentrate
1.3 Roughages
1.4 Agro Industrial by products
1.5 Supplements

Unit 2: Feed evaluation

2.1 Laboratory chemical evaluation
2.2 Digestibility and balance trial

Unit 3: Storage and handling of feeding stuffs

MODULE 2: Method used in ration formulation for various classes of farm animals.

Unit 1: Pearson square method
Unit 2: Algebraic method
Unit 3: Trial and error
Unit 4: Computer soft wares
Unit 5: Feed formulation on-farm

MODULE 3: Economic factors in ration formulation
Unit 1: Advantages and disadvantages of compound feeds.
Unit 2: Problem of feedstuffs availability and adulteration.
Unit 3: Anti-nutritional factors in livestock feedstuff and compounded feeds.

MODULE 4: Feed milling in Nigeria
Unit 1: Raw material handling,
Unit 2: Feed milling machineries and equipment
Unit 3: Feed milling process
Unit 4: Handling, leveling, storage and delivery of finished products.

MODULE 5: Legislation and quality control for commercial feed formulations
Unit 1: Laws governing establishment of feed mill
Unit 2: Standard organization and feed standard

Video pelleting machine https://www.youtube.com/watch?v=7ZSKNtOf|Y
Video feed milling machine https://www.youtube.com/watch?v=EnAFxfGA OA
https://www.youtube.com/watch?v=mAKiJm9QwYk

Assessment

The assessment of the course shall be in two parts. The Tutor-Marked Assignments (TMAs) will take a part while the end of course written examination takes the second part. As a result, you must do the TMAs applying the knowledge and techniques learnt in each unit. The assignment must be submitted to your tutor/facilitator for assessment in accordance with the set time in the presentation schedule. The TMAs assessment will constitute 30% while the written examination account for 70% of the total mark for the course.

Tutor-Marked Assignment

The TMA is a continuous assessment component of your course. It carries 30% of the total score. You will be given four TMAs to answer. Three of these must be answered before you are allowed to sit for the end of the course examination. The TMA would be given to you by your facilitator and you should submit after you have done the assignment.

End of Course Examination

The examination concludes the assessment for this course. It constitutes 70% of the mark for the whole course. You will be informed of the time for the examination.

Summary

Feed formulation is a course that gives you a good understanding of the different kind of feedstuffs for livestock, raw materials for processing, different methods for compounding feeds. It teaches the skills of handling, processing storing feeds and also feeds availability for livestock. Other information inclusive are ant nutritional factors in livestock feeds, law governing establishing of feed mill

Best wishes.

MODULE 1: CLASSIFICATION OF FEEDS, FEEDSTUFFS AND SUPPLEMENTS

Unit 1 Classification of feedstuffs

Unit 2: Feed evaluation

Unit 3: Storage and handling of feeding stuffs

UNIT 1 CLASSIFICATION OF FEEDSTUFFS

CONTENTS

1.0 INTRODUCTION

Many types of feed ingredients or feedstuffs are available to supply the nutritional needs of livestock. These feedstuffs are the raw materials that are converted into animal cells, tissues, organs, and products. A familiarity with the chemical and nutritional composition of the various classes of feedstuffs is essential in order to formulate the most economical and profitable rations. It is also important to be familiar with the various feedstuff types to plan for planting, harvesting, and storage of homegrown feedstuffs. Proper preservation of stored feedstuffs is a critical profitability factor for some types of farms and ranches.

Feed is any Edible material which is consumed by animals and contribute energy and/or nutrients to the animal's diet. (Usually refers to animals rather than man (AAFCO, 2000).

2.0 OBJECTIVES

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

- Know the different classification of feeds
- Identify the different type of concentrates
- Know the different types of Agro-industrial by-products

3.0 MAIN CONTENT

3.1 Concentrates

3.1.1 Energy concentrates

3.1.2 Protein concentrates

3.1.3 Roughages

3,1.4 Agro-industrial by-products

3.1.5 Feed supplements and Feed additives.

3.1 Concentrates are feeds that contain a high density of nutrients, usually low in crude fibre content (less than 18% of dry matter (DM)) and high in total digestible nutrients. Concentrates may be high in energy, referred to as energy concentrates , such as cereals and milling by-products, or high in protein, with over 20% crude protein, referred to as protein concentrates . Concentrates may be fed in raw or milled forms as individual feeds (sometimes referred to as straights), or maybe blended or formulated into balanced rations for particular production purposes (compound feeds). Compound feeds may be mixed on-farm but are also produced by the commercial feed compounding industry. Available published data on compound feeds mainly refer to the latter.

Raw materials for concentrate feeds

Raw materials for concentrate feeds are commonly classified into the following categories:

Cereals: the main cereals are rice, wheat, barley, oats, rye, maize, sorghum and millet

Grains: all cereals except rice

Coarse grains: all cereals except wheat and rice

Food grains: grains used for human food consumption

Feed grains: unmilled grains to be used as livestock feeds

Milling by-products: by-products from the milling of cereals and pulses, such as brans and pollards

Feed-grain substitutes: dried roots and tubers (chiefly cassava and sweet potatoes), or by-products of crop processing such as molasses, maize gluten feed, distillery and brewery grains, dried citrus pulp etc. In some classifications, 'roots and tubers' are classed separately while the latter kinds of feeds may be regarded as 'other concentrates' or 'non-conventional concentrates'.

Oil meals and cakes: products of oilseeds (including copra, cotton seed, groundnuts, linseed, palm kernel, rapeseed, sunflower seed and soyabeans) and fish after extraction of their oil component either by expeller methods (oilcakes) or solvent-extraction methods (oil meals).

Other concentrates: other energy or protein concentrates including processed livestock products (inedible fats and oils, meat, blood and bone meal and milk products) and industrial products such as urea and single-cell protein.

Non-conventional feeds and processed harvested forages: these include a variety of feeds not widely used in commercial livestock diets; some may be considered as concentrate feeds after processing, such as dried lucerne (alfalfa) leaf meal, dried cassava leaf, cassava pulp, processed pea and bean meals, sal and rubber seed meals, citrus pulp wastes and others.

3.1.1 ENERGY CONCENTRATES (GRAINS AND BY-PRODUCT FEEDS)

The main nutrient contribution of grains and by-product feeds is energy. Oats and barley are moderately high in CP. Processing grain (rolling, crimping, cracking, or grinding) increases its digestibility when fed to cows. As much as 30 percent of the whole grain will pass through cows intact if the grain is not processed before feeding. Breaking the seed coat increases digestion. Coarse-textured, processed grain enhances palatability and intake. Fine grinding of grain can increase digestibility, but can also lower milk fat percent and cause rumen acidosis. Pelleted grain is not dusty, and may increase palatability and intake, but has the same disadvantages as finely ground grain on rumen fermentation. Because young animals chew their feed more thoroughly than adults, whole grains can be fed up to 12 months of age.

Barley is a good source of energy and protein. If barley is used in large amounts in dairy cattle rations, cattle should be adjusted gradually. Rolling is superior to fine grinding for palatability. If barley is finely ground, it shouldn't make up more than 50 percent of the grain ration.

Beet pulp can be obtained either in plain form or as molasses beet pulp. It is relatively high in energy, adds highly digestible fiber and bulk to diets, and enhances palatability. Maximum feeding rate is 30 percent of the ration DM.

Cottonseed, whole or fuzzy, is a medium protein, high fat, high fiber, and high energy feed. Whole cottonseed is white and fuzzy, while de-linted cottonseed is black and smooth in appearance. The amount fed should not exceed 7 pounds per cow per day.

Corn glut n feed is a relatively high fiber, medium energy, medium protein by-product of the corn wet milling industry. The by-product is sold as either a dry or wet product. Corn gluten feed (wet or dry) should not exceed 25 percent of the total ration DM.

Corn, ear or corn and cob meal is a relatively high energy feed relished by cows. It contains 10 percent less energy than shelled corn. However, the fiber supplied by the cob aids in maintaining fat test and keeping cows on feed.

Corn, shelled is the most common grain fed to dairy animals. It is one of the highest energy feeds available for use in dairy rations. Where corn can be grown successfully, it is generally an economical source of energy. Because of its high caloric density, good management (determining the amount to feed, frequency of feeding, mixing with other feeds, etc.) is needed to obtain maximum consumption without causing digestive disturbances.

Corn, high moisture offers these advantages:

1. Grain can be harvested 2 to 3 weeks earlier, reducing field losses and harvest problems associated with adverse weather.
2. Storage and handling losses are reduced.
3. It fits automated feeding programs.
4. The expense of drying grain is eliminated.
5. Grain is highly palatable.
6. Daily labor of grain processing or grinding is reduced.

High moisture ear corn should be stored from 28 to 32 percent moisture and processed prior to storage. The wet cob is more digestible than the cob in dry corn.

High moisture shelled corn should be stored within a moisture content of 25 to 30 percent. In airtight silos, the shelled corn can be stored whole or ground, and rolled upon removal from the silo. In conventional silos, bags or bunkers, it should be processed (ground or rolled) before storing. Propionic acid can be used effectively to treat and preserve high moisture corn for dairy cattle.

Hominy feed is a fine, dusty ground corn feed from which the bran and gluten have been removed. It is the by-product from the manufacture of hominy grits. Fat content is generally about twice that of corn grain, but quite variable. Hominy can replace corn in the diet, but is low in starch.

Fat is a concentrated energy source. Several kinds of animal and vegetable fats or oils are available for feeding. Amounts to feed and responses from feeding will vary with fatty acid (saturated or unsaturated) composition of the fat. Total added fat in diets should not exceed 4 percent (DM basis) with animal, vegetable or rumen inert fats individually not exceeding 2 percent.

Molasses (cane and beet) supplies energy and is used primarily to enhance the acceptability of the ration. The amount used should be limited to 5 to 7 percent of the grain mix (10% in pelleted feeds) to maintain flow characteristics in automatic feeding equipment and to avoid undesirable rumen effects.

Oats contain 15 percent less energy but 20 to 30 percent more protein than shelled corn. The advantage of adding oats to dairy rations is that it adds fiber and bulk, and may help maintain rumen function.

Screenings are often an economical buy. However, they vary in protein and energy

3.1.2 Protein concentrate, a human or animal dietary supplement that has a very high protein content and is extracted or prepared from vegetable or animal matter. The most common of such substances are leaf protein concentrate (LPC) and fish protein concentrate (FPC).

LPC is prepared by grinding young leaves to a pulp, pressing the paste, then isolating a liquid fraction containing protein by filter or centrifuge. Herbaceous plants and legumes, such as clover and lucerne, produce higher yields of protein concentrate than perennial grasses. The protein quality of some LPCs has been found to approach that of the soybean, the most protein-rich of the oilseeds; all LPCs require supplements, however, because they are deficient in two of the nutritionally essential amino acids, lysine and methionine.

FPC, processed directly from fish, is most commonly incorporated in cereal or wheat-based foods as a source of lysine. FPC flour is made by grinding the fish and adding to it an isopropanol solvent, which separates liquids and solids; the solid material is then extracted by centrifuge, and the process may be repeated several times. After the final centrifuging, the solid material is dried and ground. The most common of such substances are leaf **protein concentrate** (LPC) and fish **protein concentrate** (FPC). ... Herbaceous plants and legumes, such as clover and Lucerne, produce higher yields of **protein concentrate** than perennial grasses.

3.1.2.1 Protein isolates and concentrates

1. **PROCESS OF MAKING PROTEIN ISOLATES AND CONCENTRATES**

INTRODUCTION • Proteins are nitrogen-containing compounds made of up amino acids unit. They are the major structural component of muscles and other tissues in the body. • Proteins are available in different varieties of dietary sources including animals, plants origin, and from highly marketed spot supplement industry. • Typically, all dietary animal proteins (e.g. eggs, milk, meat, fish and poultry) are considered complete protein because they contain all essential amino acids. • Proteins from vegetable sources (such as legumes, nuts and soy) are incomplete proteins since they are lacking one or two essential amino acids.

PROTEIN ISOLATES • Isolate are the most refined form of protein products containing the greatest concentration of protein but unlike flour and concentrates contains no dietary fibre. Isolates originated from United State around 1950s . • They are very digestible and easily incorporated into different food products. • Protein isolates are nowadays believed to have played a major role in the development of new class of formulated foods. It is high concentration of protein with the advantage of colour, flavour and functional properties make it an ideal raw ingredient for used in beverages, infant foods and children milk food, textured protein products and certain types of specialty foods. • Protein isolates have been developed from a variety of legumes among which are soy bean, peanut, canola, cashew nut, almonds, sesame, pinto and navy beans

Protein isolate from different plant and animal sources • Proteins that are utilized in food processing are of various origins, and can roughly be classified into animal proteins (gelatins), vegetable proteins (e.g. peanut protein, soy protein, wheat proteins, Almond protein, canola meal protein etc.), and animal derived protein (e.g. milk proteins).

3.1.2.2 PROTEIN CONCENTRATES • Protein concentrates are those which contain some level of carbohydrates • Its content is less as compared to Isolates • Many concentrates are 80% protein, which means on a dry basis, 80% of the total weight is protein • Protein concentrate, a human or animal dietary supplement that has a very high protein content and is extracted or prepared from vegetable or animal matter. The most common of such substances are leaf protein concentrate (LPC) and fish protein concentrate (FPC).

LPC is prepared by grinding young leaves to a pulp, pressing the paste, then isolating a liquid fraction containing protein by filter or centrifuge. Herbaceous plants and legumes, such as clover and lucerne, produce higher yields of protein concentrate than perennial grasses. The protein quality of some LPCs has been found to approach that of the soybean, the most protein-rich of the oilseeds; all LPCs require supplements, however, because they are deficient in two of the nutritionally essential amino acids, lysine and methionine. • FPC, processed directly from fish, is most commonly incorporated in cereal or wheat-based foods as a source of lysine. FPC flour is made by grinding the fish and adding to it an isopropanol solvent, which separates liquids and solids; the solid material is then extracted by centrifuge, and the process may be repeated several times. After the final centrifuging, the solid material is dried and ground.

EXAMPLES • a Whey protein isolates (WPI) • Whey is the liquid by-product of cheese which can further be processed into a spray dried products like instance whey protein concentrates (WPC), whey protein isolate (WPI) or whey protein hydrolysate (WPH). • Whey isolates have had their base component (water) removed and are generally considered almost lactose and cholesterol free — they are typically at least 90% protein. • Whey protein isolates can be obtained by 2 methods: 1) Ion Exchange method 2) Membrane filtration method

FISH PROTEIN ISOLATES (FPI) • Fish protein isolate is a protein concentrate which is prepared from fish muscle without retaining the original shape of the muscle. It is not generally consumed directly, but used as raw material for production of other value added products. • Fish protein isolate does not retain the original shape of muscle, and is normally utilized as ingredient for the production of value added products. It is still a good source of protein for the production of ready to eat fish products. • The overall processes involved are simple. The proteins of the muscle tissue are first solubilised. The solubilisation can be accomplished by addition water with alkali added to approximately pH 10.5 or higher, or with acid added to about pH 3.5 or lower. It is usually necessary to choose the pH at which the consistency of the solution decreases to a value that allows the removal of undesirable material. • The mixture is then centrifuged, and due to density differences the oil rises to the top and can then be removed. Other insoluble impurities such as bone or skin are also sedimented at this stage. • The muscle protein are then precipitated and collected by a process such as centrifugation.

PEANUT PROTEIN ISOLATES (PPIS) • Peanut (Arachis hypogeae L.) is an annual herbaceous plant belonging to the suborder papillonacea of the order Leguminosea. It contains 26-29% protein with good nutritional quality. Peanut proteins are used for their functional properties (emulsification, forming) or for their nutritional properties in different food products. They are also used for human nutrition in developing countries to supplement cereals, beverages and skim milk. • Peanut protein isolate can be prepared from the defatted peanut cake or powdered by macerating with high salt phosphate buffer (20mM Na2HPO4, 2mM KH2PO4, 5.4 mM KCl, 1M NaCl, pH 7.4), centrifuging and then supplementing the supernatant with (NH4)2SO4 to 90% saturation. • After centrifuging the pellet can be dialyse against distilled water overnight at 4oC and freeze-dried.

SOY PROTEIN ISOLATES (SPIS) • Soy protein isolate is a common isolate. It has high protein content of about 90%. It is made of defatted soy meal by removing most of the fat and carbohydrates. • A soybean is crushed into oil and defatted meal. The meal is usually used as animal feed, while smaller amount is further processed into food ingredients including soy flour, protein concentrate, protein isolates and textured protein. • Soy protein isolate is usually combined with other food ingredients such as vitamins, minerals and flavour in preparation of soy protein shake powder. • The production of soy protein isolate involve solubilising the protein and carbohydrate at neutral or alkaline pH and the recovery of the solubilised protein, separation and optionally washing and neutralization before drying.

Three steps involved in the processing of soy protein isolates (SPI) are (1) The soy flakes are slurried with water under alkaline conditions (pH 6.8-10 at 27-66oC using sodium hydroxide and other alkaline substances approved for food used) so that the protein and the oligosaccharides can dissolve into the solution. The protein solution is then separated from the insoluble residue by centrifugation, (2) The supernatant containing the protein and sugars is then acidified to isoelectric pH 4.5 (where the solubility of proteins is minimal), using hydrochloric acid (HCl). This leads to the precipitation of protein as curd, (3) The solubility of the precipitated protein is restored by neutralizing to alkaline pH of 6.5-7.0 after re-diluting with fresh water or spray dried in its acidic form and packed in multilayer paper bags.

SOY PROTEIN CONCENTRATES • Soy protein is made from dehulled, defatted soybean meal. The concentration of protein is achieved by removing most of the soluble non-protein compounds. These compounds are mainly soluble carbohydrates and some nitrogenous substances and minerals. • There are three methods to produce soy protein concentrate. 1) Aqueous alcohol wash process 2) Acid wash process 3) Water wash process with heat denaturation

AQUEOUS ALCOHOL WASH PROCESS • with this process the sugars are dissolved with alcohols (methanol, ethanol or isopropyl alcohol) in a batch or a continuous process. These alcohols do not dissolve the soy proteins. Defatted soy flakes are used as raw material. After the extraction of the sugars, the alcohol is recovered and re-used. This recovery is accomplished by evaporation and rectification in a distillation column. The final flakes are dried with hot air and milled.
Acid-wash process The soybean protein becomes insoluble in water when the pH is adjusted to 4.2. With this low pH, it is possible to dissolve the sugars without the use of special solvents. This process is a lot safer due to the absence of flammable solvents. On the other hand, it is more difficult to remove the water from the soy protein. Most of the water is removed with rotary vacuum filters or centrifuges. The obtained solids wet milled and spray dried. • Water extraction process with heat denaturation With this process, the soy proteins of defatted soy meal are first rendered insoluble by thermal denaturation. The meal is heat treated and then extracted with hot water to remove the sugars. The process is similar to the acid-wash process.

WHEY PROTEIN CONCENTRATES • Whey Protein Concentrate is the substance obtained by the removal of sufficient nonprotein constituents from pasteurized whey so that the finished dry product contains > 25% protein. WPC is produced by physical separation techniques such as precipitation, filtration or dialysis. The acidity of WPC may be adjusted by the addition of safe and suitable pH adjusting ingredients.

3.1.3 ROUGHAGE

Roughages are plant-based feedstuffs. Technically, forage and herbage are defined as plant materials available for consumption by an animal. Technically, roughage refers to a feedstuff with a higher fiber content forages. Practically speaking, the terms are used interchangeably. The National Research Council classifies a roughage as a feedstuff with a minimum crude fiber content of 18% and a maximum content of total digestible nutrients (TDN) of 70%. Roughages provide a range of nutrients to animals. Roughages also function to maintain and optimize the efficiency of the GI tract for selected species. For selected species, fibrous carbohydrates function to maintain structure, activity, and microbial population of the GI tract, essential for optimal function of the GI tract. Roughages are a link to the efficient utilization of earth's resources. Roughages alone are of minimal value to humans. However, roughages consumed by selected species provide a means for conversion of relatively low-quality raw materials to relatively high-quality products such as food and fiber that may be used to fulfill human needs. Roughages may be fed either in a fresh, dried, or ensiled state. Types of roughages used as feedstuffs include grazed roughages (e.g. pasture and range), preserved roughages (e.g. hay and silage), and crop residues and by-products (e.g. straw, stover, and hulls). The following is a general introduction to roughages. It is important to note significant exceptions to the generalizations do exist.

The protein, mineral and vitamin contents of roughages are highly variable. Legumes may have 20% or more crude protein content, although a most of may be in the form of non- protein nitrogen (NPN). Other roughages, such as straw may have only 3-4% crude protein, most others fall between these two extremes. Mineral content may be exceedingly variable; some roughages are relatively good sources of calcium and magnesium, particularly legumes. Phosphorus content is apt to be moderate to low and potassium content high; the trace minerals vary greatly depending on plant species, soil and fertilization practices.

Roughages are sub-divided into two major groups; dry and green or succulent roughages based upon the moisture content. Green roughages usually contain moisture from 60-90%, whereas, dry roughages contain only 10-15% moisture. For the sake of convenience, succulent feeds are again classified into various types such as pasture, cultivated fodder crops, tree leaves, roots and crops. Dry roughages have been further classified as hay and straw, based on the nutritive values and methods of preparation.

Roughages are the bulkier feeds in the ration; feedstuffs with less mass per unit volume. Generally, the digestible energy contents of roughages are low. The digestibility of other nutrients, such as protein, are also relatively low. Roughages are high in fibrous carbohydrates such as hemicellulose and cellulose. Fibrous carbohydrates are primarily present in the cell wall of the plant cell. As fibrous carbohydrates are associated with the structural components of plants, fibrous carbohydrates are often referred to as structural carbohydrates. Roughages may also contain relatively high amounts of lignin. Lignin content increases with plant maturity. In a nutrition analysis, the fiber components of roughages may be expressed as crude fiber, acid detergent fiber (ADF), and/or neutral detergent fiber (NDF). Crude fiber contains cellulose and a portion of the lignin. ADF contains cellulose and lignin. NDF contains hemicellulose, cellulose, and lignin.The nutritional value of roughages varies. In addition to other factors such as plant species, the nutritional value of roughages depends on the proportion of cell contents to cell wall components and on the extent of cell wall lignification. Most roughages can be effectively incorporated into at least one type of ration. Effective use of a roughage requires matching nutrient requirements of an animal with the nutritional value of a roughage. Effective use of a roughage also requires appropriate processing and supplementation.

In ruminants, enzymes from rumen microorganisms are required for the digestion of roughages. As the population of rumen microorganisms is dependent upon the feedstuffs consumed, the composition of the diet influences the extent and rate of digestion of roughages. Feeding of high-energy feedstuffs has a negative associative effect on the degree of utilization of a roughage. A negative associative effect occurs when the addition of one feedstuff negatively influences the utilization of another feedstuff. One of the primary species responsible for the digestion of roughages is cellulolytic. The primary end-product of digestion is the acetate. Acetate is a relatively weak acid. The primary end-product of fermentation of high-energy feedstuffs is propionate. Propionate is a relatively strong acid. An additional end-product of microbial fermentation of high-energy feedstuffs is lactate. Lactate is also a strong acid. Compared to roughages, the digestion rate and extent are higher and the resultant pH of the rumen is lower for high-energy feedstuffs. The lower pH has a negative effect on the microorganisms responsible for digestion of roughages; the cellulolytic microbes are inhibited by a pH of 6.0 or lower. Therefore, the incorporation of high-energy, high-nonfibrous carbohydrate feedstuffs decreases the utilization of roughages.

Management strategies to increase the utilization of roughages include:

1) addition of buffers, such as bicarbonate, to the diet;
2) increasing particle size of roughage to increase the production of bicarbonate in the animal; and/or

3) reducing the rate of fermentation of high-energy feedstuffs either by substitution with another feedstuff or applying an alternative method of processing.

As with other feedstuffs, addition of roughages to rations is dependent on the GI tract.

