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Ministry of Labor and Skills

ANIMAL HEALTH

LEVEL – II

BASED ON MARCH 2022, VERSION 4 OCCUPATIONAL STANDARD



Module Title: Applying Animal Feeding and Nutrition

LG CODE: AGR ANH2 M04 LO (1-3) LG (11-13)

TTLM CODE: AGR ANH2 M04 TTLM 0922v1

September 2022

Addis Ababa, Ethiopia

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Introduction to the Module

This module covers the knowledge, skills and attitude required to carry out animal nutrition and feeding practices in order to enhance production and productivity of livestock industry. It also covers good management practices, record and reporting after completion work

LG # 11 — LO # 1- Identify Animal feed source and Digestive Physiology

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Sources and categories of animal feed
- Temperature requirements for feed storage, preserve and processing
- Identifying and describing feedstuffs classification
- Identifying and describing feed contents
- Differentiate the role of GIT hormones, pH & Enzymes on the digestion

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify sources and categories of animal feed
- Follow temperature requirements for feed storage, preserve and processing
- Identify and describe feedstuffs classification
- Identifying and describing feed contents
- Differentiate the role of GIT hormones, pH & Enzymes on the digestion

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

Information Sheet 1

1.1. Sources and categories of animal feed

1.1.1. Introduction

'Food' is a term which is often reserved for human foodstuffs, while animal feed is usually called 'feed'. This usage is arbitrary and either word can be used to refer to animal feed. The animals associated with humans cover the spectrum from herbivores, the plant eaters (ruminants, horses and small animals such as rabbits and guinea pigs); through omnivores, which eat all types of food (pigs and poultry); to carnivores, which eat chiefly meat (dogs and cats). Under the control of humans these major classes of animal still pertain, but the range of foods that animals are now offered is far greater than they might normally consume in the wild (for example, ruminants are given plant by-products of various human food industries and some dog foods contain appreciable amounts of cereals). Animal nutrition is defined as the process of providing and obtaining the food necessary for the health and growth of animals.

Terms used to describe animal feed:

- Nutrition: is the science of dealing with the utilization of food by the body processes which transforms food into body tissues and energy.
- Nutrients: Nutrients are chemical elements or compounds present in feed that support health, basic body maintenance, or productivity. Fundamental nutrients include water, carbohydrates, protein, fat, vitamins, and minerals.
- 'Diet' and 'ration' often have the same meaning in animal nutrition. The term 'ration' is usually reserved for a mixture of feed ingredients which have been formulated to provide specific amounts of nutrients. 'Diet' usually means the same as 'ration', or even 'feed', but it can also imply a particular type and/or amount of feed or mixture of ingredients
- Dry matter (DM): the portion of a sample remaining after water has been removed.
- Crude protein (CP): the content of nitrogen in a sample multiplied by the factor 6.25 to provide an estimate of the protein content of the sample.
- Crude fiber (CF): structural carbohydrates of plants (i.e., hemicellulose, cellulose, and lignin).

1.1.2. Sources of animal feed

Depending on its sources or origin animal feed is categorized into two major classes. These are roughages and concentrates. These classification of animal feed sources are illustrated in as figure below