As roughages are high in fibrous carbohydrates and microbial enzymes are required for digestion of fibrous carbohydrates, utilization efficiency of roughages is dependent on the site and extent of microbial fermentation in the GI tract. Roughages are primarily added to the rations of herbivores. The proportion of forage in the ration varies with species and class of animal and also cost of feedstuffs. Based on the relatively high utilization efficiency of roughages in the GI tract and roughages are a source of fibrous carbohydrates to maintain optimal functioning of the GI tract, generally, roughages are added to ruminant rations. Although the utilization efficiency is less, roughages are also used in the rations of horses. In the horse, the cecum is the primary site of microbial fermentation. As the cecum is located posterior to the primary site of absorption, horses may practice coprophagy or consumption of feces to increase efficiency of utilization. For monogastrics such as swine and poultry, the low utilization efficiency limits the use of roughages in rations. Roughages can be added to the ration of swine with low nutrient requirements.

3.1.4 AGRO-INDUSTRIAL BY-PRODUCTS

Cotton by-products

Cottonseed has been the most used. However, it has been observed that availability is dwindling. There has been a significant drop in production of this by-product, directly related to cotton production in West Africa. After starting in 2004, this decline worsened in 2007 and the trend seems to persist. Global cottonseed supplies amounted to over 2 million tonne for the sub-region in 2005, and dropped to only 1.134 million tonne in 2009. Between 75 and 83 percent of the annual output comes from Burkina Faso, Mali and Benin, the leading cotton producers in the sub-region, followed by Côte d'Ivoire. Cakes are the solid residues obtained after extracting oil from the seeds or oilseed fruits (rich in fat). These are the co-products of crushing, hat is, the industry of oil manufacturing. At global level, the availability of cakes follows the same trend as cottonseeds. The same countries lead, with Burkina Faso clearly ranked first with between 37 and 50 percent of the total supply, depending on the year.

Nevertheless, in absolute terms, these figures should be treated with caution since the production data for some traditional ginning and seed crushing units are not known. Moreover, oil yields, and consequently cake yields, vary considerably. While in modern factories they reach 16–20 percent, they are only 8–10 percent in traditional oil mills.

Finally, in some traditional oil mills, the mode of extraction is far from efficient, but could be carried out without separating the shell from the seed.

Soybean cake

Even though soybean is a recent and still marginal crop, it is gaining in importance in West Africa. It seems that in most cotton producing countries, farmers are turning to soybean since it provides them with increased autonomy in their commercial exchanges compared with cotton. As can be seen in Burkina Faso and Benin, production has increased exponentially in reaction to (or as a consequence of) the decline in cotton production.

Groundnut cake

A sharp recovery in groundnut production in Senegal boosted UEMOA production to about 2.5 million tonne of groundnut cake in 2009. However, that increase is virtually attributable to Senegal alone within UEMOA.

In comparison, Niger, a former leading groundnut producer, currently produces only 250 000 tonne, compared with the more than 1 million tonne produced by Senegal. In fact, in Niger, groundnut oil production is mainly done using traditional methods, and to a lesser extent using semi-modern methods. Consequently the by-product obtained is marketed in the form of groundnut paste intended for human consumption. A similar situation can be observed in Mali and Burkina Faso. Thus, these by-products are not traditionally fed to animals in those countries, even though this practice can be observed here and there among individuals.

Local cereal bran

It is very difficult to obtain figures for local cereal brans due to the key role played by artisanal units in their processing, the number and capacity of which are difficult to obtain.

Moreover, it was not possible to obtain similar data for rice and other grain mills. Consequently, the quantity of bran was estimated based on the conversion factors of the quantities of seeds provided (Kossila, 1988). It is not surprising that sorghum and millet provide the highest quantities of bran: 1.3 million tonne of sorghum bran, and between 1.5 and 1.8 million tonne of millet bran, with trends that are naturally similar to those of seed production. Obviously, the ranking per country remains the same for seeds, and Sahelian countries are still the largest producers of bran cereals (Figure 12). To estimate the production of wheat bran, a 0.35 percent coefficient was applied to the quantities of wheat imported in view of the difficulty in obtaining reliable and complete data and since the quasi-totality of processed wheat is imported (sub-regional production is very low). The results of this estimation are shown in Table 18, where it can be observed that Senegal and Côte d'Ivoire produce between 75 and 80 percent of the total production of wheat bran in the sub-region, and that this production has been increasing over the past years. Burkina Faso and Niger have the lowest production. Their supplies vary from 5 to 7 kg/TLU/year, depending on size of production.

Molasses

The production of molasses was estimated based on the production of sugar cane, knowing that during processing, molasses accounts for 3 percent of sugar cane. The UEMOA region produces approximately 100 000 tonne of molasses yearly, and this production has been stable (Table 19). Within West Africa, Côte d'Ivoire produces about 45 percent and Senegal 15 percent of the total molasses production. Mali and Burkina Faso share almost equally the remaining 15 percent. The supplies per TLU are negligible: from 0.5 kg/TLU/year in low producing countries, to 25–30 kg/TLU/year in countries such as Côte d'Ivoire and Senegal.

3.1.5 SUPPLEMENTS

FOOD SUPPLEMENTS AND ADDITIVES

Animal feed additives are substances, micro-organisms or preparations purposely added to animal feed or water. Vitamins and probiotics are two well-known examples of additives.

Animal feed additives meet the nutritional needs of animals and/or have a positive influence on (several options are possible):

-the properties of an animal feed
-the properties of animal products
-the colours of decorative fish and birds
-the environmental impact of animal production
-animal production, performances or welfare (e.g. by acting on gastrointestinal flora or digestibility of animal feeds)

Additives are the non-nutritive substances usually added to basal feed in small quantity for the fortification in order to improve feed efficiency and productive performance of the animals. Some commonly used feed additives are as below:

1) Antibiotics e.g. Terramycin, Zinc bacitracin, Flavomycin etc.
2) Enzymes e.g. Amylase, lipase, protease, pepsin etc.
3) Hormones eg. Estrogen, progesterone, hexosterol etc.
4) Thyroprotein e.g. Iodinated casein.
5) Probiotics e.g. Microbial species. Lactobacillus.
6) Biostimulators e.g. Extracts of living organs like spleen, liver, ovary, chick embryo etc.
7) Antioxidants e.g. Vitamin E (Tocopherols), BHT (Butylatedhydroxy toluene).
8) Mold inhibitors e.g. Propionic acid, acetic acid.
9) Pellet binderse.gGur, meal, molasses, sodium bentonite. 10) Coccidiostats e.g. Amprolsol powder, Furasol powder.

Animal feed additives may also be added for their coccidiostatic or histomonostatic effects (antibiotics other than coccidiostats or histomonostats are not allowed as additives).

Animal feed supplements consist of essential nutrients that are widely used for maintaining good health in animals. Feed supplements are rich in minerals, vitamins, carbohydrates, phosphorous and many more essential nutrients. Animal feed supplements are expected to be completely safe to use and is free from side effects. These supplements stimulate the appetite and helps in improving the diet and growth of the animal.

Animal feed supplements are easy to consume and digest hence slowly improves the health of the animals. The supplements can also bring good immunity level and prevent them from various diseases.

Benefits of Animal Feed Supplements:

1.These supplements are free from contaminants.

2. Supplies nutrients to the animals.
3.These animal feed supplements are free from side effects.
4.Available in cost effective prices.
5.Provides a healthy environment to the workers.

Feed supplements are the compounds used to improve the nutritional value of the basal feeds so as to take care of any deficiency. Commonly used feed supplements are

1) Vitamin supplements e.g. Rovimix, Vitablend, Arovit etc.

2) Mineral supplements e.g. Minimix, Milk min, Nutrimilk, Aromin etc.

3.1.5.1 PROTEIN SUPPLEMENT

Feeds containing more than 20% protein or protein equivalent. High in nitrogen content. Highly digestible. Examples: soybean meal, cottonseed meal, linseed meal, peanut meal, meat meal, fish meal, feather meal, urea, brewer's grains.

Bloodmeal is dried blood from animal processing plants. Spray or ring dried bloodmeal is superior to batch dried because less heat damage occurs. Bloodmeal is high in true protein, UIP and the amino acid lysine. Limit the amounts fed to less than 1 pound per cow per day and do not feed in diets high in moisture, as palatability can become a problem.

Brewer's grain, a by-product of the beer industry, is available dry or wet. Wet brewer's grains contain 70 to 80 percent water. Feeding more than 20 percent of the ration DM or 40 to 50 pounds of wet feed per cow has been shown to reduce intake and milk production. On a DM basis, brewer's grains are high in protein and a fair source of energy.

Canola meal is relatively new high-protein supplement produced from the crushing of canola seeds for oil. New varieties of canola, previously called rapeseed, are low in goitrogenetic compounds. Canola meal can be substituted for soybean meal in diets.

Corn gluten meal is produced from wet milling of corn for starch and syrup. Two corn gluten meals are produced, a 40 percent and 60 percent CP supplement, with the 60 percent being the most common. Both supplements are good sources of UIP. Energy content of corn gluten meal is only slightly less than corn grain. Limit amounts to 5 pounds per cow per day because of palatability problems.

Cottonseed meal is a high protein by-product from the extraction of oil from whole cottonseed. It is quite palatable, but may be variable in CP content. Cottonseed meal and other cottonseed products can contain a toxic substance known as gossypol. Limit the total amount of cottonseed products in diets to 8 pounds per cow per day or less.

Distillers dried grains, with or without soluble, is a by-product of grain fermented for alcohol production. Corn is the most common grain fermented, but other grains are used, and the composition of the distiller's grains will vary depending on grain source. Dried distillers grains are moderate sources of CP (23 to 30 percent), but a good source of UIP if not heat damaged.

Feather meal is hydrolyzed poultry feathers. High quality feather meal is both high in CP (85 to 92 percent) content and digestibility, but low in several important amino acids. Feather meal is rather unpalatable and should be introduced into diets gradually and limited to 1 to 1.5 pounds per head per day. Combinations of feather meal and blood meal are recommended for balanced amino acid supplementation.

Fishmeal is a by-product of the fish industry. It includes bones, head, trimmings, and fish parts. Quality can vary, depending on source and handling. Fish oil reduces fiber digestion in the rumen, and should be limited to 50 grams per day. Limit fish meal to 1 to 2 pounds per day.

Linseed meal is a product of the flax industry and is a good protein supplement (39 percent). It is very palatable and can be used as a replacement for soybean meal. Malt sprouts consist of dried sprouts and rootlets produced during the malting (sprouting) of barley for beer. The feed is similar to dried brewers grain, especially in UIP, but bitter tasting, reducing palatability. Limit amounts in the diet to less than 5 pounds per cow per day or 20 percent of the grain mix.

Meat and bone meal is a rendered and dried product from animal tissue. It does not contain horn, hide, hair, manure, or stomach contents. Meat and bone meal is a good source of CP, UIP, calcium and phosphorus. Limit amounts fed to 2.5 pounds or less per day. Meat and bone meal needs to be handled properly and stored in dry places to avoid salmonella contamination.

Soybeans are an excellent source of CP and fat (18 percent) for dairy cattle. Raw soybeans can be fed up to 5 pounds per cow per day. Cows should be adjusted to beans gradually to avoid diarrhea and off-feed. Raw beans contain urease, an enzyme that releases ammonia from urea when soybeans and urea are mixed together. Urea and raw beans should not be mixed and stored together. Microbial degradation in the rumen reduces anti-protein factors in raw beans (trypsin inhibitor, for example). Roasting, extruding, or other heat processing reduces anti-protein factors and urease activity and i creases UIP v lue of the soybeans. Heating temperature (290 to 300 degrees F) and steeping time (30 to 45 minutes) must be carefully controlled to avoid under- or overheating soybeans. Heat-treated soybeans can be fed up to 8 pounds per day. Cost of processing, including bean shrinkage, should be evaluated.

Soybean meal is the most common and usually the most economical vegetable protein supplement. The most common soybean meal contains 44 percent CP as fed. Two other sources of soybean meal are: dehulled soybean meal (48 percent CP), and expeller or old processed soybean meal (42 percent CP and 5 percent fat). Many commercial supplements contain substantial amounts of soybean meal.

Sunflower meal protein supplements range from 28 to 45 percent protein. The protein percentage varies inversely with fiber percentage: lower protein, higher fiber. Sunflower meal is a good source of protein and phosphorus. Palatability problems have been observed in some herds when sunflower meal is topdressed.

Urea is a NPN compound containing about 46 percent N. It has a protein equivalent of 287 percent (46 percent N x 6.25). It is a good source of SIP. Urea fits best in diets high in carbohydrate energy (grains and corn silage), low in protein, and low in SIP. Limit amounts fed to .4 pounds per cow per day, 1 percent in grain mixes, or 0.5 percent in corn silage (10 lb/ton added at ensiling). If urea or another NPN source like ammonia is added to corn silage, the amount of urea included in a grain mix should be reduced so that the intake of urea or urea equivalency does not exceed the maximum of .4 pounds per cow per day. Urea is not a palatable feed and should be mixed thoroughly into the grain mix or silage. Urea is best utilized when incorporated into total mixed rations (TMR) and/or fed frequently in mixtures with other feeds.

3.1.5.2 MINERALS

Minerals are essential for optimum health for all living species. Requirements differ from one species to the next, but they all need adequate amounts of each mineral for healthy bodily functions. Mineral deficiencies can lead to disease and so can mineral excesses. So getting the correct amount in the right ratios is the key to optimum health. Most natural diets will provide these minerals in appropriate balances, but with commercially prepared diets, this can cause imbalances.Most farmers know of the importance of adequate mineral levels in their livestock. They can see the benefits to their health when mineral licks are placed out for stock to take. Better health is visible when these extra minerals are provided.Symptoms of mineral deficiencies may show up as rough, harsh coat, flaky skin, eating dirt, poor growth, recurring disease, fence chewing, de-barking trees, unhealthy skin, tooth decay and much more.

These minerals are divided into two groups,

1. Macro minerals- Many elements are essential in relative quantity; they are usually called "bulk minerals". Some are structural, but many play a role as electrolytes .They include, calcium, sodium, potassium phosphorus e.t.c.

2. Trace minerals - Many elements are required in trace amounts, usually because they play a catalytic role in enzymes .they include, cobalt, copper, manganese, iron .et.c.

Of the macrominerals, only NaCl, Ca, and P routinely added to livestock rations.

Trace minerals most likely to be deficient: Cu, Fe, I, Mn, Zn, C , and Se. Providing mineral supplements to animals: self-fed (most common). Incorporate into diet Commercial mineral mixtures. Frequently do not meet the needs when used (One size does not fit all.)Often have excesses of some minerals but deficient in others but most people do not have the equipment (or knowledge) to mix minerals properly. May interrelationships among minerals. Commercial mix usually best.

3.1.5.3 VITAMINS

As with the minerals discussed above, some vitamins are recognized as essential nutrients, necessary in the diet for good health. (Vitamin D is the exception: it can alternatively be synthesized in the skin, in the presence of UVB radiation) Certain vitamin-like compounds that are recommended in the diet, such as carnitine, are thought useful for survival and health, but these are not "essential" dietary nutrients because the human body has some capacity to produce them from other compounds. Moreover, thousands of different phytochemicals have recently been discovered in food (particularly in fresh vegetables), which may have desirable properties including antioxidant activity (see below); experimental demonstration has been suggestive but inconclusive. Other essential nutrients not classed as vitamins include essential amino acids, choline, essential fatty acids, and the minerals.

Vitamin deficiencies may result in disease conditions: goitre, scurvy, osteoporosis , impaired immune system, disorders of cellmetabolism , certain forms of cancer, symptoms of premature aging , and poor psychological health (including eating disorders), among many others. Excess of some vitamins is also dangerous to health (notably vitamin A), and animal nutrition researchers have managed to establish safe levels for some common companion animals. For at least one vitamin, B6, toxicity begins at levels not far above the required amount. Deficiency or excess of minerals can also have serious health consequences. Vitamins required in minute amounts. Feed content varies. Affected by species, part of plant, harvesting, storage, processing. Easily destroyed by heat, sunlight, oxidation, mold growth.

Ruminants- .Rumen microorganisms synthesize K, C, and the B vitamins

Swine- Main concern for Vitamins A, D, E, riboflavin, niacin, pantothenic acid, B12, and choline.

Horses- Not much research data. Vitamin A -No problem with green grass and good quality hay, otherwise supplementation advised. Vitamin D-Supplement if horse kept indoors or sunlight erratic.Vitamin E -No problem with fresh forages and quality hay. Grains are low.Vitamins C and K synthesized by cecal microorganisms.

B vitamins-Normally not needed as in ruminants.Riboflavin and niacin suggested for horses under stress or heavy work.

3.1.5.4 ADDITIVES

Additive is an ingredient or combination of ingredients added to the basic feed mix or arts thereof to fulfil a specific need. Usually used in micro quantities and requires careful handling and mixing (AAFCO, 2000).

Nonnutritive substances which when added to feed will improve feed efficiency and or production of animals.Examples: Ionophores (Rumensin, Bovatec), Bloat control (poloxalene), Anthelmintics, Drugs / Antibiotics, Hormones,Flavoring agents

4.0 CONCLUSION

In this unit, we have highlighted feeds in livestock production and found out that there are different types of feeds for livestock in animal production.

5.0 SUMMARY

- The purpose for animal production must be known or considered before formulation of feeds
- The source of feeds to be used are of paramount importace so as to avoid the use of contaminated feeds

6.0 TUTOR MARKED ASSIGNMENT

1. Differentiate between concentrates and roughages
2. Enumerate the types of feed additives you know

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UNIT 2 FEED EVALUATION

CONTENTS

1.0 INTRODUCTION

This chapter outlines the role of feed evaluation in animal production, providing an overview of feed evaluation methods, current feeding systems and empirical and mechanistic modelling, and attempts to link these methods, systems and models. THE NEED FOR FEED EVALUATION Animal production is concerned with providing food (and clothing) of animal origin for man. Animal production science, which underpins this goal, provides the rational basis for livestock management practices. Feed evaluation concerns the use of methods to describe animal feedstuffs with respect to their ability to sustain different types and levels of animal performance. In feed evaluation, emphasis is placed on determining specific chemical entities, although the physical characteristics of the feed are also important. Subsequently, the acquired data are used, with appropriate animal indices, in feeding systems comprising suitable predictive routines (normally based on empirical equations) to determine whether a desired level of animal performance can be achieved from various diets. The practical goal of feed evaluation is to optimize the efficiency of feed utilization, animal output and, ultimately, financial return to the producer. In this context, it is important to establish the potential of major feedstuffs and the need for appropriate supplements in order to overcome nutritional deficiencies and raise the level of performance. With respect to the animal, the level of performance will be dictated by the amount of feed voluntarily consumed and the efficiency of utilization of the major nutrients, namely energy and protein. Furthermore, the composition of the animal products.

2.0 OBJECTIVES

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

- Know what are concentrates
- Determine the nutritive value of feedstuffs
- Know how to handle and store feeds

3.0 MAIN CONTENTS

METHODS USED IN FEED EVALUATION

3.1 Laboratory Chemical Analysis

The analysis of ruminant feeds generally involves determining the dry matter (DM), organic matter (OM), structural carbohydrate (fibre or nonstarch polysaccharide, NSP), soluble carbohydrate, starch (where applicable) and crude protein (CP) content of the feedstuff. Silages require further analysis, notably for their pH, ammonia N and organic acid contents; recent research suggests that their true protein content should also be characterized. The DM of a feedstuff is usually determined by oven drying at 60 or 100°C, whilst silages require special treatment (e.g. toluene DM determinations) due to their high content of volatile organic acids; thus DM is usually determined by distillation. OM is determined by dry ashing (at 500°C until all the carbon has been removed); the residue or ash can be used to determine the content of individual mineral elements in the feedstuff. The most widely used methods for analysing the structural constituents, or fibre, are the detergent extraction methods of Van Soest. These methods involve extraction of plant biomass with neutral detergent to leave a fibrous residue of predominantly cellulose, hemicellulose and lignin (i.e. the neutral detergent fibre or NDF of plant cell walls) or with acid detergent to leave a residue of cellulose and lignin (i.e. the acid detergent fibre or ADF of plant cell walls). As these are gravimetric procedures, the exact composition of the NDF and ADF residues is not known. The fibre content of a feedstuff may be described more accurately by NSP analysis, whereby alditol acetate derivatives of carbohydrate monomers derived from acid hydrolysis of washed, polymeric, de-starched samples are quantified by gas chromatography. With NSP analysis in addition to obtaining details of the chemical composition of the fibre, the values measured are independent of food processing and storage, and hence the amounts present can be quantified more accurately. Crude protein content is calculated from the nitrogen (N) content, determined by the Kjeldahl procedure involving acid digestion and distillation. More recently, Dumas methods, involving combustion and determination of released gaseous N, are being used. Ammonia N in fresh silage is determined on water extracts by either distillation or use of specific ion-sensitive electrodes. These methods measure N rather than protein; the quantity of N is therefore multiplied by 6.25 (assuming the N is derived from protein containing 16% nitrogen) to obtain an approximate protein value. In recent years, near infrared reflectance spectroscopy (NIRS) has also been adopted for determining the composition of feedstuffs. In terms of accuracy, precision, speed and unit cost of analysis, the NIRS technique, provided it is calibrated correctly, is preferable to traditional laboratory methods. However, the technique ultimately relies on a set of stan ard samples whose composition has been determined by traditional methods.

3.2 Digestibility

In addition to chemical composition, several methods have been developed to characterize feedstuffs in terms of their digestibility. These comprise in vivo, in situ and in vitro methods. In vivo measurements provide the standard measure of digestibility as they represent the actual animal response to a dietary treatment. However, such trials cannot be considered routine in most laboratories, and cannot be carried out for all the possible feeding situations found in practice. Therefore, a number of in vitro and in situ methods (e.g. batch culture digestibility, enzyme digestibility, gas production, polyester bag) have been developed to estimate digestibility and the extent of ruminal degradation of feedstuffs, and to study their variation in response to changes in rumen conditions. Thus in vitro and in situ techniques may be used to study individual processes, providing information about their nature and sensitivity to various changes. This information is of great importance in the development of mechanistic models.

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4.0 CONCLUSION

By the end of this unit, you should be able to know the different types of concentrates and their sources. You should be able to analyse feed samples in the laboratory, how to handle and sore feedstuffs.

5.0 SUMMARY

In this unit, you have learnt the different types of concentrates, roughages, supplements, additives and there sources. You also learn methods of feed evaluation.

6.0 TUTOR-MARKED ASSIGNMENT

1 List and explain the different types of energy and protein concentrates

2 Discus the different methods of feed evalution

3 What are vitamins and minerals?

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UNIT 3: STORAGE AND HANDLING OF FEED STUFFS

CONTENTS

1.0 INTRODUCTION

Feedstuffs for livestock feedstuffs include forages and grain-based and coproduce feeds. Grazed forages generally make up the bulk of livestock diets in Mississippi, but stored forages and grain-based feeds are also used, particularly during winter. Feedstuff storage, handling, and feeding characteristics affect which feedstuff is the best choice for an operation.

2.0 OBJECTIVES

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

- the different ways storing and handling feed stuffs for livestock
- animal feesd storage guidelines

3.0 MAIN CONTENT

3.1 HANDLING CONSIDERATIONS

Handling capabilities and producer preferences for feedstuff handling may determine whether or not a particular feedstuff is a good choice for a particular beef cattle operation. Not all commodity feeds flow through auger systems effectively. Some feeds require special handling. For example, fuzzy whole cottonseed does not flow easily. Whole cottonseed coated in cornstarch flows better but typically costs more. One often overlooked characteristic of feedstuffs is percent moisture. Some high-moisture feeds, such as wet distiller's grains and silages, are attractive on a cost per ton basis, but they have handling limitations. High-moisture products tend to bridge up and not flow as smoothly as drier products. These products can also corrode handling systems and storage facilities. Be sure to factor in the cost of hauling large proportions of water in high-moisture feedstuffs. Excess moisture effectively adds to the cost of other feed nutrients, including energy and protein. The type of truck necessary for hauling a specific feedstuff depends on whether auger transport is possible and the type of storage facilities to be loaded. Common feed delivery truck types are hopper bottom, dump, and walking floor trailer. The type of storage facility receiving delivery may prohibit or require the use of a specific delivery vehicle type. Truck auger height must be able to reach the openings in top-loading feed storage bins. Additional equipment, such as a tractor with front-end loader bucket or portable auger system, may be needed to move feedstuffs to a storage destination. Feed delivery vehicles also vary in capacity and number of separate storage compartments on a single trailer. On-farm facilities impact feedstuff-handling capabilities. Feedstuff delivery vehicles must be able to navigate to and from on-farm delivery sites easily. Narrow gates, poor road surfaces, and driving obstructions can limit on-farm feed-receiving capabilities.

3.2 STORAGE AND MANAGEMENT

Facilities for the bulk storage and handling of feed commodities are needed when the ration is processed on site. The required type of storage ranges from dry feed commodity storage, fermented feeds(including silage and high moisture corn), by-products, processed roughage, liquid feedstuffs (such as molasses) and liquid supplements. The bulk storage and handling of these feed commodities depends on many factors, including the range of commodities to be stored, the storage volume, the length of time the commodity is to be stored, the processing systems, the loading systems, the capital investment and the operational and maintenance costs of the facilities and equipment.

3.3 SILAGE STORAGE AND MANAGEMENT

Roughage, or fibre, is essential in the diet of lot fed cattle to enable normal rumen activity and may be provided as silage, hay or straw.

Silage typically contains higher levels of ME and CP than hay and is\ considered more palatable and digestible. The silage making process, design and management of storage are critical to ensure the highest quality product, while minimizing losses during storage and feeding. Good quality silage, correctly harvested and stored, maintains its quality for a long time. Where the local environment or feed processing equipment is not suited to growing and/or handling silage, a feedlot may feed hay instead

3.4 HAY AND STRAW STORAGE AND MANAGEMENT

Hay or straw is best fed in a chopped form when mixed with the grain and other commodities to ensure even intake of the concentrate and roughage. In an onsite feed processing facility, the relatively high percentage of roughage in a typical ration requires significant amounts of hay
(And/or silage) to be stored on site.

3.5 STORAGE AND HANDLING OF LIQUID FEEDSTUFFS

Liquid feedstuffs are used for conditioning rations, improving palatability, reducing dustiness and providing vitamin and mineral nutrients to cattle. Many liquid by-product materials are available, along with commercial liquid supplement products that incorporate minerals, vitamins and enzymes.

When liquid feeds are used in rations that are prepared on site, these need special equipment. This includes tanks and pumps designed to handle liquids.

3.6 ANIMAL FEED STORAGE GUIDELINES

General Recommendations

1. Store all feed and ingredients at a cool temperature (ideally below 77° F although this is not possible at outside locations under summer conditions).
2. Keep feed dry to prevent fungal or bacterial growth.
3. Prevent rodent or insect entry into feed.
4. Use antioxidants to preserve fats and oils in ingredients and feed.
5. Use stable forms of vitamins.

6. Expiration dates (usually on container) are required for all food items.
a. Known shelf life of some products is marked on container (e.g., canned food).
b. Prepared feeds: one week after end of experiment or 8 weeks post mixing (whichever is shorter).
c. Ground grain: One month after milling unless stabilized.
d. Fats and oils:
Opened container: One month
Un-opened or stabilized: One year post mixing.
e. Vitamin mixtures: 6 months after preparation (exceptions of up to one year if stabilized with ethoxyquin). Vitamin C hydrolyzes more rapidly.
f. Whole grain or seeds: One year after harvest
g. Fat-free ingredients, protein meals, minerals: No specific expiration dates as long as feeds remain dry and free from obvious contaminants (These items should carry an acquisition date.

Justification

Captive animals depend on caretakers for a diet that supplies adequate amounts of nutrients required for good health. Some nutrients are subject to destruction by chemical action or light. Moisture, heat, and, in some cases, light accelerate destruction of nutrients in feed ingredients. Proper preparation of feeds and appropriate storage conditions can prolong the shelf-life of feeds and ingredients, but not indefinitely. Therefore, all containers of feed and most ingredients must have an accepted expiration date. Feed should be discarded on or before this date.

3.7 PREVENTION OR REDUCTION OF DAMAGE TO FEED AND INGREDIENTS

1. Grains and Grain Products:
a. Obtain clean, insect-free grain (or treat grain with a USDA-approved insecticide). Have an effective, safe rodent control program in place.
b. Store feed in a cool, dry location, free from conditions where condensate may form.
c. Store large quantities of feed in tight paper containers or in ventilated cloth or papersacks or in bulk. These containers allow moisture to migrate and escape rather than condense, which allows mold growth.
Smaller quantities of feed, as present in feed mixing rooms, should be stored in closed plastic containers to prevent entry of insects, rodents, and moisture. The initial moisture content of the feed should be less than 14 %.
d. Grind corn and other grains shortly before use. Grinding, flaking, or crimping releases the oil in the germ of the seed. This oil contains polyunsaturated fats and a limited amount of natural antioxidants. Therefore, rancidity will occur within days or weeks after grinding.
2. Protein Sources:
a. Low-fat (<1%), dry (<12 % moisture) protein sources (e.g., casein, isolated soy protein, solvent extracted meals of soybean, peanut, etc., may be kept indefinitely). However, they should be labeled with an acquisition date.
b. Meals with fat, usually > 2% (e.g., cottonseed meal , sunflower seed meal, meat meals, meat and bone meals, poultry meals, fish meal) have a limited shelf life that

may be extended to about 6 months if an appropriate antioxidant (e.g., ethoxyquin, TBHQ, BHA-BHT) has been added. These meals should be stored in a cool location (ideally<77° F, although this may not be possible under summer conditions at the field labs). In summer, use these ingredients within 2 months of milling.

c. Whole seeds (soybeans, cottonseed, sunflower, etc.) will keep for at least one year in a cool location. Their oil is contained in oil glands along with a natural antioxidant.

3. Fats and Oils:

a. Unopened containers of vegetable oil should keep for one year only. However, once opened and exposed to air, the oil begins to oxidize. The oil may be stabilized by adding ethoxyquin (Santoquin from Novus, Inc., St. Louis, MO), or TBHQ (Eastman Organic Chemicals) at levels such that the total amount of these preservatives in the final feed does not exceed 0.0125% of the diet (125 mg//kg

4. Mixed Feeds:

a. The moisture content of feed should be <12%. Store feed in closed bags in a cool dry place. Prevent rodent and insect exposure.

b. Add an antioxidant to the feed (or with the added fat) at time of preparation

c. If no antioxidant is added, store feed in a cool location for a limited period of time.

d. If glucose monohydrate (dextrose, cellulose) is used as a feed ingredient, consider that glucose will react with the free amino groups of protein and added amino acids within hours to days.

e. Vitamin C (ascorbic acid) is stable for only days, not weeks. Ascorbic acid phosphate is a commercially available, stable form of vitamin C. It is required in diets for primates, guinea pigs, fish, and probably lizards and some other types of animals.

f. Add vitamin premixes to diets to provide all the vitamins at concentrations 4 to 5 times required level stated in the National Research Council publications on nutrient requirements of Animals (Government Printing Office, Constitution Ave., Washington, DC), except when the experimental protocol requires otherwise.

5. Vitamin and Mineral Premixes:

a. Vitamin premixes usually contain some ethoxyquin, and the vitamins A and E are added as the stable acetate derivatives.

b. Vitamin C is usually not added to vitamin premixes but rather is added separately just before mixing. However, ascorbic acid phosphate is a stable form of vitamin C, albeit more expensive.

c. DO NOT MIX VITAMINS AND MINERALS TOGETHER IN A PREMIX! This is done by some commercial mills, even done successfully using special preparations, but it is not a good, general recommendation.

3.8 DETERMINING QUALITY OF INCOMING INGREDIENTS AND OUTGOING FEEDS

Qualitycontrolofincomingingredientsiscrucialtopredictingthequalityofacompletefeed,supplement,premix,etc.Thefirststepisaccuratesamplingandcompleteexaminationoftheingredientpriortounloading.Putsamplingandinspectionprocedures inwritingandkeepthemina QualityControlProceduresManual.Proceduresforbulkingredientsandmixedfeedsbaggedingredientsandmixedfeeds,hays,syrupsandfats.

Bulk Ingredients and Mixed Feeds

•Takeaminimumofthree,2kg samples.

•Each2kgsampleshouldbethecompositeofseveralcorestakenrandomlyfromthedeliverytr uck, bulk storage bin or feed bunk, as applicable.
•Duplicate determinations are recommended for all variables measured.

Bagged Ingredients and Mixed Feeds

•Uses lotted feed Trier for sampling and take 0.45kg samples.
•For lots of one to ten bags, sample all bags.
•For lots of eleven or more, sample ten bags.
•Analyze a minimum of three sample sand average the results.

Hays

•For chopped hay, take ten samples per lot.
•For cubes, take forty cubes from a given population.
•For bales, take one twelve to eighteen in core from the end of forty bales in a given population.

Syrups and Fats

•Use a continuous flow sampling procedure at the point of delivery, or a core liquid sampler.
Establishment of are tention schedule is recommended for all ingredients and mixed feed samples.
Separate analytical analyses should be routinely performed on samples of the following for quality:
•Water
•Grains
•Roughages
•Silages
•Protein supplements
•Mineral mixtures
•Vitamin premixes
•Molasses and fat
•Specific drugs
As a starting point for insuring quality in feedlot rations, quality checks of all incoming feed ingredients for the following:
•Moisture
•Color
•Off odour
•Presence of foreign material
•Texture and uniformity
•Evidence of heating
•Deterioration due to bio toxins
More detailed analyses are performed on individual feed ingredients for the purpose of feed formulation, and sometimes before the purchasing of commodities if this information is not provided by the seller. Analyses that usually are considered to be routine for the different feed ingredients include:
Grains-grade, moisture, protein, ash
Grain By-Products-moisture, protein, ash
Dry Roughages-moisture, protein, ash, acid detergent fiber

Silages-moisture, pH, temperature, protein, ash
Protein Supplements-moisture, protein, ash, non-protein nitrogen
Mineral Mixtures-moisture, specific nutrients
Molasses-moisture, ash
Fats-moisture, free fatty acids, impurities, unsaponifiables

3.9 MANAGEMENT CONCERNS

Feed handling, storage, and delivery equipment must be maintained and kept clean for proper feed use and animal safety. Feed may cake and mold along the walls of bulk storage bins and feeders. Long-term feed storage or storage under less than ideal conditions may cause spoiled feed. Rusty or corroded feeders may have sharp edges that are dangerous to livestock. Wooden feeders may have hazards such as broken boards or protruding nails. Thorough equipment cleaning requires more than just emptying the containers prior to refilling. It often means scraping and rinsing equipment interiors. Repair and maintain equipment routinely. Patch holes to protect feedstuffs from rain, wind, rodent, bird, and insect damage and to limit feed waste. Metal feeders may need rust protection and paint applications. Before beginning a new feeding regime, take time to evaluate the capability of the facilities at hand. The nutritional value of the feedstuff is important, but it is not the only factor in proper livestock feeding. If bins, equipment, or feeders are in disrepair and feeds cannot be stored, handled, and delivered properly, the nutritional needs of livestock may not be met. Making optimal use of feedstuff helps ensure that the feeding system is safe and economical. For more information on livestock feed handling, storage, or feeding or related topics, contact your local MSU Extension office.

4.0 CONCLUSION

In this unit, we have highlighted the different ways of storing feedstuffs and thire management. We also learnt how to prevent damage to feedstuffs.

5.0 SUMMARY

The different ways storage and management of feedstuff have been learnt in this unit. Also ways of preventing damage to feeds.

6.0 TUTOR-MARKED ASSIGNMENT

1 Discuss handling considerations of feedstuff

2 Explain the various storage and management of feeds stuffs

7.0 REFERENCES/FURTHER READING

Reference Galyean, M. L., K. J. Malcolm-Callis, D. R. Garcia, and G. D. Pulsipher. 1992. Effects of varying the pattern feed composition on performance by programmed fed beef steers. Clayton Livestock Res. Ctr. Prog. Rep. No. 78. N.M. Agric. Exp. Sta., Las Cruces.

MODULE 2: METHOD USED IN RATION FORMULATION FOR VARIOUS CLASSES OF FARM ANIMALS.

CONTENTS

4.0 Conclusion
5.0 Summary
6.0 Tutor-Marked Assignment
7.0 References/Further Reading

1.0 INTRODUCTION

Feed formulation is the process of quantifying the amounts of feed ingredients that need to be combined to form a single uniform mixture (diet) for poultry that supplies all of their nutrient requirements. Since feed accounts for 65-75% of total live production costs for most types of poultry throughout the world, a simple mistake in diet formulation can be extremely expensive for a poultry producer. Feed formulation requires thorough understanding of the:

(a) nutrient requirements of the class of poultry (e.g., egg layers, meat chickens or breeders);

(b) feed ingredients in terms of nutrient composition and constraints in terms of nutrition and processing, and

(c) cost and availability of the ingredients.

Most large-scale poultry farmers have their own nutritionists and feed mills, whereas small operations usually depend on consultant nutritionists and commercial feed mills for their feeds. It is therefore essential that formulations are accurate because once feeds are formulated and manufactured, it is often too late to remedy any mistakes or inaccuracies without incurring significant expenses.

2.0 OBJECTIVES

3.0 MAIN CONTENT

3.1 METHODS USE IN FEED FORMULATION FOE DIFFERENT CLASSES OF LIVESTOCK.

3.2 TYPICAL FORMULATION

Feed formulation is both a science and an art, requiring knowledge of feed and poultry, and some patience and innovation. Typical formulations indicate the amounts of each ingredient that should be included in the diet, and then provide the concentration of nutrients (composition) in the diet. The nutrient composition of the diet will indicate the adequacy of the diet for the particular class of poultry for which it is prepared. It is common to show the energy value in metabolisable energy (kcal or MJ ME/kg feed) and protein content of the diet but comprehensive information on concentrations of mineral elements and digestible amino acids are also provided. Digestible amino acids often include not just the first limiting amino acid, methionine, but also most of the ten essential amino acids. A number of databases are available to provide information on the digestible amino acid contents of various poultry feed ingredients. For example is a comprehensive amino acid database in the world, providing digestibility coefficients for amino acids based on over 140 raw materials analyses for pigs and poultry. 5.0 includes analyses of total amino acids, standardized ileal digestible amino acids, standardized ileal digestibility coefficients for essential amino acids, proximates, minerals and energy values for pigs and poultry.

3.3 LIVESTOCK FEED FORMULATION

There are about six conventional livestock feed formulation methods identified by Imamidoost, 1992 and Jerry, 2003. These methods include:

3.3.1 Pearson Square Method.

This method is relatively simple and easy to follow. Some of its merits as identified by Afolayan and Afolayan include: its simplicity of use and secondly its usefulness for balancing protein requirement. Its disadvantages include, its usability for only two(2) requirements at the same time and secondly, its reduced consideration given to other nutritive requirements especially, vitamins and minerals.

3.3.2 Simultaneous Equation Method

This is an alternative method for the square method using a simple algebraic equation. Here, a particular requirement is satisfied using a combination of two feed ingredients. In this method, a ration is estimated, and the nutrient content calculated. These results are then compared to the nutrient needs of the animal for which the ration is being balanced. Deficiencies are corrected by changing proportions of feeds in the rations or by substituting or adding ingredient

Merits of Simultaneous Method

The system is easy to use both by beginners and the experienced feed millers.

Advantages of simultaneous equation over Pearson method are: Firstly, farmer can balance for both protein and energy. Secondly, it is useful in considering more than two feed ingredients at once when balancing more complex ration. Finally, as the equation increases.

Limitations of Pearson Square and Simultaneous Method

The limitations includes firstly, it satisfies only one nutrient requirement and uses only two feed ingredients. Another limitation is that the level of the nutrient being computed should be intermediate between the nutrient concentrations of the two feed ingredients being used.

3.3.3 Two-By-Two Matrix Method.

This method solves two nutrients requirement using two different feed ingredients. A 2 by2 matrix is formed a set and a series of equations are solved to come up with the solution to the problem.

3.3.4 Trial and Error Method.

This is the most popular method of formulating ration for the swine and poultry. It is a type of feed formulation used in many developing nations of the world (Adejoro 2004), Nigeria inclusive. As the name implies, the formulation is manipulated until the nutrient requirements of the animal are met. This method makes possible the formulation of a ration that meets all the nutrient requirements of the animal. In poultry feed formation, various cases of mineral deficiency such as osteomalacia, rickets and shellessness or soft shell formation may not be properly addressed if care is not taken to comprehensively analyze or calculate the level of calcium and phosphorus of the ration in question.

3.3.5 Imami Method.

This is an educational way to describe and balance simple rations by a common calculator with a high accuracy for farmers who do not have access to the computer.

3.3.6 Linear Programming (LP) Method.

This is otherwise called, least cost computerized feed formulation. This method of determining the least cost combination of ingredients using a series of equations which employs Linear Programming methods. This least cost can employed in feed formulation takes basic seven steps. Some of the advantages of Linear programming method include:

Scientific Approach to Problem Solving

Hence it results in a better and true picture of the problems which can then be minutely analyzed and solution ascertained.

ii. Quality of Decision. LP provides practical and better quality of decisions that reflect very precisely the limitation of the system i.e; the various restrictions under which the system must operate for the solution to be optimal. If it becomes necessary to deviate from the optimal path, LP can quite easily evaluate the associated costs or penalty It guaranteed the finding of optimal solution.

iii. Evaluation of All Possible Alternatives.Majority of the problems in animal feed formulation are somehow complicated. LP method ensures that all possible solutions are generated, out of which the optimal solution is selected.

iv. Flexibility. LP is flexible mathematical method.

Disadvantages of Linear Programming Method

Although Linear Programming (LP) is a highly successful techniques having wide applications, yet it has somedemerits which are as follows:

i. Absence of risk

ii. Linear Relationship: It can only be applied to situations where the given problem can be represented in the form of linear relationship. Hence it is based on implicit assumption that the objective as well as all the constraints or the limiting factors can be stated in the form of linear expression. Many practical problems like feed mix problem can be better expressed with a minimum of quadratic equation.

iii. Constant Value of objective and Constraint Equations

Before a LP technique could be applied to any feed mix problem, the values or the coefficients of the objective and constraints functions must be completely known and be constant over a period of time. If the values change during the period of study the LP would loose its effectiveness and may fail to provide optimal solution to the problem. However, in practical sense it is not possible to determine the coefficients of objective function and the constraint equations with absolute certainty. These variables may lie on probability distribution curve and hence at best, only the likelihood of their occurrence can be predicted. Moreover, the values change due to extremely as well as internal factors during the period of study.

iv. Fractional solutions often have no meaning.There is absolutely no certainty that the solution to a LP feed mix problem can always be quantified as an integer quite often. It can give fractional answers which are rounded off to the next integer. Hence, the solution would not be the optimal one.

v. Flexibility Limitation. Once a problem has been properly quantified in terms of objective function and constraint equations and the tools of Linear Programming are applied to it, it becomes very difficult to incorporate any changes in the system arising on account of any change in decision parameter. Hence, it lacks the desired operational flexibility.
vi. Multiplicity of Goal. The long-term objectives of any farm are not confined to a single goal. Any farm, at any point of time in its operations has a multiplicity of goals or the goals hierarchy attained on a priority wise basis for its long term growth. In a case where farm manager's goals are multiple and conflicting, the LP method fails.
vii. Degree of Complexity. Many large-scale real life practical problems can be solved by employing LP techniques even with the help of a computer due to high complexity and lengthy calculations involved. Assumptions and approximations are required to be made so that the given problem can be broken down into several smaller problems and, then solved separately. Hence, the validity of the final result, in all such cases, may be doubtful.

3.4 The art of feed formulation

Feed formulation requires in-depth knowledge of animal nutrition, particularly the nutrient requirements and the nutrient composition of the ingredients. It also requires nutritionists to know whether using certain proportions of some ingredients will impact on issues such as feed flow through the mill, pellet quality of the diet, response of the diet to feed additives, or gut health of the animal. In some parts of the world, considerations such as the colour, smell and particle size of the feed are viewed as important by the feed buyer, despite that these factors may have little influence on the nutritional quality of the feed. Ultimately, feed formulation is about economics; for some operations, it probably means the best feed conversion efficiency of the animal, whereas for others it perhaps means least cost per unit of product output.

The above methods mentioned on the formulation of feeds can be effectively applied provided that the pre-requisite is being provided and to that effect, this work provides some requirements to enable efficient formulation and thus livestock keepers can apply the methods on the data provided in the quest to provide good food with adequate nutritional values for a say class of livestocks.

3.5 MAKING A FEED FORMULATION FOR PIGS

Expansion of ***pig*** *industry* depends to a large extent on the availability of good quality ***pig feeds*** in sufficient quantity and at affordable price. Feed accounts for 60% to 70% of the total cost of production. Pigs is a ***mongastric animal***.

Quality of a good Pig Food:

- Pig food must be fresh and not stale.
- It must be well process and packaged.
- The digestibility of the feed must be high.
- The feed must support optimum growth and development of pig.
- The feed must be palatable.
- The ingredients for the feed must be available at all time.
- The feed must be affordable.
- The feed must be balanced in Nutrients.
- It must be attractive and palatable to the pig
- It must not be mouldy.

What makes up the pig's feed:

- Carbohydrates.
- Protein.
- Fat and Oil.
- Minerals.
- Vitamins.
- Water.

Some Feed ingredients for formulation of ration for pig:

Maize: The grain forms major constituents of the feed. It is a good source of energy. The metabolizable energy is about 3400 Kcal/kg. It is widely cultivated in all parts of Africa in particular. The protein content is about 10%. Yellow maize contains carotene. Maize must be properly dried before it can be used for formulation.

Sorghum: It is commonly grown in the Northern part of Nigeria. The energy level is about 2500 Kcal/kgh. If maize is scarce and expensive, sorghum could be used as substitute.

Maize offal: It contains about 2500 Kcal ME/kg. It is complimentary source of energy. The fibre level is higher than that of maize.

Wheat offal: It is another complimentary source of energy. It is a by-product of wheat after milling. The energy value is low compared to maize. the metabolizable energy is about 1800 Kcal ME/kg.

Cassava: Cassava is a good source of energy but with low protein. The by-product include: cassava peel, cassava flour, cassava chaff and sievate. One of the major limitation in using cassava is the presence of *anti-nutritional factor*, *hydocyanic acid* (HCN). Cassava must be properly dried before incorporation with other feed ingredient.

Sweet potato: It is a good source of energy. Boiled sweet potato culd be given to pig directly. When formulating diet for pig, dry sweet potato could be used to replace maize to a large extent.

Yams: There are various types of yam in **Africa**. They are grown primarily for human consumption but could also be used to feed pig. Again yam tuber or peel could be sun-dried and incorporated with other *feed ingredients* during feed formulation.

Brewer dry grains: It is a by-product of brewery industries. The energy level is low, of about 18% crude protein. It contains high fibre content of about 20%. Brewer dry grain must be properly dried before incorporating with other feed ingredient. It could be used as complimentary source of energy in pig diet.

Palm kernel cake: It forms of the major ingredients in formulating pig's ration due to low cost compared to other feed ingredients. It contains protein content of about 18% crude protein but the fibre is high, of about 12%. The energy value is about 2000 Kcal ME/kg. It is a by-product during extraction of palm kernel oil from palm kernel.

Fish Meal: It is very good source of animal protein. It is rich in both essential and non-essential amino-acid. Fish meal used in pig nutrition could be imported or local. The protein content is between 60 and 72% crude protein.