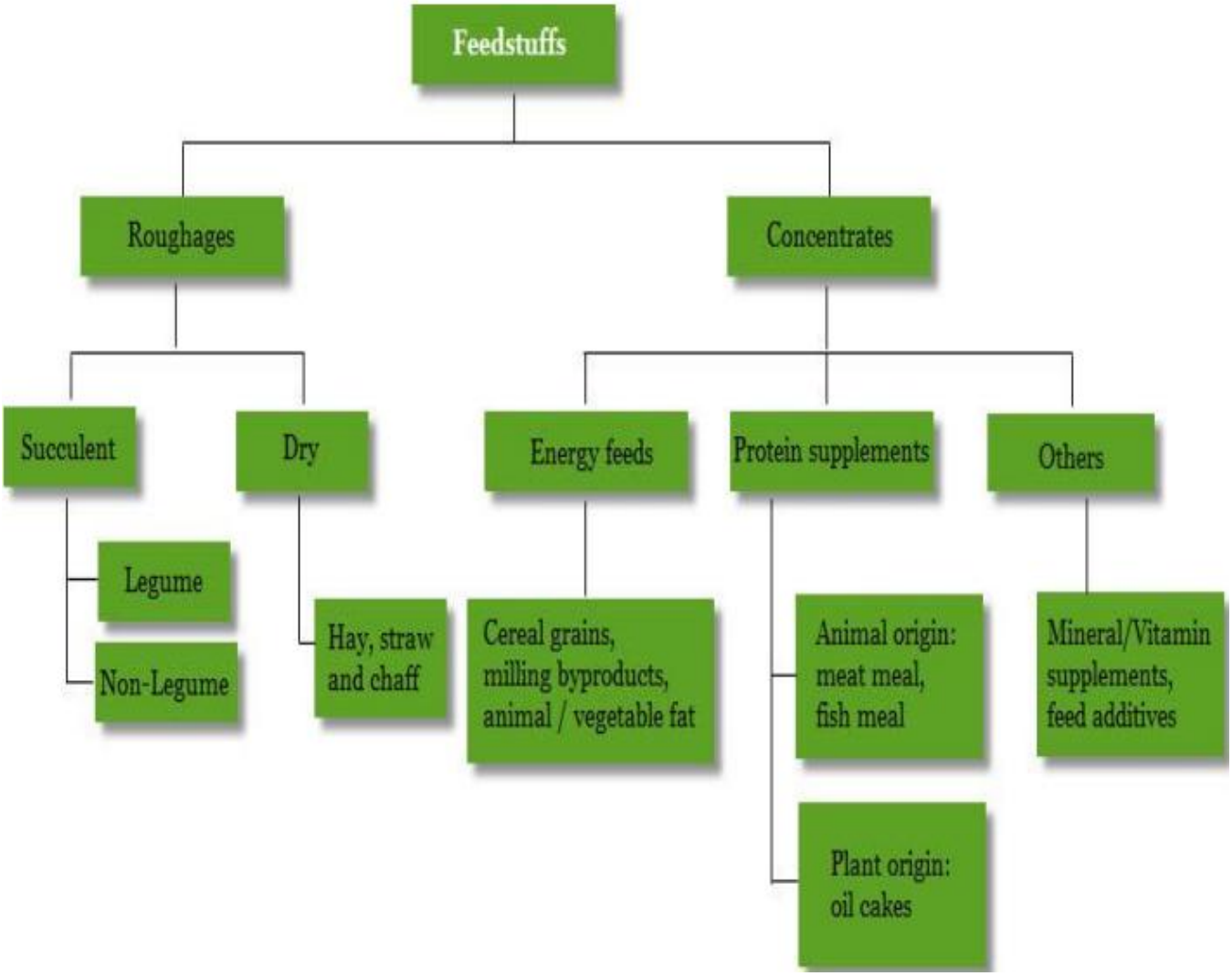


Diagram 1.1: Categories of animal feed sources

A. Roughages

Roughages is feed consisting of bulky and course plants or plant parts, containing a high fiber content and low total digestible nutrients i.e crude fibre more than 18% and low (about 60%) in total digestible nutrients on air dry basis. Therefore, roughages are bulky feeds high in fiber and

low in energy. Forages and roughages are sometimes used intergenchabily but forage is used to refer fresh plant materials strictly speaking to grazing and browsing or forages are plants grown to be used specifically for feeding animals such as grasses and legumes whereas roughage is meant to imply either dry or fresh plant material used for animal feeding. Roughage feed sources are also categorized in to two. These are succulent roughages and dry roughages.

i. **Succulent roughages:** A condition of plants characterized by juiciness, freshness and tenderness, making them appetizing to animals. On the other hand succulent roughages sources can be;
    - Legumes: E.g cowpea, berseem, lucerne etc,. superior to grasses in protein and mineral content, particularly calcium, phosphorus, magnesium, copper and cobalt.
    - Non-Legumes: E.g. Tree fodders and roots and tubers (like potatoes)

ii. **Dry roughages:** Feeds in dry state that are bulky and low in weight per unit volume; usually they contain more than 18% CF and relatively low in energy. E.g hay, straw and chaff and silage.
    - Hay: hay is reducing the moisture content of the green crop to a level low enough (12-14%) to inhibit the action of plant and microbial enzymes is the aim of hay making.
    - Silage: silage is the preserved material produced by the controlled fermentation of crop under anaerobic conditions in a structure known as silo.
    - Straw and chaff: they are crop residues left over portion of the crop after the main crop is harvested for human consumption.