Groundnut cake: It is a good source of plant protein. The protein content is about 45% crude protein. The energy content ia about 2600 Kcal ME/kg. Ground cake must be well dried and stored to avoid mouldiness.

Soybean Meal: It is another good source of plant protein. The protein content is around 45% crude protein. Soybean meal could be used to replace groundnut cake but the methionine and lysine content of the former are higher then that of the latter.

Bone Meal: It is a good source of calcium and phosphorus which is responsible for bone and skeleton. The calcium content of bone is around 37% and phosphorus content is about 17%.

Oyster Shell: It is a good source of calcium. The price of oyster hell is lower then that of bone meal. the calcium conent is about 35% and contains no phosporus.

REQUIREMENTS FOR DIFFERENT GROWTH STAGES OF PIG:

Protein Requirements

Stages of Production	**% Protein Requirement**
1.) Piglets2.) Growers	1814-16
3.) Breeders	16-18

4.) Lactating	14-16

Energy Requirement

Stages of Production	**Energy Requirements**
1.) Piglet2.) Growers	2400 – 26002400 – 2500
3.) Breeders	2400 – 2500
4.) Lactating	2400 – 2600

Fat Requirement

Stages of Production	**Fat Requirement (%)**
1.) Piglets2.) Growers	3.03.0
3.) Breeders	3.0 – 4.0
4.) Lactating	3.0 – 4.0

Fibre Requirement

Stages of Production	**Crude Fibre Requirement (%)**
1.) Piglets2.) Growers	3.0 – 4.04.5 – 5.0
3.) Breeders	3.0 – 4.0
4.) Lactating	3.0 – 4.0

Calcium and Phosphorus Requirement

Stages of Production	**Calcium Requirement**	**Phosphorus Requirement**

	(%)	(%)
1.) Piglets2.) Growers	0.450.4 – 0.5	0.30.45
3.) Breeders	0.4 – 0.6	0.4 – 0.5
4.) Lactating	0.4 – 0.6	0.3 – 0.5

Note that the above pig feed formulation should not been seen as a standard. A lot of factors need to be considered during *pig feeds formulation*, i.e. Availability and cost of feed ingredients, health status and environmental factors.

3.6 MAKING A FORMULATION FOR FISH

Feed formulation is essentially applied nutrition. A number of terms and expressions are introduced that will be put to practical use as information is presented on the nature and qualities of various feedstuffs and the information presented on the nutrient requirements of fish. Precise understanding of these terms is essential to their correct application. One must recognize that some of these terms have a built-in error that cannot be escaped. This does not eliminate their usefulness in feed formulation. However, one must appreciate the fact that some are useful approximations of the values and not true values.

The terms that one needs to understand to formulate practical fish diets are: crude protein level; energy level, either expressed as metabolizable energy (ME) or as digestible energy (DE); specific amino acid levels; crude fibre level; and ash level. Since most complete practical fish diets are supplemented with a vitamin premix at levels in excess of the dietary requirement, this category of nutrients will be ignored temporarily. The potential problems occur when one fails to recognize that all of the above mentioned terms, except ME and DE, represent the quantity or level of a nutrient in the feed as determined by chemical tests on a specific sample of a feedstuff. These chemical tests generally correlate well enough with biological methods of feed evaluation (growth studies, tissue, levels) to be very useful to feed formulators, but they are still chemical tests that are subject to experimental error during nutrient level determination. For example, the proximate composition of fish meals changes during the spawning season. Generally, the lipid levels increase before spawning and decrease after spawning. This will alter the percent of protein, ash, and carbohydrates in fish meal as the seasons change. Similarly, many plant feedstuffs vary in proximate composition with their stage of maturity at harvest, location grown, and other environmental conditions, such as the weather. Tabled values represent an average value that is usually close enough to the actual value to allow accurate feed formulation. However, one must be aware that assumptions are being made in order to recognize the potential sources of error that may exist.

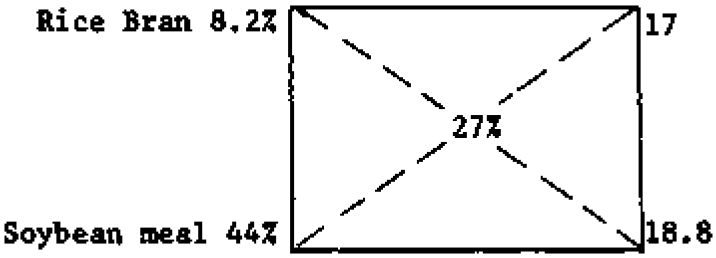
Metabolizable, energy and digestible energy values are obtained biologically and, thus, should accurately represent the true energy value of feedstuffs to fish. However, ME values may be obtained in different ways (faeces collection methods) and thus may be subject to experimental error. It has recently been reported that the digestibility of feed by rainbow trout was lower at 7°C than at 11°C or 15°C. At 11°C and 15°C body size (18.6 g, 207.1 g or 585.7 g) did not affect feed digestibility. The digestibility of carbohydrate and energy was slightly reduced by meal size in rainbow trout fed at 1.6 percent body weight. Protein and lipid digestibility was not reduced by meal size. Obvious differences exist between fish species in nutrient digestibility, especially in the carbohydrate fraction of feed. Herbivorous and, to a lesser extent, omnivorous fish have longer digestive tracts than do carnivorous fish and are able to obtain more digestible energy from carbohydrates. An awareness of these facts will prevent misuse of ME and DE values.

Each feedstuff in any diet formulation should be present for a specific reason; i.e., it is a good energy source, it is rich in a limiting amino acid, etc. In addition, each feedstuff in a particular diet formulation should be the least costly ingredient available for its particular function in the diet. This leads to another assumption in feed formulation; that is, any nutrient in a particular feedstuff, such as an amino acid, is just as valuable as the same nutrient in any other feedstuff. This allows feed formulators to interchange one feedstuff with another as cost and availability change. Thus, it is assumed that there is no "ideal formulation", but rather an almost infinite number of possible feed formulations that met the nutritional needs of the fish equally well. While this assumption may not be entirely valid and some nutritional judgement must be employed in any feed formulation, it does seem to be valid in most cases. As with the previously mentioned assumption, an awareness of the potential pitfalls involved is necessary for the fish feed formulation so that allowances can be made in diet formulation and problems can be anticipated and avoided.

3.7 BALANCING CRUDE PROTEIN LEVEL

In most animal diets, protein is the most expensive portion and is usually the first nutrient that is computed in diet formulation. The energy level of the diet is then adjusted to the desired level by addition of high energy supplements) which are less expensive than protein supplements. The square method is an easy way to determine the proper dietary proportions of high and low protein feedstuffs to add to a feed to meet the dietary requirement of the animal to be fed.

For example, suppose rice bran and soybean meal were available as feedstuffs to prepare a diet for carp that was 25 percent crude protein. A square is constructed and the two feedstuffs are put on the two left corners along with the protein content of each. The desired protein level of the feed is placed in the middle of the square. Next, the protein level of the feed is subtracted from that of the feedstuffs, placing the answer in the opposite corner from the feedstuff. Ignore positive or negative signs.

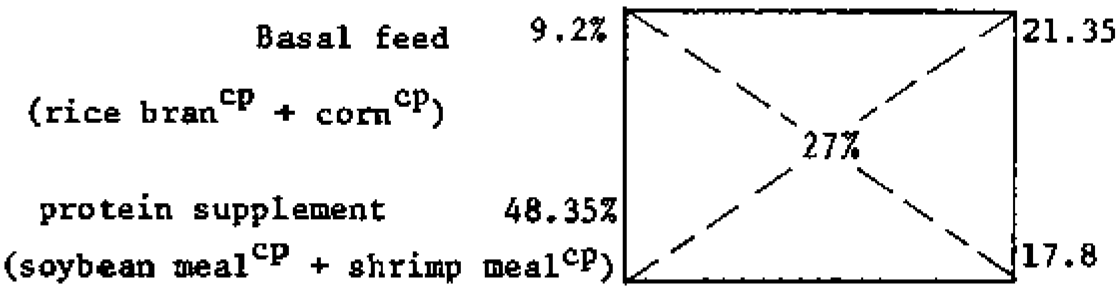


To make the 27 percent crude protein carp feed, we must mix 17/35.8 of rice bran with 18.8/35.8 soybean meal.

Rice Bran 17/35.8 = 47.5%
Soybean meal 18.8/35.8 = 52.5%

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

If more than two feedstuffs are used in a feed, they may be grouped into basal feeds (CP < 20 percent) and protein supplements (CP > 20 percent), averaged within each group, and plugged into the square method. For example, suppose shrimp meal and corn were also available for the carp feed mentioned above. The crude protein levels of the shrimp meal (52.7 percent) and of corn (10.2 percent) are averaged with soybean meal and rice bran, respectively.



Basal feed = 21.35/39.15 = 54.53%
Protein supplement = 17.8/39.15 = 45.47%

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

Rice bran 27.265 kg
Corn 27.265 kg

Soybean meal 22.735 kg
Shrimp meal 22.735 kg

The square method is helpful to novice feed formulators because it can get them started in diet formulation without the need to resort to trial and error. The square method can also be used to calculate the proportion of feeds tuffs to mix together to achieve a desired dietary energy level as well as a crude protein level. If one wanted to make a feed containing 2 500 kcal ME/kg using wheat middlings (1663 kcal ME/kg) and anchovy fish meal (4 371 kcal, ME/kg) a square could be constructed as follows:

The square method cannot be used to simultaneously solve for both crude protein level and ME level.

3.8 STEPS IN FEED FORMULATION

The first step in diet formulation is balancing the crude protein and energy levels. This can be accomplished by trial and error, by the square method for either crude protein level or energy level and then adjusting, or by solving simultaneous equations. At first, it is helpful to use at least three feeds tuffs during the initial balancing of protein and energy levels: one high in protein and high in ME, one low or intermediate in protein and high in ME, and one low or intermediate in both protein and ME. Once practice makes one more proficient at diet formulation any number of feedstuffs can be used. One must remember to reserve room in the formulation for any feed additive, such as a vitamin or mineral pre-mix.

The second step in diet formulation is to check the levels of indispensable amino acids in the formulation to be sure the dietary levels meet the requirements of the animal to be fed. The requirements of fish for indispensable amino acids is expressed as the dietary level (as a percent of the diet) or as a percent of the dietary protein level. To convert an amino acid level from the percent of diet to percent of protein, divide the dietary level of each amino acid by the dietary protein level. It might be of interest to calculate the dietary levels of all of the indispensable amino acids, but it is not practical to do it all of the time. If the levels of arginine, lysine, methionine, and tryptophan meet the dietary requirements of the fish to be fed, the levels of the other six indispensable amino acids will most likely be above required levels. When using unconventional protein supplements, the levels of all ten indispensable amino acids should be checked.

If the diet formulation is low in any amino acid, a feedstuff that contains high levels of that amino acid must be added to the diet at the expense of another ingredient. Once the amino acid requirements are met, the dietary protein and energy levels must be rechecked to, see if any substitution of ingredients has imbalanced the formulation.

A diet mixing sheet should be constructed to standardize diet formulation. A sample sheet is shown in Table 1. The amino acids listed are for illustration purposes only and may be changed to suit different circumstances.

In practical feed formulation, pellet quality and acceptability must be considered in addition to nutrient levels and cost. These considerations will vary from species to species and with the type of pell

3.9 FEED FORMULATION FOR CATTLE

The final step of beef cattle nutrition is correcting nutrient deficiencies. The first approach to correct nutrient deficiencies is to establish an accurate description of the cattle being fed. Once an accurate description of the cattle is established, their nutrient requirements can then be determined from nutrient requirement tables. The next step is to determine the feeds available for use. List their composition on a dry matter basis from a composition table or a chemical analysis. Now the amounts of the feeds necessary to balance the ration can be determined.

Three common methods to ration balancing include the Pearson Square, substitution formulation and computer-assisted formulation based on substitution or linear programming for least-cost formulation.

4.0 FEED FORMULATION FOR SHEEP AND GOATS

Goats and sheep are small ruminants that require slightly different feeding patterns and ingredients from cattle but the methods of feed formulation are the same.

Sample Feed Formula for Kid & Lamb Starter

Ingredient	Quantity (KG)
Total	100
Maize	37
Groundnut cake	15
PKC	25
Wheat bran	20
Salt	0.5
Mineral mix	2.5

Sample Feed Formula for Goat & Sheep Finisher Feed

Ingredient Quantity (KG)

Total	100
Maize	15
Groundnut cake	37
PKC	10
Wheat offal	35
Salt	1
Mineral mix	2

Sample Feed Formula for Nursing Goat & Sheep

Ingredient	Quantity (KG)
Total	100
Maize	52
PKC	8
Wheat offal	37
Salt	1
Mineral mix	2

Sample Feed Formula for Pregnant Goat & Sheep

Ingredient	Quantity (KG)
Total	100
Maize	35
PKC	20
Wheat offal.	42
Salt	1
Mineral mix	2

How to prepare a Mineral Mix for Goat and Sheep.If you want to prepare the mineral mix at home rather than buying it, then follow the composition below.

Sterilized bone meal= 35%

Limestone= 45%

Iodized salt= 20%

Copper Sulphate= 22 g/tonne of mineral mix

Ferrous Carbonate= 11 g/tonne of mineral mix

Zinc Oxide= 11 g/tonne of mineral mix

4.0 CONCLUSION

In this unit, we have highlighted the different ways of formulating diets for different class of livestock using different methods.

5.0 SUMMARY

In this unit, you have learnt the different methods of ration formulation for different classes of livestock and also we get to know the different types of feedstuff use in compounding diets for different specie of animals

6.0 TUTOR-MARKED ASSIGNMENT

1 Discuss the different methods of feed formulation

2 Explain the various steps to be considered in ration formulation.

7.0 REFERENCES/FURTHER READING

MODULE 3: CLASSIFICATION OF FEEDS, FEEDSTUFFS AND SUPPLEMENTS

UNIT 1 Advantages and disadvantages of compounded feeds

CONTENTS

1.0 INTRODUCTION

Compound feeds are unique among manufactured products in that they represent, as it were, a vital link in the human food chain. Like other links in natural food chains, one diet may differ from another generically, yet both satisfy to the same degree the nutrient requirements of the animal. For example, the dietary needs of rapidly growing broiler chickens can be just as satisfactorily met by a ration made from mixtures of tropical feeds tuffs such as rice bran, cassava, groundnut cake, copra cake, fish meal, and leaf meal, as by another ration made from mixtures of maize, soyabean meal, fish meal, and alfalfa meal. Considering the urgent need for increased animal protein production and the under-utilization of primary food resources in many developing countries, the establishment of viable feed processing industries in those countries represents a special challenge with broad socio-economic ramifications for national governments and almost unlimited opportunities for entrepreneurs.

2.0 OBJECTIVES

In this unit, you should know:

- Advantages of compounded feed
- Disadvantages of compounded feed

3.0 MAIN CONTENT

3.1 ADVANTAGES OF A COMPOUNDED FEED

3.1.1 Efficiency

When compounded feed is fed to animals, there is no wastage and no selective eating by the animal because the component of the feed are well blended and mixed together. Efficiency is obtainable because the quantity of feed given to animals at a particular period of time is well consumed, and for this reason, it helps the farmer to maximize feed usage.

3.1.2 Economy

When cross bred animals e.g pigs are fed with nutritionally balanced feed, they grow faster, reduce the growing period and yield other benefit. If there is 50% replacement of the local feeds with nutritionally balanced compounded feed, the following benefit are expected

a. Reaches the body weight requirement within a short period of time.

b. Early farrowing e.g pigs and produces 1-2 additional piglets per farrowing.

c. Saves feed required for the extra growing period

d. Saves (women) labour used in cooking feed.

e. Saves costs of firewood in cooking feed.

f. No extra labour, machinery, mixing or storage costs.

3.1.3 Performance

A well prepared feed fed to animals works perfectly in terms of health and conversion of such feeds into body weight conformation. If the balanced feed is compounded locally, price and quality can be controlled which in turn have impact to maintain and convert the feed to body weight. .

3.1.4 Quality

Ingredients are carefully selected and controlled therefore the quality of feed is maintained. Every ingredients found in the feed is carefully selected and the amount is well controlled. That is why expertise is required to carefully select the ingredient and to use them in the right amount in order not to overdose feed with a particular ingredient.

3.1.5 Service

Efficient ordering and delivery service, no time lost and farmers can easily access the feed for their livestock

3.1.6 Nutrition

Compounded feeds are highly nutritious compare to other sources of anima`s feed. And there is high digestibility when animals are fed with compounded feed compare to straight feed and other feeds .Expert knowledge, experience and technology are both employed in compounding the feed therefore its highly nutritious and can easily be di

gested by animals.

3.1.7 Value

Compounded feeds all add up to excellent value for money. Those who are into such business make a lot of money because the business is highly lucrative.

3.1.8 Compound feeds are rations, normally available in either a cube or mix form, which are fed alongside with good quality forage.

3.1.9 Traceable

Feed ingredients, including additives, are traceable which enable proper record keeping for timely and effective withdrawal or recall of products if known or probable adverse effects on consumers' health are identified. Records should be maintained and readily available regarding the production, distribution and use of feed and feed ingredients to facilitate the prompt trace-back of feed and feed ingredients to the immediate previous source and trace-forward to the next subsequent recipients if known or probable adverse effects on consumers' health are identified.

3.2 DISADVANTAGES OF COMPOUNDED FEED

3.2.1 Compounding the feed requires an expertise

In compounding the feed, one has to be knowledgeable and well trained, selecting the ingredients is not an easy task and if the ingredients are wrongly selected or used in the right proportion, it can interfere with the animal`s health. Therefore in preparing compounded feed, a knowledgeable and a technical-know-how individual is needed to control the amount of ingredient needed, consider the specie of the animal and to know how the manipulate the machine.

3.2.2 Accumulation of chemical additives

Chemical additives in compounded feed accumulate in animal tissues, potentially exposing consumers to unwanted chemicals such as veterinary drugs residues and heavy metals. Compounded feeds that have high amount of chemicals additives has negative effect on the animal. When animals consumed such feed overtime, they may likely to come down with diseases due to the accumulation of chemicals in their tissues, and such diseases may be zoonotic in nature i.e it can easily be transmitted to man when he consume animals that were fed with compounded feed that has chemical additives.

3.2.3 Compounding the feed could be capital intensive

For commercial purpose, compound feeds can appear expensive, particularly specialist diets such as those designed for breeding horses. The ingredients required to make the feed may not be available at all time in appreciable quantity, and this could lead to an increase in the prices of the raw material needed to prepare the feed.

3.2.4 Mixing the feed, it is time consuming

Blending and mixing the feed is time consuming most especially when the feed is meant for commercial purpose. Compounding the manually, can be stressful and time consuming. But when machines are used to mix the feed, the time consumed is less compare to when a farmer is compounding the feed manually.

3.2.5 It can look boring for animals to consume

Compounded feed appears in different shapes and sizes colour, some appear in cubes, nuts or other shapes but those in nuts shapes seems to be looking boring for animals to consume. Even the colour of the feed can also affectthe feed consumption rate of the animal. Some colours of the feed may look strange and scary to the animal.

3.2.6 Compound feed is very expensive compare to straight feed.

Most farmers prefer straight feeds compare to compounded feed not because the straight feed is more nutritious than the compounded feed but because compounded feeds are very expensive and not all farmers can afford the feed for their animals. Even the raw materials required to make compounded feed cannot be easily sourced. So therefore farmers tend to go for straight feeds since they are cheaper and their raw materials can be easily sourced

3.3 RECOMMENDATION

- All feed and feed ingredients should meet minimum safety standards. It is essential that levels of undesirable substances are sufficiently low in feed and feed ingredients that their concentration in food for human consumption is consistently below the level of concern.
- The presence in feed and feed ingredients of undesirable substances such as industrial and environmental contaminants, pesticides, radionuclides, persistent organic pollutants, pathogenic agents and toxins such as mycotoxins should be identified, controlled and minimised.
- Feed additives and veterinary drugs used in medicated compounded feed should be assessed for safety and used under stated conditions of use as pre-approved by the competent authorities.
- Veterinary drugs used in medicated feed should comply with the provisions of the Codex Recommended International Code of Practice for the Control of the Use of Feed and feed ingredients.
- Compounded Feed should only be produced, marketed, stored and used if they are safe and suitable, and, when used as intended, should not represent in any way an unacceptable risk to consumers' health. In particular, feed and feed ingredients contaminated with unacceptable levels of undesirable substances should be clearly identified as unsuitable for animal feed and not be marketed or usedVeterinary Drugs

4,0 CONCLUSION

The use of suitable, safe and good quality feed and feed ingredients is of paramount importance to livestock production. Safe feed is an essential element to reduce and prevent food safety hazards entering the food chain.

The presence in feed of food safety hazards that can lead to public health problems should be prevented or minimised. Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP) and, if applicable, Hazard Analysis and Critical Control Point (HACCP) are important instruments to control hazards in the feed production process.

5.0 SUMMARY

Below is the summary of what you have learnt in this unit:

- Problems of feed availability and how to solve such problems
- Adulterants in feedstuff and how to handle them

6.0 TUTOR-MARKED ASSIGNMENT

1. How do you tackle losses during storage?
2. What is adulteration and give some examples of adulterants.
3. How do you solve problem of feed availability.

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UNIT 2 PROBLEM OF FEEDSTUFF AVAILABILITY AND ADULTERATION

CONTENTS

1.0 INTRODUCTION

Feed stuff availability is an important factor in animal husbandry, productivity of the livestock industry depends on this factor to a very large extent. Feed availability has some militating factors which is the main focus of this literature. Availability of feedstuff can be hampered by climatic changes, economic problems, mycotoxins occurrence in feedstuff, insects, microorganisms, deteriorative changes and losses in storage. For effective feed production, these challenges have to be taken into consideration in order to help proffer solution for sustainable growth and improvement of the livestock feed industry.

2.0 OBJECTIVES

In this unit, you are expected to know:

- Factors that affects feed availability
- Ways of handling such problems

3.1 CLIMATE CHANGE EFFECT ON FEED AVAILABILITY

The climate change is expected to heighten the vulnerability to livestock feed in terms of quality and quantity. The hot and dry seasons has been induced the greatest reducti on in biomass yield for different types of grass-growing in low land environments. Th e research facts made by had indicated that increases in temperature, carbon dioxide le vels and nitrogen deposition decrease the primary production in pastures. Conversely, many already semi-arid areas are predicted to experience lower rainfall as a consequen ce of climate change. The length of the pasture growing period is expected to decrease in many parts of the tropics and this may be accompanied by greater variability in rain fall patterns with more frequent droughts. The study made by Tubiello et al. on evalua tion of climate change impact on quality of forage species revealed that high temperat ures tend to increase lignifications in plant tissues and hence decrease the digestibility of forage and concurrently it was induced a shift from C3 grass species toC4 grasses which has direct implications for forage supply. Rangeland is important assets for past oral communities and the study made on range land productivity to recognize the effe ct of climate change had demonstrated that climate change based effects have been de pressing range pasture productivity and encouraged botanical change in vegetation co mposition. The changes in seasonal patterns of forage availability could pose addition al challenges for grazing management in the rangeland. Similarly, the climates becom e hotter and drier; pasture composition is likely to shift to species that may be less suit able for grazing. Climate change has observed to affect rangeland species richness an d biodiversity. Evidently, the studies made in the Qinghai-Tibet Plateau area had show n that a trend of warming and drying is driving a transition of highly productive alpine adapted *Kobresia* communities to less productive steppe *Stipa* communities. Moreove r, Nardone et al. also reported that environmental warming and drying trend are negati vely affected the rangeland productivity by lowering the quantity and nutritional quali ty of forages besides causing water scarcity. Pertaining to the range forage species co mposition, as temperature and CO_2 levels change, optimal growth and dynamic of ran ges species also change. The study made from Ethiopia by demonstrated that the Afar clans from Baadu have pushed 150 km Westwards by the Issa from their traditional ra iny season pastures and further exacerbating the lost rainy season pastures is the invas ion of the pasturelands by exotic species, for instance *Prosopis juliflora.*

3.2 ECONOMIC PROBLEMS

There are several factors that affect the economic viability of the feed industry: volatil ity in the price of raw materials and exchange rates; the effect of the biofuel industry o n the market of feedstuffs; the changes driven by a consolidation of the global meat in dustry; and also political regulations on specific issues like the policy on genetically-modified organisms (GMO's) that affect the competitiveness of the industry in differe nt parts of the global market. The emergence of the biofuel industry has strengthened t he relationship between agricultural prices and crude oil prices resulting in a more vol atile financial scenario. Moreover, biofuel production requires an important supply of raw materials that affect market availability and pricing. On the other hand, this increa sed production of biofuels from crops generates co-products which are of economical interest to the feed industry. The increasing availability of rapeseed meal, glycerol and dry distiller grains (DDGS) results in changes on the feed composition and quality of the feeds. The feed industry will undergo continued consolidation as the customer base consolidates and changes. Global meat industry is already consolidating especially in the US, Brazil and the EU to a less extent. The GMO policy and in particular the asynchronous authorizations of new GMO varieties has a very significant effect on the relative cost of feed and profitability of meat production in different parts of the world, with a negative impact on the EU production. All these factors will play a key role in deciding where the animals will be produced and thus feed manufactured in the future to meet the growing and consolidated demand for meat, milk and eggs. This production needs to be developed in a sustainable manner from and environmental and social standpoints. Issues like a responsible soya production, control of greenhouse gas emissions and efficient use of byproducts are key challenges in coming years. The industry has created an international forum to address negative environmental and social impacts of the soy production and its expansion in South America. Regarding greenhouse emissions, the compound feed industry is one of the stakeholders having a role in minimizing the environmental impact through the control of emissions by the feed industrial process as well as the control of emissions by the animal. The reductions of emission from the feed plant are related to an efficient use of energy, but they are far less important than the potential reduction of emissions by the animal which can be influenced through feed composition. Different nutritional strategies are available to reduce the emission of nitrogen and phosphorus in the manure, as well as to reduce the emission in the air and odor problems. Finally, an efficient use of byproducts in the feed industry is also a top priority from the standpoint of social and environmental responsibility, as well as for their economic impact for the society.

3.3 LOSSES OCCURRING DURING STORAGE

Losses occurring in feedstuffs during storage fall under four major categories:

(a) weight loss,

(b) quality loss,

(c) health risk, and

(d) economic loss.

These losses arise from the foraging activities of insects, micro-organisms and animals ; improper handling; and, physical and chemical changes, all of which are interrelated. Storage loss in a feed mill is primarily due to material eaten or destroyed by insect and animal pests and fungi. When serious infestation by these pests occurs there is extensive weight loss accompanied by damage to quality. Intense insect activity often results in mould growth which not only completes the destruction of the feedstuffs but also poses serious health risks to animals or fish feeding on rations containing damaged feed ingredients.

The first three categories of storage loss are of primary concern to the compound feed manufacturer. Weight loss due to loss of moisture content or to the presence of a large insect population in stored feed is problematic in developing countries where post-harvest handling and processing are often improperly conducted. Ineffective enforcement of quality standards (if, in fact, such standards exist) results in the production and supply of inadequately processed feed ingredients which often are more susceptible to deteriorative processes. The lack of quality standards reflects the relative unimportance attached to aesthetic considerations in commercial transactions of feed commodities in these countries. Hence, economic loss which we shall define here as the cost incurred in inspection, prevention, and control to maintain quality standards (although considered to be of overriding importance in most industrialized countries) is superseded by the other three major categories of storage losses in developing countries.

This article looks at the effects of insects and micro-organisms and the deteriorative changes that result from their presence in stored ingredients in feed mills in the tropics.

3.4 INSECTS

Insects feed on most feed ingredients and contaminate them with faeces, webbing, body parts, foul odours, and micro-organisms. Beetles and moths are the most destructive of the grain insects, and many are capable of destroying an entire store of feed.

3.4.1 FACTORS AFFECTING INSECT INFESTATION OF FEEDSTUFFS

The occurrence and development of an insect infestation is dependent on many factors such as source of insects, available food, temperature, moisture, air, condition of the f eed-stuff, presence of other organisms, and the efforts to exclude or kill the pests. Maj or factors affecting population growth of most insect species are: temperature, relative humidity, and moisture content of the feed ingredient. The nutritive content and certai n physical properties of feeds will also determine the vulnerability of such materials to attack. Only a few insect species are able to attack sound kernels of feed grains. High moisture content (16 percent or more) renders feed grains soft and susceptible to attac k. Meals pressed into cakes or hard flakes are more resistant. Insects appear to eat sma ll particles more readily than large ones.

3.4.1.1 Temperature

All insects attacking stored feedstuffs have an optimum zone of temperature at which populations increase most rapidly. Most of the important insect pests are tropical speci es with an optimum temperature of about 28°C. It is, therefore, evident that losses fro m insect infestation will be greatest in the tropics.

3.4.1.2 Relative humidity

As a rule, relative humidity affects the rate of population increase in insects less dram atically. Up to 70 percent relative humidity, there is progressive increase in insect mul tiplication. Beyond 70 percent relative humidity, mould formation sets in and complic ates the situation. The moisture content of feedstuff is closely related to the relative hu midity. A low moisture content coupled with low humidity will provide protection aga inst insect infestation.

3.4.2 Feeding Habits of Insects

Some insects are not discriminatory in their feeding habits whereas others are highly s elective in their choice of the parts of a feed ingredient eaten. For example, moth larva e generally feed on or near the surface of the grain mass; beetles are destructive throu ghout. Most larvae spread silk webbing over the surface of feed grains and their by-pr oducts, making them not only unsightly but also creating handling and processing pro blems as well.

Insect infestations sometimes cause excessive heating of grain. When the insect popul ation reaches a certain density, their metabolic activities release more heat than can be dissipated. In localized areas where the insect population is extremely dense the tempe rature may reach 45°C. Associated micro-organisms, mainly fungi, may raise this to n early 75 °C, causing extensive spoilage and, occasionally, spontaneous combustion.

3.4.4 Nature of Losses Due to Insect Attack

The best warning of serious weight loss is the presence of a large insect population. T his is easily identifiable in sacked grain by the appearance on the sack surface of frass resulting from feeding activity of the insects. High temperature, high humidity, softne ss, and high nutritive value of the feedstuff and storage in small quantities are all cond ucive to insect damage, but are often unavoidable. Loss may be aggravated by prolong ed storage. Failure to keep the storage area clean and retention of infested sweepings will increase the liability of insect attack.

3.4.4.1 Weight loss

Weight loss in infested feed is not always evident unless it involves sacked grain or oil cakes when the appearance of grass on the surface of the sack points to the feeding act ivity of a large insect population.

3.4.4.2 Quality loss

For the feed manufacturer, one of the most important considerations of insect attack o n feedstuffs is the loss of quality. The effects on quality are various. Most stored feed material undergoe some chemical changes that alter their flavour and nutritive value. As well as eating some of the feed, insect pests tend to accelerate these harmful chemi cal changes. Secretion of enzyme lipase by the insects themselves will enhance deteri orative chemical processes. Few stored feedstuffs are homogeneous and insects and m ites are known to select those parts or particles of feed they prefer.

Many feedstuffs contain a high percentage of fat which tends to break down during sto rage. This breakdown is accelerated by insect attack, especially when the insects break off small particles, introduce micro-organisms, or raise the temperature or moisture co ntent. Evidently, the insects use the fat in the material they eat. The breakdown of fat causes an increase in free fatty acids which cause off-flavours. The free fatty acid involved in product rancidity is assumed to be oleic acid, and the quantity released in a result of oxidation of fats in certain feedstuff is quite substantial.

Scavenging insects, such as cockroaches, may cause contamination with pathogenic bacteria such as Salmonella.

3.5 Control

Climate is the most important factor determining the effectiveness of a storage system for feed ingredients because of the close relationship between insect growth and ambient climatic conditions. An important relationship also exists between insects and micro-organisms in stored feedstuffs.

Total eradication of insect populations from tropical warehouses for feed ingredients is not possible. The degree of infestation can, however be brought to manageable proportions through a programme of vigilance and effective control measures. Heavily infested ingredients should not be brought into the store. Infested material, if accepted, should be kept separate until fumigated (this is to be done as soon as possible) to totally eradicate the pests.

Good house-keeping involving the sweeping up of spilled material will check scavenger insects as well as rodents which may carry insects in their fur.

3.6 COMMON ADULTERANTS IN FEEDS AND FODDER

Adulteration is defined as a mixture of a pure substance with some cheaper and low quality substance. It is done intentionally usually to make money. In costly feed ingredients like oil seed cakes and feeds of animal origin like fish meal, adulteration is done by spraying urea in order to raise their protein content. However, sometimes brans, molasses are also added. Besides urea, oilseed cakes are adulterated with husk, non edible oilseed cakes. There adulteration and the following toxins are to be analyzed to avoid injuries to the animal health. Examples of toxins in various feeds include:

- Gossypol in cotton seed
- Halmagglutinins in soybean and castor beans

- Glucosinolates in rape seed
- Tannins in sorghum, oil seed meal, mango seed kernel, mustard oil cake and Lucerne meal.
- Cyanogenic glycosides in linseed and cassava
- Phytic acid in cereals, oilseed meal
- Mycotoxins, primarily aflatoxins in maize, groundnut cake, etc.

Fish meal, meat meal and bone meal should be checked for pathogenic bacteria like salmonella.

4.0 CONCLUSION

In this unit, we were able to discuss feed availability and some adulterants. We also suggests how such problems ca be taken care of.

5.0 SUMMARY

In this unit, you have learnt about the factors that cause feed unavaibility and ways to soliving them. You've also learnt how to handle adulterants available in feedstuff.

6.0 TUTOR-MARKED ASSIGNMENT

1 How do you tackle losses during storage?

2 What is adulteration and give some examples of adulterants.

3 How do you solve problem of feed availability.

7.0 REFERENCES/FURTHER READING

UNIT 3: ANTI-NUTRITIONAL FACTORS IN LIVESTOCK FEEDSTUFF

CONTENTS

1.0 INTRODUCTION

There is a wide distribution of biologically-active constituents throughout the plant kingdom, particularly in plants used as animal feeding stuff and in human nutrition (Igile, 1996). Many plant components and seeds of legumes and other plant sources contain in their raw state wide varieties of anti-nutrients which are potentially toxic. The knowledge that these compounds elicit both toxic and advantageous biological responses has given rise to several investigations in recent times as to their possible physiological implications in various biological systems (Igile, 1996). Some of these chemicals are known as ‘‘secondary metabolites’’ and they have been shown to be highly biologically active and Most of these secondary metabolites elicit very harmful biological responses, while some are widely applied in nutrition and as pharmacologically active agents (Soetan, 2008).

2.0 OBJECTIVES

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

- Outline the advantages and disadvantages of compound feeds
- Understand ways of solving problems associated with the use of compound feeds

3.0 MAIN CONTENTS

3.1 MICRO-ORGANISMS

Micro-organisms are biological contaminants of the natural environment and are present in all feedstuffs. They persist after crops have been harvested from the fields and in animal carcasses prior to rendering. Because bacterial and field fungi do not thrive at moisture levels below 20 percent, post-harvest processing of commodities and animal renderings involving heat, chemical and mechanical extraction, and dehydration eliminate most of the original contaminating microflora. Fungi spores, which are resistant to harsh processing treatment, may remain dormant in the processed feedstuff until more favourable conditions once again permit their proliferation.

3.2 Factors Affecting Fungal Growth in Feedstuffs

Recontamination of feedstuffs by adventitious micro-organisms during storage is of primary concern to the feed processor. Adventitious storage fungi grow at moisture content (15 to 20 percent) in equilibrium with a relative humidity of 70 to 90 percent and are considered the principal spoilers of feedstuffs in storage. When the relative humidity falls below 65 percent no growth occurs.

Under favourable conditions, fungi can raise the temperature in their immediate environment to 55 C with con commit tent increase in moisture content of the affected feedstuff to as high as 20 percent. When this occurs, secondary spoilage by bacteria takes place.

The most common fungi involved in the spoilage of feedstuffs belong to the Aspergillus spp. and the Penicillium spp. These grow at temperatures up to 55 C and at a minimum, relative humidity of 65 percent. They are most destructive when temperatures exceed 25 C and relative humidity exceeds 85 percent.

3.3 Detrimental Effects of Storage Fungi on Feedstuffs

The chief effects of storage fungi on feedstuffs are:

(a) mycotoxin production,

(b) heating,

(c) moisture increase, and

(d) mustiness (staleness).

3.4 Mycotoxin production

Mycotoxins are compounds produced by fungi growing in infested agricultural commodities. They are toxic to both humans and animals. The aflatoxins, a group of highly toxic and carcinogenic metabolites produced by Aspergillus flavus are perhaps the most important among mycotoxins contaminating feedstuffs. Transmission of the toxin to milk, meat, and eggs through farm animals feeding on contaminated feed poses an increasing health hazard. Studies on the toxicity of aflatoxin to fish have not been extensive but toxicity to trout (oral LD 50:0.5 mg/kg body weight) is comparable to toxicity to ducklings, the latter recognized as the most susceptible animal to aflatoxin poisoning

Feedstuffs known to be contaminated by A . flavus include: groundnut cakes, maize, sorghum, sunflower, cottonseed cakes, copra, and cassava. To produce aflatoxin, however, A. flavus must be present alone in a practically pure culture. The presence of other fungi, yeast, or bacteria seems to interfere with aflatoxin production. Crops such as peanuts, cottonseed, and copra are high aflatoxin risks precisely because A. flavus often infest them as a practically pure culture with few or no other microflora. In addition, the fungus produces the toxin in these crops at relatively low moisture levels, 9 to 10 percent, compared with 17 to 18 percent moisture for most feed grains. Feed grains such as maize and sorghum grown in the tropics, therefore, also pose high risk.

3.5 Mycotoxin Challenges in Production of Poultry Feed During Rainy Season

Mycotoxicosis is a major problem in poultry industry. There are about 50 fungi species harmful to poultry known to produce toxins, which are collectively called as mycotoxins. These mycotoxins are metabolites produced by fungi during metabolism of nutrients present in feeds and feed ingredients. High moisture content in fresh maize and grain highly favour mould growth. Many mycotoxins are stable during grinding and crushing in mill and also during feed storage.

The type of fungus, temperature, moisture and grain determine which toxin will be produced and in what amount. According to the United Nation's Food and Agriculture Organization (FAO), approximately 25% of world's grain supply is contaminated with mycotoxins. The economic loss due to this has been estimated to run into millions of rupees annually.

Individual fungus usually produces more than one toxin. It is uncommon to find a single mycotoxin occurring under field condition. Usually they occur in combination of two or more. These toxins therefore often act in synergism. This means that their combined effect is much more damaging than that of the individual mycotoxins. In feed, even if aflatoxin content is very low, its harmful effect is greatly increased by the presence of ochratoxin, even though its presence may be at a low level.

Aflatoxicosis and Orchatoxicosis mycotoxicosis are the most commonly seen mycotoxicosis in poultry. Other mycotoxicosis is less common. Mycotoxicosis is wide spread under hot and humid Indian conditions as well with poor storage facilities.

3.6 Aflatoxicosis:

Aflatoxins are a group of closely related, highly toxic, mutagenic and carcinogenic compounds. Aflatoxin is the most common and the most important mycotoxin. It is a highly toxic mycotoxin produced by various species of fungi Aspergillus. The fungus Aspergillus flavus produces most of the Aflatoxin and also gives this toxin its name (“A” from Aspergillus and “fla” from flavus). However, aflatoxin is also produced by Aspergillus Parasiticus and Penicillium puberulum. Both the fungi are widespread in the environment and produce aflatoxin in warm (30-35°C) temperature and high humidity conditions. Mould growth occurs more rapidly when moisture content is more than 10% and temperature at 28-30°C. Aflatoxin can withstand extreme environmental conditions and are highly heat stable. Aflatoxin contamination is more common in grains or handled in a tropical country like India. Handling and storage of grains in these conditions anywhere will also stimulate production of aflatoxin. Poultry feed and ingredients are easily prone to fungal growth and aflatoxin formation.

Aflatoxin is found in maize, groundnut cake, rice, cottonseed, millet, sorghum and other feed grains. Its concentration at field levels is 20-100 ppb and may even up to 500 ppb.

Mycotoxin may get 30-50 times more concentrated in the broken grain as compared to whole grain. Naturally occurring aflatoxin contains B1, B2, G1 and G2. Designations B and G are given after their Blue (B) or Green (G) colour reaction to fluorescent light. Of all, aflatoxin B1 is usually found in the highest concentration and is also the most toxic. It damages mainly liver. Aflatoxin is stable once formed in grains, and is not destroyed during normal grinding and crushing in the mill and storage. Young birds are more sensitive to aflatoxin than adult. There are also large species differences as duck being 10 times more sensitive than chickens.

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3.6.1 Post mortem findings

In the affected birds metabolic changes lead to enlargement of liver, kidney and spleen as well as decrease in the size of bursa of fabricus, thymus and testes. With high dose exposure, fat accumulates inside the cell of liver as clear vacuoles. As a result, liver is greatly enlarged, yellow and friable (easily broken). Small haemorrhages may occur following injury due to decreased clotting factor synthesis and increased fragility of minute blood vessels. This leads to a condition known as “bloody thigh syndrome”. Aflatoxin is rapidly excreted in the bile and urine and does not accumulate or persist in the body tissues. This explains the rapid recovery of egg production and hatchability after ingestion of toxin has stopped.

3.6.2 Harmful effects of aflatoxin

Aflatoxicosis causes loss of egg production (layer), anaemia, haemorrhages, liver damage, paralysis and lameless, poor performance, feed efficiency (in broiler), increased mortality from heat stress (in broiler) and increased susceptibility to infectious disease both in broiler and layers. Aflatoxin affects egg production by reducing synthesis and transport of yolk precursors in the liver. Egg size, yolk weight and yolk as percent of total egg size are decreased. Aflatoxicosis affects weight gain, feed intake, feed conversion efficiency, pigmentation, eggs production and reproductive performance of male and female. Even less than 100 ppb in broiler can result in poor feed conversion and reduced weight gain which may be due to liver damage and reduced nutrient absorption. Once the damage has been done, birds may not fully recover even if they return to toxic free ration.

3.6.3 Immuno suppression

Aflatoxicosis suppresses the immune response. As result, aflatoxicosis is associated with increases susceptibility to infectious disease. In chicken, aflatoxicosis increases susceptibility to or severity of Caecal Coccidiosis, Marek's disease, E. coli infection, Salmonellosis, Inclusion Body Hepatitis and Gumboro disease. Vaccination failure is emerging as result of aflatoxicosis in chicken. Aflatoxicosis induced immune suppression is due to reduction in the size of bursa of fabricus, thymus and spleen. Immune suppression in breeders can be serious as it reduces the passive maternal immunity.

3.7 Ochratoxicosis

Ochratoxicosis is caused by the mycotoxin “Ochratoxin”. Its name is derived from the fungus “Aspergillus ochraceous”. Ochratoxicosis is less common in poutry than aflatoxicosis, but is much more harmful. Although, aflatoxin B1 is the most potent of all aflatoxins, ochratoxin is three times more harmful. Thus, Ochratoxin are among the most toxic mycotoxins for poultry. They damage mainly kidney.

Apart from Aspergillus ochraceous, five other species of Aspergillus also produce it. Ochratoxin are formed on numerous grains and feed stuffs and are of four types A, B, C and D. Of these, orchatoxin A is the most toxic, most common, also produced in gre ater quantities and is relatively stable. Ochratoxin occurs in maize, rice, most small grain and in animal feeds. It readily forms in poultry feeds under conditions of high temperature and high moisture. Field levels are between 20-200 ppb, but may be even up to 2.0 ppm. In the naturally occurring disease, ochratoxin A is the main toxin involved. Ochratoxin B and C occur only with high concentration of ochratoxin. Young birds are most sensitive to ochratoxin ingestion. Severe (acute) ochratoxicosis causes death due to kidney failure.

3.7.1 Harmful effect of Ochratoxin

Ochratoxins is broilers causes mortality and failure to gain weight. Growth rate, feed conversion and pigmentation are also affected. Ochratoxicosis in growers delays sexual maturity. Ochratoxin can reduce egg size and interior quality. Immuno-suppression by ochratoxin-A is mainly due to reduce size of thymus, although all lymphoid organs are affected. Cell mediated immunity is significantly damaged in broilers. Antibody mediated immunity is affected after depletion of antibody containing cells in lymphoid tissues. As a result, vaccination response is severely damaged and the severity of concurrent Coccidiosis and Salmonellosis is increased.

3.7.2 Symptoms

Affected birds are depressed, dehydrated, usually pass more urine and die from kidney failure. Those that survive are stunted, poorly feathered and have anaemia and immune-suppression (Ochratoxin level more than 0.6 ppm). There may be reduced weight or develop wet dropping causing increased numbers of stained eggs. There is also a decrease in egg production and hatchability (at ochratoxin level more than 2.0 ppm) and poor performance in progeny derived from affected hens.

3.8 Mycotoxin binders

Mycotoxin binding agents include activated charcoal, yeast cell wall products, synthetic Zeolites and mined mineral clays such as aluminosilicates, sodium bentonite. Effectiveness of these compounds depend upon the adsorptive capacity, their structure, their purity and the characteristics of the targeted mycotoxin.

a) Zeolites (Sodium Zeolites A) and aluminosilicates have strong affinity to aflatoxin and form a stable complex.

i) Hydrated Sodium Calcium Aluminosilicates (HSCAS) and nutrients with antioxidant capabilities (Selenium, Methionine and Vitamin E)

ii) HSCAS and Virginiamycin

b) Mannan Oligosaccharides, developed by esterifying yeast cell wall glucomannans, can specifically adsorb Aflatoxins, Ochratoxin and Fusariotoxins.

c) Dietary supplementation of activated carbon reduces the toxic effects of many insecticides, pesticides and other toxins by adsorption and elimination in the faeces.

3.8.1 Treatment

i) Toxic feed should be removed and replaced with uncontaminated feed. Poultry usually recover from most mycotoxicosis soon after an uncontaminated feed is available.

ii) Increase the dietary levels of protein. The mycotoxins affect the protein and amino acid metabolism. Increasing the dietary level of proteins can minimize the ill effects especially when uncontaminated with aflatoxin. Increase also the vitamin supplementation.

iii) Supply of methionine and other sulphur containing amino acids, over and above the requirement can protect the chicks from growth depressing effects of aflatoxin.

iv) Treatment of bacterial or parasitic diseases.

v) Poor management is particularly harmful to poultry stressed by mycotoxins and should be improved.

vi) Liver tonics may be given. Additional amount of lipotropic agent like choline helps in minimizing liver damage.

vii) Vitamin D3 supplementation can minimize the adverse effect of aflatoxin, such as leg weakness and poor egg shell quality.

viii) Mycotoxins are free radical generators and therefore challenge the antioxidant responses within the poultry. Therefore, increase the supplementation of vitamin E, vitamin C and selenium.

3.8.2 Control of Mycotoxins

Occurrence of mycotoxins in grains is extremely common and therefore requires a programme for controlling their ill effects in poultry.

i) Purchase a clean feed stuff

ii) Discard the grains suspected of contamination (i.e. mouldy and caked feed).

iii) Keep the moisture of grain less than 12%.

iv) Sun drying is the best method to prevent mould growth. But, it does not destroy the toxin.

v) Store the feed and ingredients in well ventilated dry place; which is water, insect and rodent proof.

vi) Adequate ventilation of poultry house to reduce humidity (removes moisture available for fungal growth and mycotoxin formation in feeders).

vii) Avoid storage of feed for more than a week.

viii) Mycotoxin may form in decayed, crusted feed in feeders, feed mills and storage containers. Therefore, regular inspection of feed containers is essential.

ix) Withdraw toxin contaminated feed immediately.

x) Pelleting feed destroys fungal spores and decreases fungal burden. The combination of pelleting and antifungal agent has additional effectiveness.

xi) However, despite all the precautions, mycotoxins do get into the feed. Therefore, to deal with this difficult problem, the most practical way is to use effective mould inhibitors and scientifically tested broad spectrum toxin.