B. Concentrate feed

According to the Association of American Feed Control Officials (AAFCO, 2000), Concentrate feed is the feed used with another to improve the nutritive balance of the total and is intended to be further diluted and mixed to produce a supplement or a complete feed. A better explanation of concentrate is that: it is an incomplete feed that contains a higher percentage of energy, protein, premix (vitamins, minerals, amino acids, enzymes, organic acids) and other feed additives

depending on the type of concentrate. Concentrate feed is just feed that is intensely focused on one class of nutrients. There are:

- **Energy concentrate**; these include
  - ✓ cerial grains: cereal grains consists of (Maize, Barley, Oats, Wheat, Rice, Rye, Millets, Sorghum. Cereal grains are rich in starch containing 8-12% of CP with low lysine and methionine, 2-5% fats, less than 0.15% of calcium and relatively higher phosphorus to the extent of 0.3-0.5%. Cereal grains are rich source of thiamine and vitamin E but deficient in vitamin A and riboflavin except yellow maize, which is rich in provitamin A.
    - ✓ milling-byproducts: consists of;
      - Bran: It is the outer coarse coat of the grain separated during processing. E.g. rice bran, wheat bran, maize bran.
      - Middling: A byproduct from flour milling industry comprising several grades of granular particles of bran, endosperm and germ.
      - Polishing: During rice polishing this byproduct accumulates to contain 10-15% protein, 12% fat and 3-4% crude fibre.
      - Molasses: Byproduct during juice / extract prepared from selected plant material. E.g cane molasses a product of sugar industry

- **Protein concentrate**: there are two protein concentrate feeds sources. These are plant origin and animal origin.
  - ✓ plant origin Protein concentrate
    - Vegetable or plant origin energy concentrates are oil seed cake / meal. E.g groundnut or peanut oil meal, soybean oil meal, linseed meal, coconut meal, cotton seed meal, safflower meal, sunflower meal which are the byproducts left after extraction of oil from oil seeds are used for feeding all kinds of livestock.

  - ✓ Animal origin protein concentrates
    - Animal protein concentrates @15% in the ration. Animal protein concentrates are expensive. Animal protein concentrates should be free from pathogens like salmonella and E.coli. Protein supplements

from animal origin are Fish meal, Meat meal, Blood meal, Hatchery waste and Milk products.

- Minerals, vitamins, and additives concentrate

1.1.3. Categories of animal feed based on nutritional values

Food can be defined as anything solid or liquid which when swallowed, digested and assimilated in the body provides it with essential substances called nutrients and keeps it well. Nutrition is defined as the science of foods, nutrients and other substances they contain; and of their actions within the body including ingestion, digestion, absorption, metabolism and excretion. According to their nutritional valued feed are categorized as balanced feed, unbalanced feed, supplementary feed, vitamins & minerals, and Water

a. Balanced feed

A balanced diet is one which includes a variety of foods in adequate amounts and correct proportions to meet the day's requirements of all essential nutrients such as proteins, carbohydrates, fats, vitamins, minerals, water, and fibre. Such a diet helps to promote and preserve good health and also provides a safety margin or reserve of nutrients to withstand short durations of deprivation when they are not supplied by the diet.

b. Unbalanced feed

Unbalanced diet means an excess or deficiency of dietary part, such as: proteins, fat, carbohydrates, fibres, vitamins, minerals.

c. Supplementary feed

Supplementary feeding is the additional supply of feed containing energy, protein or vitamins and minerals to grazing livestock that may be lacking in the pasture. It is important to ensure that the whole diet of the animal, including supplement and pasture, is balanced. Feed supplements may include hay, grain, trace element, vitamins and sources of specific-purpose feeds Supplementary feeding may be required to cover seasonal, drought or other feed shortages and trace element deficiencies. Supplementary feedings consists of;