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xii) The most effective method of neutralizing mycotoxins already in feed is binding them to an inert compound therefore they can.?? cannot be absorbed from the intestines.

The most appropriate practices for mycotoxin control are:

i) Prevention of fungal growth on crops in the field, at harvest time, during storage of feedstuffs and processing of feed.

ii) Application of appropriate mycotoxin binder in order to achieve good productivity and economy.

iii) As with most poultry diseases, prevention is more economical than treatment.

3.9 Heating and moisture increase

Mould growth in feedstuffs is accompanied by rising temperatures and moisture content. Aspergillus glaucus, which has a minimum moisture requirement of 14.5 percent, is the first significant species involved during mould infestation of feed grains. Temperature elevation that accompanies this initial attack flavours the proliferation of a second species, A . candidus, which raises the moisture level of the infested grain to 18 percent or higher. At such high moisture levels, A. flavus activity becomes intense and total destruction of the wholesomeness of the feed grain becomes complete.

Fungal activity in stored feed- grains is not often apparent until after serious damage is done. This is because such activity takes place not near the surface where temperature gradients produced by such activity are quickly abolished, but within the interior of the storage container. Silos for grains should, therefore, be equipped with temperature sensors to provide early warning of trouble. Similar preventive measures are not possible for bagged material. The common practice of storing bags of grains in large piles to minimize and control insect infestation actually promotes fungal activity, especially in the tropics. The "sweating" of bags within a large stack is evidence of serious fungal damage to the stored grain. The surface of such bags will feel warm to the touch, and when a hand is inserted into the grain, it will actually feel hot.

Staleness

Feedstuffs that are damaged by fungi tend to become lumpy. Feed grains suffer discol ouration while damaged maize turns a dark brown with some blackened kernels being evident. The grain also exhibits a characteristic bluish sheen. Staleness or mustiness is another characteristic of commodities damaged by fungi.

4.0 Control

The prevention of mould contamination of stored feedstuffs depends mainly on the su ccessful control of insect infestation, because the destructive activities of insects often create conditions favourable to mould; viz., increased moisture and temperature and th e destruction of the protective hulls of feed grains expose their moist interiors. There i s no effective way of eliminating mould, although effective measures have been devel oped to control their growth in compound feeds. These measures include the use of pr opionate and, more recently, gentian violet.

4.1 DETERIORATIVE CHANGES IN STORED FEEDSTUFFS

Most stored feedstuffs undergo some chemical changes altering flavour and nutritive v alue. These changes are usually deteriorative in nature and are associated with the lipi d content of the feedstuffs. Lipids tend to break down during storage into free fatty aci ds.

4.1.1 Factors Affecting Deteriorative Processes

4.1.1.1 Environmental factors

Environmental factors that determine the extent of deterioration of stored feedstuffs al so affect the rate of growth of its insect and microbial population. These include ambi ent temperature and relative humidity. Other environmental factors relate to the gener al cleanliness of the storage areas and to design features of the storage building; e.g., p rotection against rain and insulation against scavenger pests.

4.4.1.2 Insects and micro-organisms

The role that insects and micro-organisms play in the breakdown of lipids in the feedst uffs they attack has been discussed earlier. The increase of fatty acids as a result of lip id breakdown is of particular importance in the storage of fish meal, cereal brans, and oil seed derivatives; e.g., copra, groundnut, and palm kernel meal. This increase in fre e fatty acids in improperly stored feedstuffs results in rancidity.

4.1.2 Rancidity

There are three major chemical processes that give rise to rancidity: oxidation, hydrol ysis, and ketone formation. Due to the relative unimportance of the other two processe s in stored feedstuffs only oxidation of fats will be described here.

4.1.2.1 Lipid oxidation

Rancidity resulting from lipid oxidation is the most important deteriorative change occ urring in stored feedstuffs. Feedstuffs containing lipids which are highly unsaturated (e.g., rice bran and fish meal), are especially susceptible to oxidation. The mechanism of lipid oxidation begins with auto-oxidation involving the direct reaction of lipids wit h molecular oxygen to form hydroperoxides. This is followed by secondary reactions yielding diperoxides if further oxidation takes place, or ketoglycerides if the hydroper oxides are dehydrated. Fission of hydroperoxides yield products containing carbonyl a nd hydroxy groups which will react further to form other products. Oxidation of carbo n-carbon double bonds in other molecules gives rise to epoxides and hydroxy glycerid es. These products of secondary oxidation of lipids contribute to 'off flavour' and inclu de toxic compounds frequently-associated with rancidity. Furthermore, carbonyl grou ps produced by the fission of aldehydic hydroperoxides can react with the epsilon - a mino group of lysine, thereby reducing the nutritive value of the protein.

4.1.2.2 Factors affecting lipid oxidation

The chief factors increasing the rate of lipid oxidation in stored feeds are as followss:

(a) enzymes the presence of lipoxidase and perhaps other enzymes as well

(b) hematin this factor is important in the storage of fish and meat meals

(c) peroxides these compounds which are themselves products of auto-oxidation of lip ids catalyze the oxidation of lipids

(d) light ultra violet light is involved in the photolysis of peroxides

(e) high temperature in general, the higher the storage temperature the more rapid the breakdown of lipids

(f) trace metal catalysis: many metals, notably iron, copper, cobalt, and zinc accelerate lipid oxidation. Iron and copper does this by direct electron transfer in redox reactions , while zinc induces the breakdown of hydroperoxide to free radicals.

Lipid oxidation can be inhibited by adding compounds known as anti-oxidants. Two c ommonly used feed anti-oxidants are ethoxyquin and butylated hydroxytoluene which sequester free radicals formed during oxidative processes. Cereal grains contain effect ive quantities of natural anti-oxidants (e.g. tocopherols) which impart considerable sta bility to their lipid contents, unless the kernels are damaged by storage pests.

4.1.2.3 Feedstuffs susceptible to lipid oxidation

Fish lipids are especially susceptible to oxidation due to the greater chain lengths of th e fatty acids and the greater number of unsaturated carbon-carbon bonds along the fatt y acid chains. Storage of fish meal is problematical, due to the frequent occurrence of exothermic oxidation which could lead to spontaneous combustion. The heat generate d also leads to amino sugar reactions which lower the digestibility of protein. Most fis h meals marketed commercially contain added anti-oxidant to inhibit lipid oxidation a nd thus reduce the risk of fire during sea transit and prolonged storage under unfavour able ambient conditions.

Other feedstuffs which have storage problems associated with high lipid content are ri ce bran and expeller oil cakes with high residual oil content. Among the latter, the mo st susceptible are copra cake and palm oil cake. This is due to the significant levels of unsaturated fatty acids in coconut and palm oil. The lactose contained in milk powder has a tendency to react with loosely associated milk proteins to form melanoids in the Maillard reaction. These sugar-protein compounds have very low digestibility.

4.2 Storing Feedstuffs

Some weight loss of feedstuffs during storage is unavoidable. The extent of loss is aff ected by:

(1) the general hygiene of the store, because that determines whether or not insects ca n breed in the buildings away from the produce;

(2) the turn-over of the goods, because they determine the length of storage;

(3) the way in which waste and odd lots are handled which determines whether or not large foci of infestation can develop in neglected produce; and

(4) the size of stacks and the closeness of packing. Most insect species are confined, m ore or less, to the surfaces of a stack, and weight loss is usually highest at the peripher y.

Sometimes, especially in the tropics and in imported produce, materials are infested be fore stacking. If the core of the stack is infested from the start of storage, then the heat of metabolism of the insects will raise the temperature in the core and, hence, the rate of increase of the insect population and the amount of damage done.

If the stack is small and much of the heat is dissipated, the temperature will remain fav ourable for insects and weight loss will be very great. If the stack is large, the accumul ated heat in the core will get too hot for the insects. After that, weight loss will occur o nly at the outside of the stack. For this reason, large stacks are advocated in the tropics . However, the high temperature has harmful effects that must be set against preventio n of weight loss. Continuous high temperature accelerates chemical degradation, espe cially for vitamin destruction and the development of rancidity.

4.0 CONCLUSION

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 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 different classes of 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. As such it is important to know the quality of feedstuff and it negative effect when fed to an animal and how these negative effects can be taken care of to enable the feed material consumable by the animal.

6.0 TUTOR-MARKED ASSIGNMENT

1. Compare the harmful effects of aflatoxin and ochratoxin in animal feed.
2. What is mycotoxicosis?
3. How is mycotoxicosis controlled?

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MODULE 4: FEED MILLING IN NIGERIA

Unit 1: Raw material handling,

Unit 2: Feed milling machineries and equipment

Unit 3: Feed milling process

Unit 4: Handling, leveling, storage and delivery of finished products.

UNIT 1: RAW MATERIAL HANDLING

CONTENTS

1.0 Introduction

Nigeria is known for its huge raw and solid minerals deposits. Unfortunately, today, only 46.71% of raw materials used by manufacturing industries are sourced within the country as most local manufacturers now source raw materials from other countries.

For a country with large deposits of minerals and raw materials like cocoa, rubber, iron ore, coal, animal skins, among others, there is no reason why local manufacturing industries should not not generate much of their raw materials locally. Experts however believe that the ability of any nation to engage in the transformation of raw materials to finished goods significantly develops its economy.

2.0 Objectives

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

- Understand what is Feed millings are.
- Different types of feed milling machines.
- Source of raw materials for feed milling.

3.0 MAIN CONTENTS

3.1 Classification of Raw Materials

Raw materials needed for industrial use could be classified into four (4) major classes, namely:

- Unprocessed Agricultural Products – these are usually in their natural state, like Cassava, Yam, Grains, Fruits, and Vegetables etc.
- Semi-Processed Agricultural Products – they are in the form of dry cocoa beans, dry sugar, pasteurized milk, grain flour, cocoa mass, malted grains.
- Finished Products - of a particular industry can serve as raw material or ingredient for another industry, e.g refined granulated sugar, starch, ascorbic acid, flavor, etc.
- Bye –Products or Effluent - of an industry can serve as input for another industry, as molasses can be used for the production of alcohol and yeast,

while the biscuit dust can be used for production of animal feed (livestock and fishery)

However, to facilitate a streamline presentation, the Nigerian food industry can be divided in two Major categories:

- Milling Industries: Flour mills, Rice mills, Edible oil mills etc
- Processing Industries: Beverages, Cereal products, Dairy products, Confectionery, Fruit and Vegetable products, Meat and Poultry products.

Each of these can derive all tier raw materials locally. The milling industries requires mainly agricultural products and the outputs are generally finished products offered for sale as domestic food items after suitable packaging. There are three broad categories of raw materials, namely primary agricultural produce, secondary and tertiary raw materials.

3.2 Methods of Sourcing for Raw Materials

In sourcing, there is a general principle that most industries use. The aim of sourcing is to obtain the best quality raw materials at a most economical rate. In Nigeria, the approaches used include direct, indirect or combination of the two.

3.2.1 Direct Source

This requires the establishment of raw material purchasing department in the industry, which is charged with the responsibility of getting the required raw material for the industry. Where in-direct sourcing is used, the problem of monitoring specification of raw material can be reduced. This is because such quality specifications are built into the production system.

3.2.2 In-Direct Source

This is the opposite of direct source. When such materials have to be purchased, the raw material specifications must be given to the supplier.

3.3 Limitations and Constraints of Local Equipment

- Many of the raw materials, especially seasonal ones such as Maize, Yam and Fruits are inadequate for industries due to the fact that they are used as staples and also due to low production from non-implementation of agricultural mechanization. This unavailability leads to instability of price.
- The finishing of most of the locally manufactured equipment is/are of low quality, as a high percentage of fabrications depend on the untrained/uneducated fabricators.
- The range of equipment resolves round already known technologies.
- The prevalent unit cost of equipment, although cheaper than imported ones, is still too high with a resistant effect that only few can afford them.
- The ‘me too’ copy technological development characteristics of Japan, and Asian countries is bound to be greatly hampered in Nigeria with the non-availability or limited number of founding facilities and petrochemical products necessary for food processing and packaging equipment.

- Stainless steel and aluminum, which are required for building food containing components of machines are not produced locally but imported.
- Absence of pilot plant stage where the developed equipment could be evaluated for technical economic and operational feasibility under real condition make many attempts at equipment development a mere academic exercise.

4.0 CONCLUSION

By the end of this unit, you should be able to know the importance of the milling industry in Nigeria cannot be over emphasize and neglected even thou this sector has not been fully exploited but recent development in the Sector has given a new hope and direction in fulfilling and maximizing its full potentials to the benefits of both humans and to all animals. This has indeed, simplify workloads and has also made work faster with greater precision.

5.0 SUMMARY

In this unit, you have learnt the different types of raw materials and there sources. You also learn challenges facing the mill industry and type of milling machines used.

6.0 TUTOR-MARKED ASSIGNMENT

1. State the different types of milling machines you know
2. Name the different sources of raw materials used in milling.
3. Explain the Nigeria milling Industry

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UNIT 2: FEED MILLING MACHINERIES AND EQUIPMENT

CONTENTS

1.0 INTRODUCTION (Macro-Economic Overview)

Over the last few years, the Nigerian economy has experienced a series of reforms and restructuring of its key sectors. Such reforms include the Financial, Petroleum, Power Sector, among others. The financial sector reform has been the most noticeable as the banks and insurance companies have been mandated to recapitalize in line with government regulatory requirements. The telecommunications industry also experienced a major transformation when the general system for mobile telecommunications (GSM) was introduced in 2001. The deregulation of the downstream petroleum sector and privatization of many previously government-owned parastatals also represent some of the many structural changes that have been made in recent years.

A noticeable trend in the economy's growth pattern is the increasing contribution of the non-oil sector, particularly the agricultural and manufacturing sectors to the nation's GDP. It is expected that in the years ahead, other key sectors such as construction, consumer goods and tourism may begin to play more important roles in overall economic growth and development. As the on-going economic reforms continue to trickle down into other segments, and barring any unforeseen circumstances, we expect a much more balanced and self-sustaining economy in years to come.

2.0 OBJECTIVES

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

- Understand what is Feed millings are.
- Different types of feed milling machines.
- Source of raw materials for feed milling.

3.0 MAIN CONTENT

3.1 Nigeria's Milling Industry

3.1.1 Animal

In the Animal Feed Milling Industry, different materials (Cereals, Coarse powders, and Fine powders, Mash, Bran, Liquids and Molasses) are milled, fed and weighed, and mixed together including additives to obtain the final product.

Corn, Sorghum, Wheat and Barley are the most used cereals in the preparation of feed for the livestock, poultry, swine, and fish industry. Roller and Hammer mills are the two types of processing equipment generally used to grind grains into smaller particle sizes. Milling cereal grains by mechanical action involves several forces like compression, shearing, crushing, cutting, friction and collision. The particle size of the ground cereal is very important in the animal feed production, smaller particle sizes increase the number of particles and the surface number of particles and the surface area per unit volume which increase access to digestive enzymes.

3.1.2 Flour

Feed Mill is a process and/or a combination of processes used to produce a processed food for fish, animal or human consumption. The Nigerian Flour Milling industry ('the industry') comprises a large number of players that can be segmented on the basis of their installed capacity. The top two players have an installed capacity of approximately 11,000 MT per day and control over 65% of the market. Given the industry's high fixed cost regime, profitability is largely dependent on the company's ability to increase volumes.

Shortages of cassava flour coupled with surging wheat prices at the world market are adversely affecting the operations of flour milling companies in the country. In the flour mills industry, almost 90% of the raw materials are imported because Nigeria's climate is not viable for production of wheat. Rising prices of wheat is therefore a major challenge being faced in the industry as a ton of wheat is currently priced at between $180 and $240 respectively.

Another major challenge is the problem of low capacity utilization and erratic power supply by the state owned Power Holding Company of Nigeria (PHCN). Rising prices of refined products has also led to an increase in general overheads as many manufacturing concerns are compelled to source alternative forms of power generation. These financial pressures invariably make the unit cost of doing business in Nigeria relatively expensive.

Wheat consumption in Nigeria at 69g per capita is currently among the lowest in the developing economies. With a population of over 140 million as well as a projected population growth rate of 3%, there is still a lot of room for growth in flour consumption in the immediate future. This to a large extent will however depend on certain exogenous factors such as inflation rate and availability of substitutes among others. Tariff policies and other government regulatory requirements may however hinder the supply capacities required to meet up to the expected increase in demand.

There are currently 21 flour milling companies in Nigeria. Unfortunately, about 80% of market share is dominated by only 6 of the 21 firms and as such there's a lot of disparity between the 'big players', the 'mid-size firms' and the 'smaller companies'. The 6 major players by market share include:

- Flour Mills of Nigeria Plc
- Dangote Flour Mills Plc
- Ideal Flour Mills Ltd
- Honeywell Flour Mills Ltd
- Standard Flour Mills Ltd
- Crown Flour Mills Ltd

As a result of the strong hold of the total market by the 'big 6', there are 'invisible entry barriers' for prospective and aspiring flour millers. Keen competition exists only within the various tiers of the market with occasional movements between the small and mid-tiers. There however exists a wide gap between the top tier category and the other companies in the sector.

The Flour Milling industry in Nigeria has a total installed capacity of over 22,000 metric tones with Flour Mills of Nigeria controlling about 38%. Other top producers by installed capacity include Dangote Flour Mills (18%), Honeywell, Ideal Group and Crown Flour with 7%, 14% and 8% respectively.

3.2 Industry Characteristics

The Nigerian Flour Milling Industry is characterized by many key features which distinguish it from other sectors of the economy. With turnover and earnings driven primarily by market share and capacity utilization, the major determinant of success among its players is organic growth. A summary of the said features include:

- Stiff Competition

  The level of competition that exists within the industry is extremely keen. With the success of each individual company hinged on its ability to gain market share, industry players go through various lengths to increase capacity. Also, being an oligopoly the pricing is determined by the Flour Millers Association who would determine a 'fixed' price which the producers are not allowed to exceed. This 'sticky' price is however often violated especially by the companies which control reasonable share of the market.

- High Volumes

  The flour Milling Industry is volume driven with most of the producers scrambling to get increased capacity in order to boost production and sales. Due to high overheads as a result of heavy cost burdens, margins within the sector are relatively thin and as such earnings are determined by ability to increase sales. Therefore, the more profitable firms are those that are capable of out-producing the competition while keeping costs relatively stable.

- Heavy Cost Outlay

The Flour Milling Industry is largely dependent on imported inputs. The basic raw material for flour processing is wheat and it is estimated that about 97% of the wheat that is used by flour milling companies is imported. With high tariffs being imposed on imports, the cost of producing flour in Nigeria is very high. Many prospective companies are either forced out of business or have to grapple with very thin margins and therefore cannot compete effectively.

- Seasonal

  The existence of seasonal variation is prevalent in the industry. Demand for wheat based foods is usually higher in the dry season (between March and September) while the wet season is characterized by demand for other substitute foods such as maize, groundnuts etc. These foods are cheaper and are more readily accessible and therefore in higher demand when available. The strategy therefore is to take advantage of the 'peak periods' by aggressively growing volumes while reducing their outputs during the 'off-peak' periods in line with forces of Demand and Supply.

- Price Sensitive Demand

  Being a staple food with many substitutes within the consumer goods industry, the products are characterized by high elasticity of demand. Any slight increase in price could lead to a higher decrease in quantity demanded as consumers will instantly shift their preference to other cheaper substitutes. Also, quality control standards are a key feature of the flour milling industry with producers constantly improving on the quality of their products in order to retain customers. The demand for flour is therefore dependent on several factors such as quality, price of substitutes, seasons as well as other exogenous factors.

3.3 Critical Success Factors

- Capacity

  One major critical factor for the success of flour millers is capacity. Being a volume driven market, the ability to constantly increase its production capabilities clearly distinguishes the more successful players from the less successful. The ability to increase capacity is also directly related market share, ultimately leading to greater output and profitability.

- Marketing Strategy

  Aggressive marketing is a significant factor for the success of flour millers. Being a manufacturing related industry with keen competition among its players, large resources should be deployed towards promotions, advertisements and general publicity. Various media for marketing are usually deployed such as print (newspapers and magazines), electronic (TV, radios and internet) as well as billboards and sponsorships of events /programmes. All these efforts create awareness in the minds of consumers, invariably leading to greater patronage.

- Adequate Distribution

  An effective and efficient distribution network is a key requirement for the success of flour millers in Nigeria. Since flour is consumed in virtually all areas of the country, it is pertinent that the end product gets to the final consumer as at when needed. Also, the demand for flour is heavy in certain areas and as such producers should ensure a higher preference in such areas. Adequate distribution network therefore compliments the productive and marketing strategies of the companies.

- Good Management

  Just like in any other industry, an essential ingredient for success lies in the quality of its management team. The track record, experience and competence of top management determines to a large extent the ability to grow volumes and margins. Most of the flour milling companies are owner managed and so it bestows on the owners to clearly distinguish family from business. Also, competent staff should be employed in strategic units to ensure a positive impact on the company's bottom line.

- Adequate Storage Facilities

  Wheat is essentially a perishable commodity, therefore adequate storage remains a key success factor. With proper storage in place, losses and wastages due to spoilage and deterioration will be reduced to the bearest minimum. With companies incurring high cost outlays due to overheads from distributing, marketing and other miscellaneous costs, reduction of wastages will greatly help reduce overall cost burden and help improve profitability. Storage Facilities should therefore be situated close to distributors in order to reduce turnaround time and to save costs. In addition to the quality of the facilities, they should also be kept safe to prevent losses from theft and pilferation.

- Pricing

  Pricing within the flour milling market is regulated primarily by the Flour Millers Association. However, the big players prefer to set prices which are higher than the fixed price in order to increase their margins and grow profits. Since costs are very high, most producers usually make the 'extra cash' through optimal pricing of their products.

3.4 Challenges & Risk Factors

Regulatory and Operating Environment Due to the strict and highly regulated operating environment in which flour millers operate, import duties, levies, taxation and other encumbrances impose heavy burdens on manufacturers thereby increasing overall cost of production. Such heavy overheads reduce producers' overall margins.

- Lack of Sufficient Infrastructure

  The problem of infrastructure continues to be the bane within the real sector of the economy. With erratic power supply from the Power Holding Company of Nigeria (PHCN) as well as lack of adequate amenities such as water supply and good roads, distribution and marketing costs are continually on the increase. Since flour millers require constant electricity to run their heavy duty machinery, its inadequacy and/or ineffectiveness imposes heavy financial burdens.

- Low Demand for Wheat

  Comparatively, demand for wheat in Nigeria is very low. Official statistics suggest that at 69g per capita, wheat consumption in Nigeria (relative to its 2006 population figure of 140 million) is below that of other developing economies such as Syria (490g), Turkey (484g), Chile (370g), Egypt (397g), Argentina

(344g) and South Africa (318g) with much less population headcount. This demand inadequacy creates supply gaps especially in certain areas where demand is extremely low.

- Continuity

Most flour milling concerns have issues of continuity since a large portion of their equity contribution is dependent on single individuals. Only 3 of the 21 flour milling companies are quoted while the 18 private companies are characterized by sole ownerships by key men. As such, the instance of death or incapacity of the individual owners renders the companies concerned vulnerable to possible financial crises and/or liquidation.

- High Cost of Operations

Even though the industry is highly competitive with free entry and exit, the existence of high initial set-up costs means that only high net worth individuals and/or institutions have access to the financial capital required to run the business. Also, the high cost structure and capital intensive nature of flour milling imposes huge economic difficulties for prospective and existing manufacturers.

- Foreign Exchange Fluctuation

Due to poor climatic conditions, majority of the wheat used by local manufacturers is imported especially from countries like the US and Brazil. Such practices create foreign exchange risks as currency volatility sometimes works against the producers. However, the recent appreciation of the naira against the dollar seems like a good omen which would help hedge against such risks.

- Inflationary Pressures

In the past, inflationary pressures have been a major impediment to the growth of producers. Official figures from the Federal Office of Statistics (FOS) suggest that the consumer price index has been on the rise for the few years. However, due to Nigeria’s economic recovery programme, inflation is now on a steady and consistent decline having attained single digit figures in recent times.

3.5 TYPES OF MACHINES

A milling machine is a tool in the metal industry that has numerous functions. Each machines as a cutter that operates at a various range of speed so you can form the required shape. With its adjustable feature, each milling machine can be regulated for a more precise cut. The machines is capable of handling multiple tasks such as carving, threading, milling, drilling and cutting.

Milling machines comes in various types with a variety of functions based on certain standard specifications. Some of the commonly used machines are the following:

3.5.1 Hammer Milling

In the feed process there maybe a number of ingredients that requires some form of processing. These feed ingredients include coarse cereal grains, corn which require particle size reduction which require particle size reduction which improve the performance of the ingredient and increase the nutritive value.

Advantage

- Are able to produce a wide range of particle sizes
- Ease of use
- Lower initial investment when compared with a roller mill
- Minimal maintenance needed
- Particles produced using a surface that appears polished.

Dis-advantages

- Less energy efficient when compared to a roller mill
- May generate heat (source of energy loss)
- Produce greater particle size variability (less uniform)
- Hammer mills are noisy and can generate dust pollution.

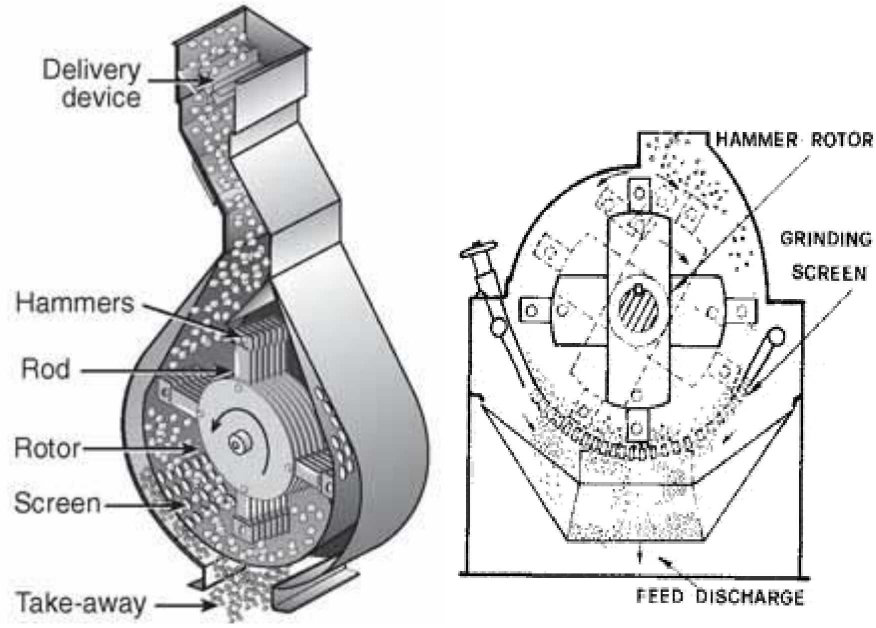


Diagram of a Hammer Mill Machine

3.5.2 Feed Mixer

The feed will not be the balanced formulation it is designed to be unless it is properly mixed. Dry mixers are a mechanical means of achieving this and come in two (2) main types – vertical mixers and horizontal mixers.

3.5.2.1 The **Vertical Mixer** consists of one or more vertical screws which elevate the ingredients to the top of the mixer where they fall by gravity to the bottom, to be mixed and re-elevated. Vertical mixers are the most common type found in small livestock feed mills. However, the vertical type is less well suited to aquaculture, poultry and fish feeds than the horizontal type, which are much more efficient in blending in small quantities of liquids (such as added lipids) or in mixing ingredients with different particle sizes.

Diagram of a Vertical Feed Mixer

3.5.2.2 The **Horizontal Mixers** Consist of a series of paddles or metal ribbon mounted on a horizontal rotor within a semi-circular trough. The Mixers usually discharge the mixed product from the bottom, using the same mixer blade action.

Diagram of a Horizontal Feed Mixer

Another type of mixer, which is similar to the horizontal type in action, has a bowl-shaped or flat-bottomed container in which a series of paddles are mounted on a spindle driven by a motor mounted either above or below the mixer. This type of mixer has the same advantages over the vertical type of mixer as the horizontal mixers mentioned earlier. In addition it is cheap and is therefore frequently used in farms, particularly in South East and South Asia. It can also be used for mixing moist feeds.

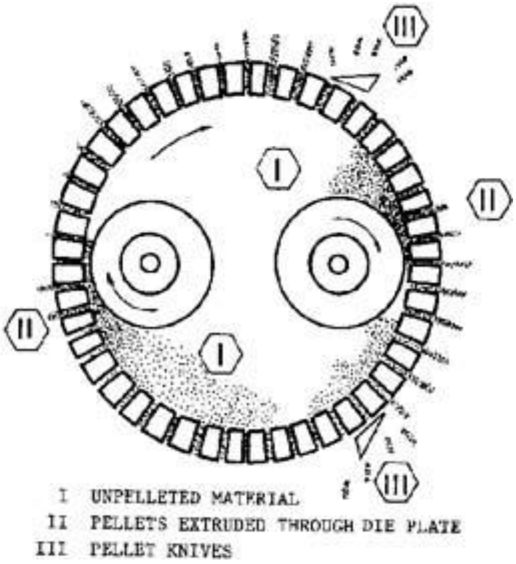
Vertical mixers are unsuitable for mixing wet ingredients. Horizontal mixers are most suitable but, because of their complex construction, are often difficult to clean properly. Efficient mixing is the key to good feed production.

Mixers (For wet feed ingredients, a bowl-shaped or flat-bottomed container)

3.5.2.3 Pellet Mills

The process of pelleting consists of forcing a soft feed through holes in a metal die plate to form compacted pellets which are then cut to a pre-determine size. The machinery which has been developed for this purpose is now very diverse in design and there is much controversy between different equipment manufacturers as to which type is the most effective. Pelleting is a key to the production of high quality nutritional feeds as they ensure that the feed formulation is in the correct quantities for all that eat them. Each bite of a pellet will have the same designed formulation ensuring all the stock are feed as intended.

Most pellet mills now have one or more conditioning units mounted above them where liquids such as water and molasses can be added to improve pelletability. The water is sometimes added in the form of steam which softens the feed and partially gelatinizes the starch content of the ingredients, resulting in firmer (and for aquafeed more water solubles) pellets.



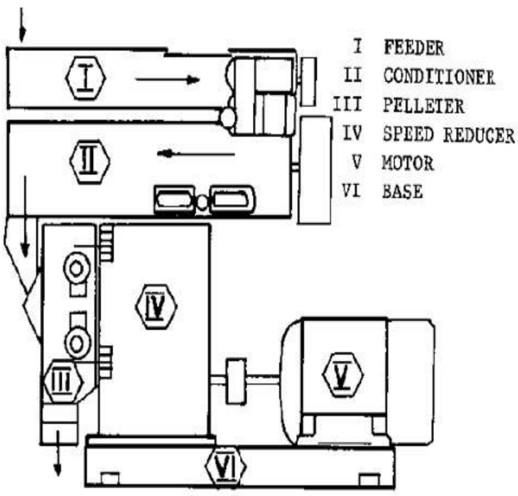


Diagram of Pellet Mill Machines and Parts

3.5.2.4 Extruders

Extruders are the machinery used to produce extruded pet food, (floating) extruded aquactic feedsand extruded animal feeds. The extrusion cooking process, because it causes a high level gelatibisation of starches, results in feeds with good water stability. It can produce “expanded” flaoting feed as well as sinking pellets. The process also improves the digestibility of the products. However, extrusion cookers are usually very large and expensive to purchase and operate.

Feeds which have ingredients such as soyabean meal and cereal grains can be made more digestble, and the nutrient are therefore more available. Floating feeds are made using extruders along with highly water-stable sinking feeds which can be made with extruders as well.In some cases, extruders are used just to prepare feed materials, such as dry extrusion of soyabeans.

Basically, an extruder is a long barrel with a screw auger inside which is specially design to subject feed mixtures to high heat and steam pressure. When feed exit the die at the end of the barrel, trapped steam blows off rapidly, the soft warm pellets expand, and a low density floating pellet is produce. Extruders are very versatile, and can make feed with many different characteristics. The main problem with extruders is that, they are expensive to buy and maintain, and the feed manufacturers pass this cost on to feed buyers.

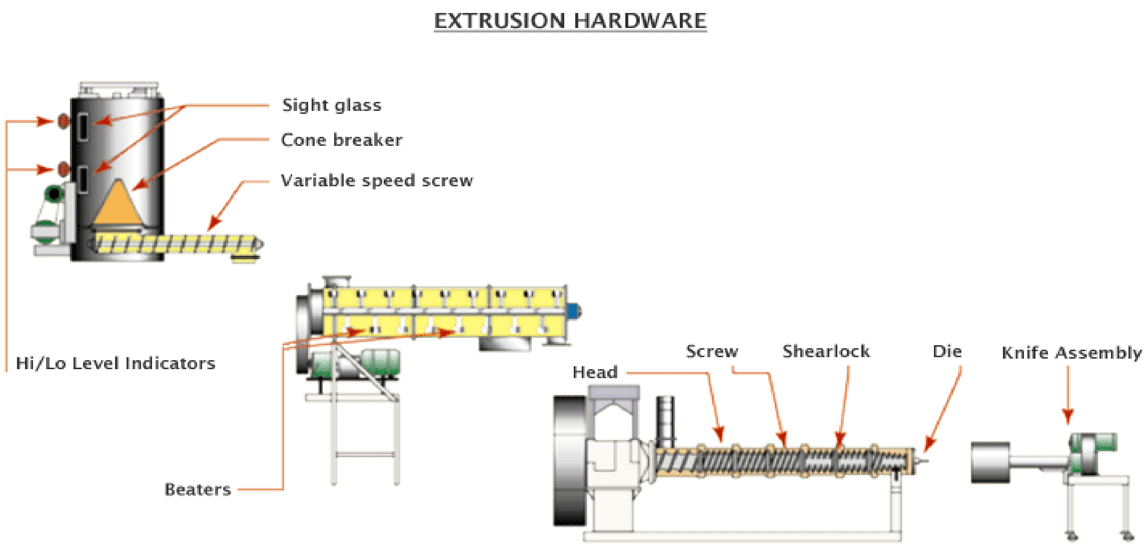


Diagram of an Extruder Machine

3.5.2.5 Crumbler (Pellet Feed)

A crumbler is a roller mill with rolls specially designed for breaking up pellets into smallers particles. Usually, the crumbler consist of two (2) corrugated rolls situated below the cooler/dryer exit. Th pellet can then be diverted into the crumbler, if crumbles or granules are desired, or they can bypass it.

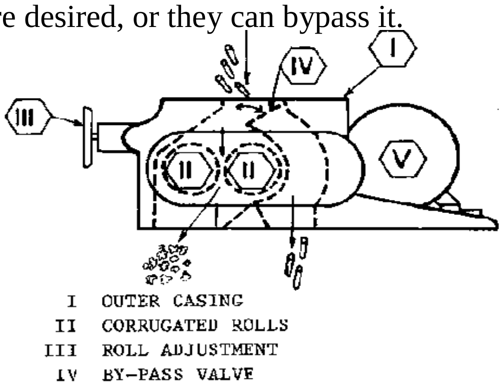


Diagram of a Crumbler Machine

3.5.2.6 Dryers (Pellet Feed)

Pellets from dry pelletters may exceeds at up 88^0C and 17 -18% moisture. The temperatire must be quickly reduced to an ambient or less and the moisture level to 10-12% or less for proper storage and handling. Pellets must therefore be cooled or dried. Moist pellets, if they are going to be converted to dry pellets, also need drying although their temperature is not normally much elevated during manufacture.

Coolers/Dryers are of two (2) basic types namely Horizontal andVertical

In the **Horizontal** type of cooler/dryer the pellets are conveyed on a perforated steel mesh or moving belt through which a cooling air stream is passed. The horizontal method is best for “sticky” dry pellets or for moist feeds (if it is necessary to dry the latter). Heat can also be applied to the air supplied to horizontal driers for reducing the high moisture contents of moist feeds to those of dry pellets for storage. This type of drier is standard in production in production of noodles and spaghetti and other pastas. Horizontal dryers may be very large and often arranged on several spatial levels.

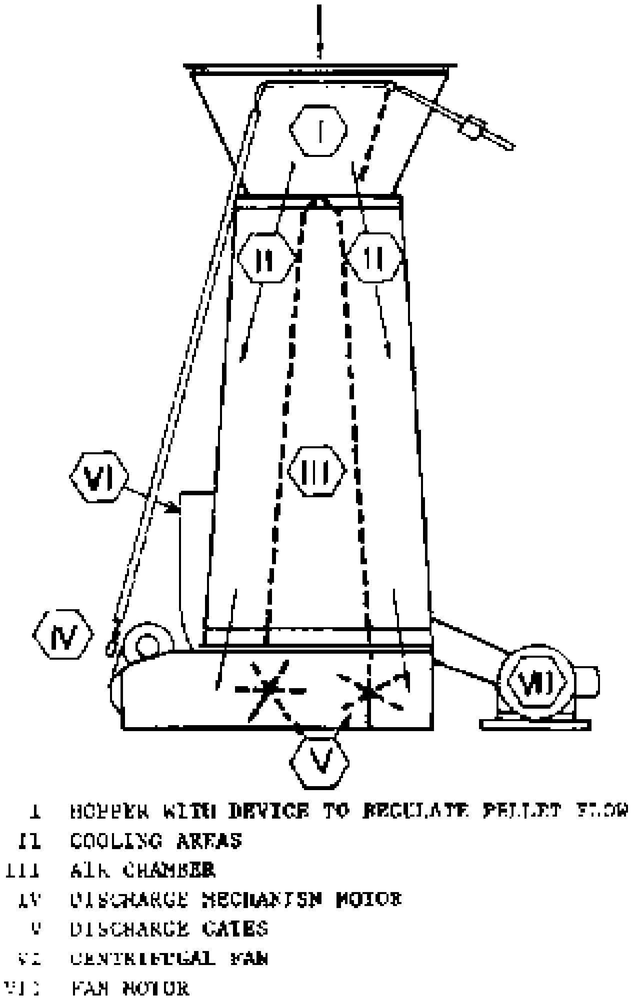


Diagram of an Vertical Dryer

In the **Vertical** type of dryer, pellets usually run by gravity into a chamber through which air is sucked by a fan.

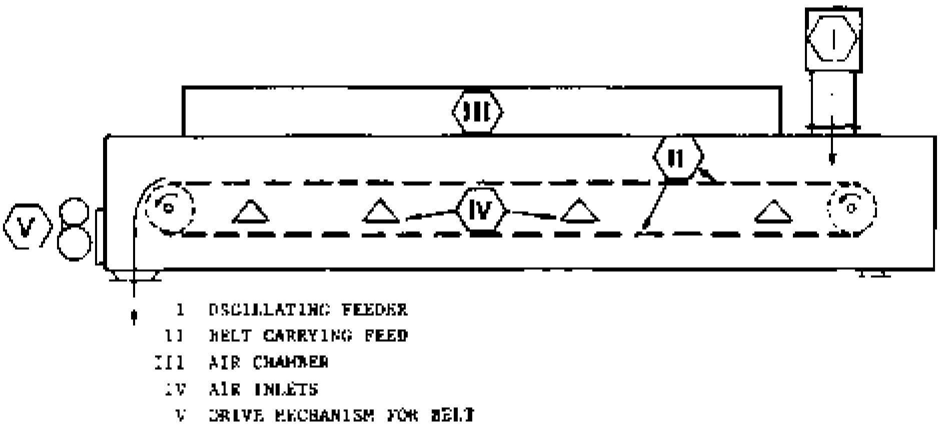


Diagram of an Vertical Dryer

Other milling machines include the following

1. **Column**
   This is the most common milling machine which has 5 basic components, they are the work table, saddle, head, knee and over arm. Considered as the simplest machine type, its cutting device is vertically suspended to all cutting device is vertically suspended to allow drilling of metals. This is typically used when creating car parts because it is small and handy.

2. **Turret**
   The turret is also known as the Bridgeport-type and can be reposition anytime you want making this machine very functional. Its versatility makes it more practical since a variety of products can be made in addition to car parts.

3. **C-frame**
   Because it is sturdier than a turret, this type is popular in industrial settings. It comes with a hydraulic motor, which makes it very powerful.

4. **Horizontal**
   The machine runs parallel to the ground. The table from which the object to be worked on is placed moves sideways while the cutting device goes up and down.

5. **Bed type**
   The worktable is located on the bed itself, instead of being paced on top, its usual position. The knee part of the machine is omitted to allow movement in a longitudinal direction.

6. **Planer-style**
   This machine type is basically the same as the bed mill. However, the planner-style includes cutters and heads that allow for a wider range of milling actions.

7. **Tracer controlled**
   This type o machine has the ability to reproduce parts based on master model. Most of the industrial sectors, especially the automotive industry, choose this type of machine because it make production and specialization of machine parts easier. With the vast classifications of milling machines, you need to choose the one you need according to how you intend to use it. However if you find it difficult to decide, do not hesitate to seek the help a specialist who can help you select the one that will give you maximum benefits.

UNIT 3: FEED MILLING PROCESS

CONTENTS

1.0 INTRODUCTION

The process of manufacturing animal feed is a means whereby raw materials of widely ranging physical, chemical and nutritional composition can be converted into a homogenous mixture suitable for producing a desired nutritional response in the animal to which the mixture is fed. The process is basically a physical one and chemical changes are few. It should be remembered however that some raw materials will have undergone extensive processing prior to inclusion into a mixed feed, for example, extraction of oil from oilseeds by solvent or mechanical extraction, heat treatment of soya beans or other beans to denature anti-nutritive factors, or the production of fishmeal and meat meal.

The feed manufacturing process may be considered to be made up of several unit operations which, in almost all circumstances, include the following:

***raw material, storage and selection
***raw material weighing
***raw material grinding
***mixing of dry ingredients and addition of liquids
***pelleting of mixed feed (optional)

***blended feed bagging, storage and dispatch.

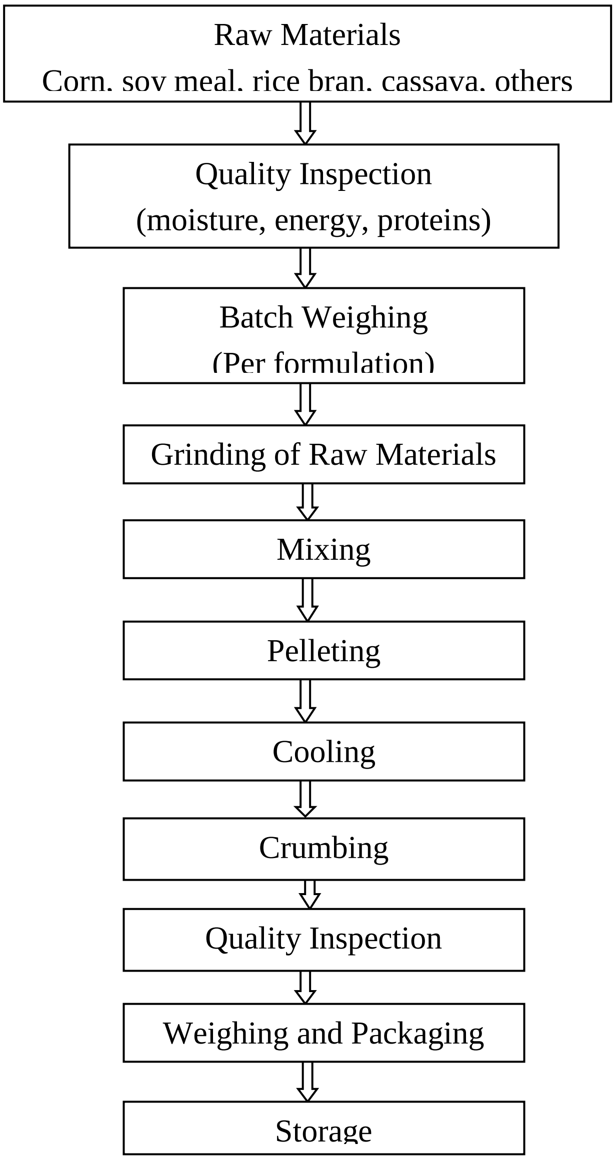
2.0 OBJECTIVES

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

- Understand what is Feed millings are.
- Different processes of feed milling.

3.0 MAIN CONTENT

3.1 Feed Manufacturing Process



Depending on the type of feed, the manufacturing process usually start with the grinding process. The figure above illustrates the workflow for general feed manufacturing process. Grinding of Feed manufacturing process selected raw material is to produce particle sizes to be optimally and easily accepted by the animals. Depending on the formulation, feed could contain up to 10 different components including carbohydrate, protein, vitamins, minerals and additives. The feed ration can be pelleted by proportionally homogenizing the specific compositions. Pelleting is achieved by various methods, but the most common means is by extrusion. A hygienic environment is important during the entire process of the feed production to ensure quality feed.

When making feeds, manufacturers consider the age, production level of the animal, species and the cost of the feed.

They then play around with figures using Pearson Square method or a computer software such as Win feed to attain the optimal theoretical nutritional levels of the formulated mash.

After formulation, some feeds are further processed into pellets by either hot or cold processing. Pellets are either formed using pelletisation or extrusion technologies. Proteins and starch forms a larger percentage of these formulations. Proteins are made up of amino acids as building blocks joined together by peptide bonds.

On the other hand, starch is a polymer of amylose and amylopectin monomers having both hydrogen and glycosidic bridges.

Poultry, swine and fish are monogastrics (have single-chambered stomach), therefore, rely on enzymatic hydrolysis of complex food components in the fore stomach. Sometimes these feeds are not effectively hydrolysed. This reduces their absorbability, impairing both the growth rate and performance of animals. Therefore, further processing of the raw formulated mash is necessary.

3.2 Manufacturers use different processing method namely:

3.2.1 Cold processing

Feeds are processed at or lower than the ambient temperature. These processes include grinding in the hammer mill, size reduction, soaking and reconstitution of dried feeds. These processes mostly influence the physical appearance of the feeds but less or no, modification on the chemical properties of the feeds. Feeds under these categories are the mash forms.

3.2.2 Hot processing

Heat treatment is applied to animal feeds to improve hygiene, nutritional quality and physic-chemical properties. Thermal energy is applied to either dry or wet ingredients such as soybeans or cereals. The aim here is to soften the seeds, modify the starch or denature the anti-nutrients such as trypsin inhibitors.

This procedure is common in steam rolling, roasting and steam flaking methods of feed processing. Steam flaking differs from steam rolling because of the high moisture content applied and the higher contact time. This process has been seen to increase starch digestibility from 22.7-51.2 per cent. These feeds therefore, increase the performance of the reared animals.

3.2.3 Popping

It is a dry hot feed processing method that is applied to the seeds. This process causes sudden rapture of the endosperm. The seeds are then rolled before being fed to the animals.

3.2.4 Pelletisation

It is another hot processing method. It involves grinding and formulating feed and then forcing it through a thick, spinning die with the use of rollers. The feeds can be made in different diameters, length and hardness. This process alters the physic-chemical properties of the feeds due to the high pressure used. Losses are minimal during feeding and transportation because the pellets do not easily break. Pelleting increases growth rate and feed efficiency by 6.6 to 7.9 per cent respectively.