- **Vitamins:** Vitamins are organic substances playing vital role for healthy functioning of the body. They are essential for proper metabolism and body immunity building. Vitamins present in minute amounts in foodstuffs. Vitamin A, B, C, D, E and K are commonly known vitamins. Vitamin A, D, E, and K are fat soluble vitamins while vitamin B groups and vitamin C are water soluble.
- **Minerals:** Minerals are inorganic elements. Many different minerals serve important functions in the body. Mineral are grouped in to macro and (micro) trace minerals. The macro-minerals are: Calcium (Ca), Phosphorus (P), Potassium (K), Sodium (Na), Sulphur (S), Chlorine (Cl), Magnesium (Mg). The micro- or trace minerals are: Iron (Fe), Iodine (I), Copper (Cu), Cobalt (Co), Fluorine (F), Manganese (Mn), Zinc (Zn), Molybdenum (Mo), Selenium (Se).

1.2. Temperature requirements for feed storage, preserve and processing

To ensure properly stored grain in bins, high-moisture grains need to be dried to at least 14 percent moisture for long-term storage and no more than 16 percent moisture for winter storage. Grain temperatures should not exceed 82 °C or there will be some browning, evidence of decreased lysine availability; therefore, an adequate fan system for cooling is desirable in some climates. Fat should not be stored at temperatures above 60 °C, with 49 °C being most ideal. Antioxidants extend the time period before rancidity of the oil starts. Vitamin stability varies greatly among vitamins, depending on conditions they are exposed to and storage time. Storage of the vitamin premixes should be in a cool, dark, dry place. Moisture, visible and ultraviolet light, heat, and contact with certain trace minerals are the most common factors that reduce vitamin stability.

Thermal processing of feed can improve the stability and hygiene of feed, might alter the chemical and physical characteristics of its constitutive ingredients, can improve the nutritional value of animal feeds. So thermal processing might have beneficial effects on the gastrointestinal function and the microbial status of gastrointestinal tract. In order to eliminate, inactivate or reduce the anti-nutrients and pathogens in the animal feed ingredients and feed, a simple heat processing method have been used for decades. This simple heat processing method could be dry or moist, and based on the purposes of the usage and its technical characteristics can be classified

as cooking, roasting, toasting, autoclaving and long term conditioning. There are many possible combinations, and types of heat applications in animal feed processing. Most commonly used thermal methods in the world are pelleting, expanding, extrusion, steam flaking, conditioning, cooking, micronisation, roasting, popping and toasting.

- **Pelleting:** Pellet units are one of the technological processes in feed mill and it can be defined as a collection of single ingredients or combinations by pressing and making it through openings in the die and cutting off of the pressed feed forms to the preferred length. Temperature of the pellet feeds usually increases to about 70°C- 80°C before inflowing the press matrix for pelleting.

- **Extrusion**: Extrusion is the procedure in which the feed and food are exposed to high heats (up to 200°C) for 1-2 minutes or more accurately the feed and food temperature rises suddenly within the last 15 to 20 seconds up to the optimal one to do the preferred effects. The extrusion process begins with the grinding and mixing of ingredients such as grains, oil and fibre sources. The basic model of extrusion procedure is high temperature, short time, whereby the high temperature is a direct outcome of dry extrusion or preconditioning and wet extrusion (steam addition), or a mixture of both. Expander or extruder are fixed as special systems for mechanical conditioning in order to heat up the material to 100-140° and even up to 170℃ before final pelleting.

- **Steam flaking**: is used as a heat treatment of all types of grains and cereals such as corn, barley, wheat, etc. Moisture content in grain, thickness of flakes, grain temperature, and period of the progression affect the procedure efficiency. Grain heat during the steam flaking treatment reaches about 100°C.

- **Conditioning:** Conditioning is a common term for procedures in which the material is prepared for the following industrial process. Conditioning commonly suggests preparation of raw materials or mixtures for pelleting or extruding and expanding in feed mill. The simplest technique of conditioning is to add water into the conditioning machine. Humidity and heat are accomplished in a more effective way in steam

conditioning procedure. Due to its vaporous state, steam spreads through the material in a more homogenous way. This procedure is carried out by direct injection of dry saturated steam into the feed and its heat can reach 95°C. The procedure of steam heating is restricted because it sources a rise in moisture content of the food and feed for 1% for every 12- 15°C of temperature increase. The required condition for worthy conditioning is dry saturated steam pressure of about 8-10 bar with the temperature of 150-180°C.