3.2.5 Extrusion processing

This recent technology operates on three principles: steam conditioning, high temperature cooking and high shear pressure. The process starts by formulation and tempering the mixture to about 30 per cent moisture content. Steam conditioning is the first step in this method. The aim of this step is to facilitate die lubrication and feed particle adhesion.

This increases pellet durability index and gelatinise starch. Broilers fed extruded pellets have a higher feed intake, this, therefore, increases live weight gain compared to those fed the mash.

Extrusion combines three parameters of **moisture, high temperature** and **pressure** to modify the starch and protein enhancing their digestibility.

There has been better performance in swine, fish and poultry fed on extruded pellets than those fed on the mash. The better performance can be attributed to:

The heat used in feed conditioning breaks down starch into its constituent monomers that are further broken down to monosaccharaides. On the other hand proteins are broken down into smaller polypeptides. This enhances feed digestibility due to the large surface area exposed to the enzyme hydrolysis, hence better performance of animals fed these feeds.

- During pelleting, the nutrients tend to concentrate in the product and pellets are also bound together. This minimises wastage during feeding and transportation hence increasing average daily gain.
- It improves energy digestibility in cereal based diets due to starch gelatinisation, unlike in the mash leading to better performance of early weaned pigs fed extruded feeds.
- Helps in improved faecal digestibility of some amino acids in chicken.
- Increases digestibility of proteins, amino acids and nitrogen by denaturing of the former and modifying side chains of amino acids. Starch gelatinisation together with the above changes on proteins results in better digestibility, increase feed intake, improved feed conversion ratio and performance in chicken.
- Extrusion results in starch gelatinization which makes it more susceptible to amylase, this enhances starch digestibility. This improves poultry performance.

3.3 Grain Milling for Feed

Preparations

Corn, sorghum, wheat and barley are the most used cereals in the preparation of feed for the livestock, poultry, swine, and fish industry. Roller and hammer mills are the two types of processing equipment generally used to grind grains into smaller particle sizes. Milling cereal grains by mechanical action involves several forces like compression, shearing, crushing, cutting, friction and collision.

The particle size of the ground cereal is very important in the animal feed production; smaller particle sizes increase the number of particles and the surface preparations area per unit volume which increase access to digestive enzymes. Other benefits are increased ease of handling and easier mixing of ingredients. The average particle size is given as geometric mean diameter (GMD), expressed in mm or microns (μm) and the range of variation is described by geometric standard deviation (GSD), with a larger GSD representing lower uniformity. According to Lucas (2004), GMD and GSD are accurate descriptors of particle size distribution when the particle size distribution is expressed as log data, and are distributed log normally. Studies have shown that grinding different grains with the same mill under similar conditions results in products with different particle sizes. The hardness of a grain sample is related to the percentage of fine particles obtained after grinding, with a higher percentage of fine particles from lower hardness grains. Rose et al. (2001) discussed that hard endosperm produces irregularly-shaped larger particles, while soft endosperm produces smaller size particles. The correlation between particle size and energy consumed is although not positive but, to obtain very fine particle sizes require higher energy which reduces the rate of production. Moreover, a very fine grind of grain has no impact on the efficiency of pelleting, nor on the power consumed during pelleting. Amerah et al. (2007) discussed the availability of more data suggesting grain particle sizes are very important in mashed diets than in pelleted diets.

4.0 CONCLUSION

Classification of raw materials, methods of sourcing of raw materials have been look into in this unit.

5.0 SUMMARY

In this unit, you have learnt that:

- there are different sources of raw materials for milling.
- there are limitations and constraints to use of local equipment

6.0 TUTOR-MARKED

1. Classify raw materials
2. How do you classify raw materials?

7.0 REFERENCE/FURTHER READING

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UNIT 4: HANDLING, LEBELING, STORAGE AND DELIVERY OF FINISHED PRODUCTS.

CONTENTS

1.0 INTRODUCTION

A commercial feed is nutritionally suitable for its intended use as represented by its labeling. A feed label allows the purchaser to select a product to meet their production needs. A label provides basic product information that would help the purchaser determine how to use the product safely and obtain the best benefits and results. In addition, a label of uniform format and composition provides a level field of play for both the purchaser and distributor.

2.0 OBJECTIVES

In this unit, you are expected to know:

- how to handle finished products
- store finished products
- transport such products without been damaged

3.0 MAIN CONTENTS

3.1 HANDLING

Small items, details and small assemblies are normally stored on toolmakers benches. Toolmakers are responsible for obtaining suitable containers for storage or movement within the factory if required

For larger items and assemblies a hand operated or electrically operated forklift shall be used The Operations Director is responsible for providing and maintaining handling equipment and the Employee is responsible for ensuring that the correct handling methods are used.

3.2 LEBELLING

3.2.1 Commercial Feed Labels

A commercial feed can be a feed ingredient or a combination of feed ingredients which are distributed to be fed to animals. The label for each package or bulk delivery of commercial feed products shall contain all of the following information in this specified order: • The product name and its brand name, if any • The purpose statement for the feed (identifying specific species and animal class(es)) • The guaranteed analysis statement • The ingredient statement • Directions for safe and effective use (commonly known as “Feeding Directions” or “Mixing Directions”) and any required precautionary statements to enable the safe use of the product by users with no special knowledge of the purpose and use of the product. • The manufacturer’s or distributor’s name and address • A quantity or net weight statement, in both standard (avoirdupois) and metric units

3.2.2 Single Ingredient Product Labels

A single ingredient, other than those exempted by the Model Bill and Regulations, is still considered a “commercial feed”. However, with all the varieties of ingredients available with a multitude of purposes and uses, it is necessary to provide some information in order to ensure correct labeling of these products. More information can be found after Commercial Feed Label Requirements. The label for each single ingredient feed shall contain all of the following information: • The product name and its branded name, if any • The purpose statement “Single Feed Ingredient”, “Feed Ingredient” or “For Further Manufacturing of Feed”, as appropriate • The guaranteed analysis statement • The ingredient statement if the ingredient is not used as the product name • Directions for safe and effective use and required precautionary statements, if any • The manufacturer's or distributor's name and address • A quantity or net weight statement.

3.2.3 Customer Formula Feed Labels

A "customer-formula feed" is a commercial feed which consists of a mixture of feed ingredients and/or commercial feeds which is manufactured according to the specific instructions of the customer. A customer-formula feed must be accompanied by the information listed below using a label, invoice, delivery ticket, or other shipping document. The label for each delivery of a "customer-formula feed" shall include: • Manufacturer's name and address • Purchaser's name and address • Date of delivery or sale •

The customer-formula feed name and brand name, if any • The complete name and net quantity of each commercial feed and each other ingredient used in the customer-formula feed • Directions for use and precautionary statements, if required

3.3 STORAGE

Steel stocks, when received, shall be colour coded in accordance with the Colour Coding of Stock Metals Chart TK-QF-039 kept up to date in the steel stores and stored in the correct rack within the area designated as the 'steel stores'. It is the responsibility of the Production Manager to see that this is done correctly. In certain circumstances the material may be passed directly to the toolmaker that is awaiting delivery without colour coding. Small tools, i.e. drills, cutters etc, together with all types of fixings shall be stored in the correct place within the area designated as the 'tool stores'. It is the responsibility of the Production Manager to see that this is done correctly.

3.4 TRANSPORT OF FINISHED GOODS AND COMPONENTS: After invoicing (See Procedure for Contract Review TK-QP-001) goods will be dispatched by post, road (Company transport or Contractor) or air, whichever is applicable, or as requested by the customer. It is the responsibility of the Office Manager to ensure that items for dispatch are correctly labeled.

4.0 CONCLUSION

The processing of livestock feedstuff is said to be successful if the handling, labeling storage of the finished products are done properly.

5.0 SUMMARY

In this unit, you learn how to handle finished products from processing to usage.

6.0 TUTOR-MARKED ASSIGNMENT

1 Explain in detail how to store finished products of livestock of feeds.

2 How can you avoid damage of such products.

7.0 REFERENCES/FURTHER READING

http://www.aafco.org or contact Jennifer Roland, by phone: (217) 356-4221 or email: aafco@aafco.org.

MODULE 5: LEGISLATION AND QUALITY CONTROL FOR COMMERCIAL FEED FORMULATIONS

UNIT 1: LAWS GOVERNING ESTABLISHMENT OF FEED MILL

CONTENTS

1.0 INRODUCTION

There are numerous factors which contribute to the low productivity of animal production countries. One major constraint is the high population density and the competition of human and livestock for feed resources. Also there is a one-sided development - most developing countries have significantly improved their breeds and numbers of livestock. There has however been no real increase in animal or human feed production and no economically viable feed substitutes have been developed. Under nutrition is still the major limitation to increasing livestock production in these countries. Because of the high cost of feed ingredients, the available feeds are usually low in metabolizable energy and protein. In some instances and even with apparently adequate feed supply animals have been observed to deteriorate. This may be attributed to at times poor quality feed ingredients and a wide variability in nutrient composition often leading to subclinical nutrient imbalances, deficiencies inessential nutrients and/or toxicities associated with mycotoxins or salmonella leading to ill-thrift. This problem of low metabolizable energy and protein leads to the legislation and quality control for commercial feed formulation.

2.0 OBJECTIVES

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

- Know legislation on animalfeed
- Determine the quality of incoming and outgoing feeds
- Understand quality control checklist for feed

3.0 MAIN CONTENTS

3.1 LEGISLATION ON ANIMAL FEED

Legislation on animal feed is harmonised at European Union (EU) level. It applies principally to feed for farmed livestock, but also covers feed for horses, pets, farmed fish, zoo and circus animals, and creatures living freely in the wild.

3.2 LABELLING AND COMPOSITION

Legislation on the labelling and composition of animal feed covers:

- ✓ the information to be provided to purchasers on feed labels
- ✓ the nutritional claims that can be made for certain feed products

- ✓ the names and descriptions to be applied to various feed materials (that is, ingredients either fed singly or included in compound (manufactured) feeds)
- ✓ the additives (including vitamins, colourants, flavourings, binders) authorised for use in animal feed
- ✓ the maximum levels of various contaminants (e.g. arsenic, lead, dioxins and certainpesticides)
- ✓ certain substances that must not be used in feed.

3.3 QUALITY CONTROL IN FEED FORMULATION

Quality control in feed production is of utmost importance in the overall success and profitability of animal enterprises. There is no other factor, directly or indirectly related to the proper nutrition and high performance of animals that is more critical than feed quality control and ration consistency. The degree of quality is the consistency in which feed is formulated, processed, mixed and delivered as compared towhat is expected. Animals thrive on a routine andrespond better if the feed is low in nutrient variation as offered to them; and is similar in moisture content, texture and rate of energy availability.

Quality has been defined as "any of the features that make something what it is" and "the degree of excellence which a thing possesses." Either definition may be acceptable if one recognizes that quality control means knowing the quantitative amounts of all components, good and bad, in a feed. However, relative values of quality over time are extremely valuable and useful in many situations.

The relationship between feed quality and animal performance is important and encompasses not only the quantitative amounts of all feed components, but also the digestibility and metabolism of those components. Thus, the challenge for nutritionists and others involved in animal feed production is to consistently monitor all aspects of the feed production system used and measure those variables that are good indicators of quality control. For the feed industry, a quality control system is the responsibility of management and involves properly trained personnel to ensure a high level of organization, documentation, and the policing of various procedures and processes necessary to guarantee the basic quality of feedstuffs and feeds..

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3.4 DETERMINING QUALITY OF INCOMING INGREDIENTS AND OUTGOING FEEDS

Quality control of incoming ingredients is crucial to predicting the quality of a complete feed, supplement, premix, etc. An important first step is accurate sampling and complete examination of the ingredient prior to unloading.

Put sampling and inspection procedures in writing and keep them in a Quality Control Procedures Manual.

The goal in sampling any lot of ingredients or finished feed is to obtain samples that are representative of the lot in question. A wrong answer -- which may arise from incorrect sampling, incorrect handling of samples, analytical error, etc. -- is worse than no answer. Thus, it is our responsibility to know proper procedures and techniques for sampling to be sure that correct formulations can be made.

Below are some suggested sampling procedures for bulk ingredients and mixed feeds, bagged ingredients and mixed feeds, hays, and syrups and fats.

3.4.1 BULK INGREDIENTS AND MIXED FEED

- Take a minimum of three, 2.25kgsamples.Each sample should be the composite of several cores taken randomly from the delivery truck, bulk storage bin or feed bunk, as applicable.
- Duplicate determinations are recommended for all variables measured samples
- Each sample should be the composite of several cores taken randomly from the delivery truck, bulk storage bin or feed bunk, as applicable.
- Duplicate determinations are recommended for all variables measured.

3.4.2 BAGGED INGREDIENTS AND MIXED FEEDS

- Use slotted feed trier for sampling and take 0.50kg samples.
- For lots of one to ten bags, sample all bags.
- For lots of eleven or more, sample ten bags.
- Analyze a minimum of three samples and average the results.

3.4.3 HAYS

- For chopped hay, take ten samples per lot.
- For cubes, take forty cubes from a given population.
- For bales, take one twelve to eighteen inch core from the end of forty bales in a given population.

3.4.4 SYRUPS AND FATS

- Use a continuous flow sampling procedure at the point of delivery, or a core liquid sampler.

  Establishment of a retention schedule is recommended for all ingredient and mixed feed samples. Separate analytical analyses should be routinely performed on samples of the following for quality:

- Water
- Grains
- Roughages
- Silages
- Protein supplements
- Mineral mixtures
- Vitamin premixes
- Molasses and fat
- Specific drugs

As a starting point for insuring quality in feedlot rations, quality check all incoming feed ingredients for the following:

- ✓ Moisture
- ✓ Color
- ✓ Off odor
- ✓ Presence of foreign material
- ✓ Texture and uniformity
- ✓ Evidence of heating

- ✓ Deterioration due to biotoxins

More detailed analyses are performed on individual feed ingredients for the purpose of feed formulation, and sometimes before the purchasing of commodities if this information is not provided by the seller. Analyses that usually are considered to be routine for the different feed ingredients include:

Grains - grade, moisture, protein, ash

Grain By-Products - moisture, protein, ash

Dry Roughages - moisture, protein, ash, acid detergent fiber

Silages - moisture, pH, temperature, protein, ash

Protein Supplements - moisture, protein, ash, non protein nitrogen

Mineral Mixtures - moisture, specific nutrients

Molasses - moisture, ash

Fats - moisture, free fatty acids, impurities, unsaponifiables

Derive an overall evaluation of feed quality delivered by determining the variation in the four major areas that affect feed consistency. They are:

- Variation of incoming ingredients
- Variation in feed mixing efficiency
- Variation in efficiency of delivery of mixed feed from mixing point to the animals
- Variation in analytical procedures

3.5 USE OF CURRENT GOOD MANUFACTURING PRACTICES IN MAINTAINING QUALITY CONTROL

The management of a feed mill has an obligation to uphold Current Good Manufacturing Practices (GMP). The use and endorsement of appropriate and proper procedures and practices in the production of feeds do not cost the feed industry. The feed mill manager is a key individual involved in the daily activities associated with the management ofpeople, facilities and resources that ensure the procedures appropriate for the production of feed in the feed mill are enforced. The feed mill manager, as well as supervisors and the people working under their direction, have an obligation to the animal food industry to maintain high quality standards in the production of feeds for animals -- to produce meat, milk, eggs, etc. for the consumer.

Good Manufacturing Practices were published by the Food and Drug Administration **(FDA)** in the November 30, 1976, Federal Register. Good Manufacturing Practices deal specifically with the manufacturing of any feed containing one or more drugs. If any feed contains a drug, it is a medicated feed. The feed mill management should have written instructions that cover GMP's and quality assurance programs. Good Manufacturing

Practices cover all areas involved in the production of feeds including personnel, facilities, feedstuffs, quality assurance checks, inventory control checks, processing methods, mixing procedures, finished feeds, and feed delivery.

Although commercial feed mills that produce and sell a complete line of feeds to the general public have a somewhat greater task in assuring quality and prevention of cross contamination of drugs, the obligation and importance in all feed mills are still great. Outlines, checklists and procedures relevant to feed mill operations are presented below.

- ✓ Conduct **Personnel Training** conducted periodically to assure compliance with procedures and insure quality of feed produced. These meetings usually are helpful in establishing and maintaining good morale and teamwork among employees.
- ✓ Construct or modify the **Feed mill and Adjacent Buildings** to minimize access to rodents, birds, insects and other pests, and locate them in an area that allows proper drainage. Maintain the building and grounds as needed to assure a clean work place for employees and for the production of feeds. Litter, refuse, improperly stored equipment and supplies are hazards, remove them. Provide sufficient space for facilities and personnel to perform their job properly. Examples of space needed for the production of medicated feeds include:
  - Appropriate area for receiving and storing of ingredients and drugs
  - Adequate space for grain processing, etc.
  - Appropriate space for feed mixing
  - Reserved area for equipment maintenance.

✓ **Equipment** must meet safety standards and be installed properly. Test all scales and metering devices for accuracy upon installation and at least once per year thereafter. Construct and maintain equipment to prevent lubricants and coolants from contaminating ingredients or feeds. Prevent excessive spills, leaks and dust problems.

Systematically monitor **ingredients** for quality factors throughout the entire process of purchasing, receiving, sampling and handling. Inspect all ingredients for any abnormality that may result in a quality risk when added to the feed, and take representative samples for assays. During this handling of ingredients, take care to prevent contamination.

✓ **Drugs and Premixes** require special handling and record keeping. Records on drugs received must show the following information:

1. Name of drug, including potency
2. Date received
3. Amount in pounds
4. Supplier's name
5. Supplier's code for drug (if applicable)
6. Supplier's lot or code number
7. Return of any damaged or unacceptable drugs

Follow these procedures in the storage, handling and use of drugs:

1. Check each drug for identification. Do not accept unless properly identified.
2. Keep all drugs and premixes stored in a neat and orderly manner for easy identification. It is preferable to store drugs in a separate room.
3. Code each bag or drug container with the supplier or company code for that drug.
4. Store packaged drugs in the storage area in their original closed containers.
5. Check bags for tears and any other abnormalities. Do not accept any drugs that are not in good condition.
6. Properly identify, store, handle and control drugs in the mixing area to maintain their integrity and identity.
7. Clean up any spilled drugs immediately, dispose of properly and record in the Drug Inventory Record.

8. Use a separate scoop for handling each drug.

9. Use drugs and premixes on a first received basis.

A daily inventory of drugs and premixes is required. Complete the Drug Inventory Record at the end of each 24 hour period. Check usage of each drug against medicated feeds produced. Weigh the drug container before it is opened and account for every pound of drug in usage or adjustment. Examples of other adjustments include improper weighing, spillage, and out of condition.

Cleaning, Processing, and Mixing of feed ingredients requires that personnel involved by thoroughly trained and properly supervised. Considerations for proper GMP's include the following:

I. Screening of grains and use of magnets.

2. Grind as uniformly as possible.

3. Accomplish flaking of grain with proper amount of steam, temperature and roll tolerance.

4. Standardize mixing directions for a feed mill. (Certain mixed feeds may require specific directions.)

5. Prevent contamination.

6. Check for accuracy for all scales used for weighing ingredients (including drugs) at least once per year as required by FDA.

Maintain FDA Complaint Files for Medicated Feeds for FDA inspection and include the following:

1. Date of complaint
2. Complainant's name and address
3. Name of feed
4. Lot or control number or date of manufacture
5. Specific details of the complaint
6. All correspondence
7. Description of investigation
8. Disposition of complaint.

3.6 QUALITY CONTROL CHECKLIST FOR FEED

Following are three checklists that identify some of the areas needing attention by all involved in ensuring quality control in feed production

3.6.1 CHECKLIST FOR SOURCES OF HIGH OR LOW ANALYTICAL VALUES

- Formulation error
- Nutrient or drug instability
- Moisture pickup or loss
- Incorrect weights (batching errors)
- Dust losses
- Non-uniformity of ingredient, supplement or premix insufficient mix time
- Residues and cross contamination
- Inadequate sampling methods Segregation in transit or of sample
- Analytical errors.

3.6.2 CHECKLIST FOR OVERALL SYSTEM EFFICIENCY

- Select intelligent and responsible suppliers
- Select intelligent and responsible mill operators
- Select adequate mixer
- Adequate mixing times, Proper ingredient formulation
- Use of appropriate feed binders
- Limit conveying of premix and finished feeds
- Accurate weighing equipment
- Emphasize cleanliness and good housekeeping
- Keep accurate records

3.6.3 CHECKLIST FOR PERFORMANCE EVALUATION

- Evaluate variation of incoming ingredients
- Evaluate mixer efficiency
- Evaluate efficiency of conveying feed from the mixer to the feed bunk
- Evaluate variation of analytical procedures
- Evaluate system efficiency

3.6.4 ADVANTAGES OF QUALITY CONTROL IN FEED FORMULATION

There are several advantages to submitting your raw materials and feeds to a quality control plan:

Legal: The manufactured feed must comply with the current legislation and the guarantees defined on the product label.

Zootechnical: The animal is certain to receive a feed that meets its nutritional constraints while allowing for the achievement of the targeted performance results.

Economic: The coherence between the quality of the raw material received in the feed mill and the nutritional values entered in the formulation software is validated. Regular checks and updates of these values can result in a financial gain of several euros for each ton of manufactured feed.

Commercial: Customers' satisfaction is sought by providing them with a feed that meets their expectations.

4.0 CONCLUSION

By the end of this unit, you should have understand the status of legislation on animal feed in Nigeria. You have also understand the quality control checklist for livestock feed.

5.0 SUMMARY

In this unit,, you have learnt the legislation on animal feed in Nigeria. You have also understand the quality control checklist for livestock feed.

6.0 TUTOR-MARKED ASSIGNMENT

1 Explain quality control in feed formulation

2 what do you understand by quality control checklist

7.0 REFERENCES/FURTHER READING

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UNIT 2: STANDARD ORGANIZATION AND FEED STANDARD

CONTENTS

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:

- the role of standard organization in Nigeria
- 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 STANDARDS ORGANISATION OF NIGERIA (SON)

The standards organisation of nigeria (SON) is the apex standardization body in Nigeria.

SON was established by SON Act No. 14, 2015, which repeals the Standards Organisation of Nigeria Act, Cap 59 laws of Federal Republic of Nigeria, 2004, and Enact the standards organisation of nigeria Act. 2015 for the purpose of providing additional functions for the organisation, increasing penalty for violation, and for related matters.

This SON Act 2015, has now replaced the Enabling Act No. 56 of 1971 which has three amendments: (Act No. 20 of 1978, Act No. 32 of 1984 and Act No. 18 of 1990).

The aims and objectives of the SON include:

1 Preparation of standards relating to products, measurements, materials and processes among others, and their promotion at the national, regional and international levels;

2 Certification of industrial products;

3 Assistance in the production of quality goods;

4 Improvement of measurement accuracy and circulation of information relating to standards.

Standards Council of Nigeria

The SON's governing body is known as the Standards Council of Nigeria (hereinafter called the "Council").

This is the policy-making body for supervising the administration and financial management of SON.

The Council is responsible for among other things:

Advising the Federal Government of Nigeria generally on the national policy on standards;

1. Standards specifications;
2. Quality control and metrology;
3. Designating, establishing and approving standards;
4. Determining the overall policy of SON

3.2 FEEDING STANDARDS

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. 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 fist feeding standards in 1945. Other countries also evolved their feeding standard based on digestible crude protein and total digestible nutrients. Separates reports form 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. Safety margins could be the extra feed fed to animals that are group fed as making absolute calculations based on individuals recommended feed intakes might result in insufficient feeds the rates of feeding differ. 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. In Nigeria, tables which have been prepared by National Animal Production Research Institutes and other research organizations are in use. These feedings 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.

3.3 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.

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. state the roles of SON IN Nigeria

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