- **Cooking:** Raw seed are saturated in water and heated for 30 to 120 minutes, and then they are dried, and given to animals as feed, whole, milled, or rolled. In this way, we can success heats higher than 100°C.

- **Micronisation:** Micronisation is a specific heat treatment in which the layer of grain on the conveyor belt is constantly carried below ceramic radiators emitting radiation with wavelength in the near infrared region ranging from 1.8 to 3.4 cm.

- **Roasting:** Roasting is difficult dry heating of raw feed and food to the temperature of 110–170°C, depending on the style of device used and the wanted product value. If the roasting temperature is too high, it decreases the availability of nutrients in the shallow layers of grain, while the central portion may stay under-treated.

- **Popping:** Popping is the method of roasting of dry grain on a hot plate ($t<400^{o}C$) in a short time. Such treatment of grain leads to quick loss of moisture, grain exploding into popcorn and increasing of its nutritive value.

- **Toasting:** Toasting that is introduced straight into the toasting vessel is a hot fluid in this procedure. The treatment is the one with the time of holding within the vessel from 10 to 20 minutes and the released temperature of up to 120°C.

Animal feed Storage Guidelines

i. Store all feed and ingredients at a cool temperature (ideally below 77° F although this is not possible at outside locations under summer conditions).

ii. Keep feed dry to prevent fungal or bacterial growth.
iii. Prevent rodent or insect entry into feed.
iv. Use antioxidants to preserve fats and oils in ingredients and feed.
v. Use stable forms of vitamins.
vi. Expiration dates (usually on container) are required for all food items.

1.3. **Identifying and describing feedstuffs classification by origin and by Crud fibre (CF%)**

Various classification systems are employed to differentiate feedstuffs, each according to a certain purpose.

1.3.1. Classification of feedstuffs based on their origin

Feedstuffs can be divided into three categories based on their origin. These feedstuffs of plant origin, products of animal origin and products from the biochemical industry

a. Feedstuffs of Plant Origin

Feedstuffs of plant origin can be divided into three groups;

- Farm products
  - ✓ With high moisture content, fresh products like grass, tubers, roots, silage
  - ✓ With moderate moisture content, like wilted silage;
  - ✓ With low moisture content, like hay, straw and stover
  - ✓ Miscellaneous, like fruits, pulp.
- By-products from agricultural industries
  - ✓ From sugar industries, like pulp and bagasse
  - ✓ From breweries, like brewers and distillers grains
  - ✓ Fruit juice/packing industries, like fruit pulps
- Artificial dried fodders like hay: Artificially dried roughage is considered an intermediate between roughage and concentrates. Classification is divided by digestibility percentage into four groups:
  - ✓ Digestibility percentage:
    - Over 70% = good digestibility

- 60 - 70% = moderate digestibility
- 40 - 60% = low digestibility under
- 40% = very poor digestibility

b. Products of Animal Origin

These products can be divided into four main groups, most of them categorized as concentrate: These are;

i. Milk and milk by-products (fresh or dried)
ii. Products from meat and carcass-industry, e.g. meatmeal, bonemeal, blood meal and feather meal
iii. Products from the fish industry like fish meal and shrimp meal
iv. Manure of poultry & pigs can be used in the nutrition of ruminants (Their CF content is too high to be classified as concentrates!)

c. **Products From the Biochemical Industry**- E.g Urea and biuret (Non-protein nitrogen sources (NPN))

1.3.2. Classification of feedstuffs is divided by CF% into two main categories:

Feedstuffs are divided by CF% into two main categories. These are;

a. **Roughage:** With a CF% in the DM higher than 18% usually vegetative plant parts
b. **Concentrates:** With a CF% in the DM lower than 18% ripe seeds/grains or products derived from these.

1.4. Identifying and describing feed contents

1.4.1. Categories of animal feed based on their contents

Animal feedstuff can be divided into two major components namely dry matter and water. The dry matter component consists of organic and inorganic matter. The organic matter consists of carbohydrates (source of energy), lipids and fats (source of energy), protein and vitamins. The inorganic matter is the source of macro- and micro-minerals. Since all nutrients are contained in the dry matter the animal must consume this portion in adequate amounts to obtain the required

nutrients. If a feed is high in moisture, the animal may not be able to consume enough of the feed to obtain the required nutrients due to limitation of rumen space.

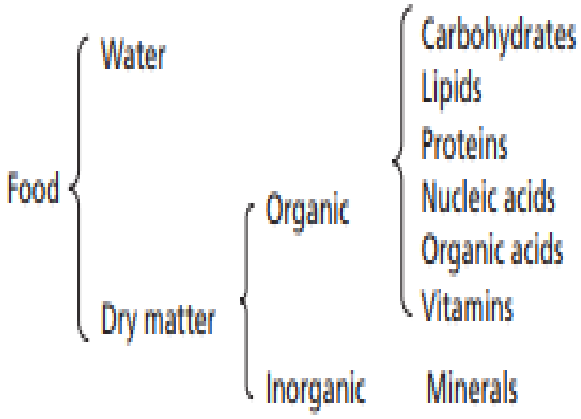


Diagram 2.1: Categories of animal feed based on components

a. Water

It is vital to the life of the organism that the water content of the body be maintained. An animal will die more rapidly if deprived of water than if deprived of food. Water functions in the body as a solvent in which nutrients are transported about the body and in which waste products are excreted. The animal obtains its water from three sources: drinking water, water present in its food, and metabolic water, this last being formed during metabolism by the oxidation of hydrogen-containing organic nutrients.

b. Dry matter (DM)

Dry matter represents everything contained in a feed sample except water; this includes protein, fiber, fat, minerals, etc. The dry matter (DM) of foods is conveniently divided into organic and inorganic material, although in living organisms there is no such sharp distinction.

- Organic material
  - ✓ Carbohydrates are neutral chemical compounds containing the elements carbon, hydrogen and oxygen and have the empirical formula $(CH_2O)_n$, where n is 3 or more.
  - ✓ The lipids are a group of substances found in plant and animal tissues. They are insoluble in water but soluble in common organic solvents such as benzene, ether and chloroform. They act as electron carriers, as substrate carriers in enzymic

reactions, as components of biological membranes, and as sources and stores of energy.

- ✓ Proteins are complex organic compounds of high molecular weight. In common with carbohydrates and fats they contain carbon, hydrogen and oxygen, but in addition they all contain nitrogen and generally sulphur. Proteins are found in all living cells, where they are intimately connected with all phases of activity that constitute the life of the cell.
- ✓ Nucleic acids are high-molecular-weight compounds that play a fundamental role in living organisms as a store of genetic information
- ✓ Vitamins are organic compounds that are required in small amounts for normal growth and maintenance of animal life. Unlike the nutrients vitamins are not merely building blocks or energy-yielding compounds but are involved in, or are mediators of, the biochemical pathways. Most food mixes prepared as supplements for ruminants and horses or as the sole food for pigs, poultry, dogs and cats are supplemented with vitamins

- Inorganic material
  - ✓ Minerals: These are inorganic nutrients necessary in serving the animal body in many different ways. Minerals have many roles in addition to their catalytic role by activation of many enzymes.
- Other types of feed components
  - ✓ Feed additives

A feed additive is defined as a feed ingredient of non-nutritive nature that stimulates growth or other type of performance or improves the efficiency of feed utilization or that may be beneficial in some manner to the health or metabolism of the animal. Examples of feed additives for dairy cattle are anti-helmintics (Dewormers), anti-bloat agents, rumen buffers (NaHCO3, MgO), flavouring agents (Molasses), rumen microbes for fibre digestion (Yea sac) and growth promoters or hormone-like substances.

- The most common feed additives:
  - ✓ Antibiotics: Antibiotics are medicine (like you take) that are fed at low levels in a ration to help reduce sickness, and therefore improve animal performance. Common antibiotics are Aureomycin and Terramycin.

- ✓ Ionophores: Ionophores are feed additives that may improve feed efficiency by 5-10%. The most common examples of ionophores are Rumensin (chemical is monensin) and Bovatec (chemical is lasalocid).
- ✓ Hormones/Anabolic agents: Anabolic agents are implants that contain steroid hormones that promote growth in cattle. These hormones are similar to the ones that are naturally occurring in the animal's body. These agents stimulate gain (especially lean gain) and common examples are Ralgro and Synovex.

1.5. Differentiate the role of GIT hormones, pH & Enzymes on the digestion

1.5.1. Introduction

The digestive tract can be considered as a tube extending from mouth to anus, lined with mucous membrane. The Gastro-intestinal tract (GIT) provides the body with a supply of water, nutrients, electrolytes and vitamines.

Function of GIT:

i. Digestion of the food
ii. Absorption of the products of digestion

Digestive processes: -

- Mechanical - Mechanical methods are;
  - ✓ mastication (chewing)
  - ✓ swallowing (deglutition)
  - ✓ movements of the GIT (motor functions)
- Chemical- Chemical means (secretions): carried out by secretions/enzymes from
  - ✓ saliva
  - ✓ gastric juice
  - ✓ pancreatic juice
  - ✓ intestinal juice
  - ✓ bile

1.5.2. Monogastric digestive system and digestion

The digestive system of monogastric animals (dog, cat, swine, rabbit, horse, etc.) consists of mouth, oesophagus, stomach, small intestine, cecum, large intestine, anus and supportive organs (pancreas, liver and gall bladder). Digestion processes of swine are shown in table below.

Table 1.1: Digestive processes of swine (https://www.intechopen.com/chapters/61960 (Accessed date 29/08/2022)

Organs	Secretion/Enzyme	Function
Mouth	Teeth	Mechanically reduces particle size and increases surface area
	Saliva	Lubricates and softens feed
	Salivary amylase (ptyalin)	Begins starch digestion
Oesophagus	—	Carries feed from mouth to stomach
Stomach	HCL	Decreases pH, denatures protein, activates pepsinogen, kills bacteria
	Pepsins	Begin protein digestion
	Lipase	Hydrolyses lipid (particularly in milk-fed young swine)
	Rennins	Coagulate milk protein (casein) in postnatal period
Small intestine	Pancreatic amylase and intestinal disaccharidases (maltase, isomaltase, sucrase, lactase)	Hydrolyse starch
	Bile acids	Emulsify lipid
	Pancreatic lipase, cholesterol esterase,and phospholipase	Hydrolyse lipid
	Pancreatic (trypsin,chymotrypsins, carboxypeptidases, elastase) and intestinal (aminopeptidases, dipeptidases, tripeptidases) proteases	Hydrolyse proteins
	Pancreatic and intestinal nucleases	Hydrolyse nucleic acids
Cecum	—	Ferments undigested nutrients by microbes
Large intestine	—	Absorbs water, volatile fatty acids (VFAs) and minerals and forms faeces
Anus	—	Removes faeces

- **Poultry digestive system and digestion**

Poultry (chicken, turkey, quail, goose, ducks, etc.) digestive system begins at the mouth/beak and ends at the cloaca and has several important organs in between [oesophagus, crop, stomach (proventriculus and gizzard), small intestine, cecum, large intestine]. Pancreas, liver and gall bladder are accessory organs in digestion.

Table 1.2: Digestive process in poutry (https://www.intechopen.com/chapters/61960 (Accessed date 29/08/2022)

Organs	Secretion/Enzyme	Function
Mouth/beak(No lips and teeth)	—	Obtains feed
	Saliva	Lubricates and softens feed
	Salivary amylase (ptyalin)	Begins starch digestion
Oesophagus	—	Carries feed from mouth to crop
Crop	Mucus	Lubricates and softens feed
Proventriculus	HCL	Decreases pH, denatures protein, activates pepsinogen, kills bacteria
	Pepsins	Begin protein digestion
	Lipase	Begins lipid digestion (particularly in carnivore avian species such as raptors)
Gizzard	—	Mechanically grinds and mixes of ingesta and continues enzymatic digestion
Small intestine	Pancreatic amylase and intestinal disaccharidases (maltase, isomaltase, sucrase)	Hydrolyse starch
	Bile acids	Emulsify lipid
	Pancreatic lipase, cholesterol esterase,and phospholipase	Hydrolyse lipid
	Pancreatic (trypsin,chymotrypsins, carboxypeptidases, elastase) and intestinal (aminopeptidases, dipeptidases, tripeptidases) proteases	Hydrolyse protein
	Pancreatic and intestinal nucleases	Hydrolyse nucleic acids
	—	Absorbs nutrients
Cecum	—	Ferments undigested nutrients by microbes
Large intestine	—	Absorbs water and minerals and storages waste
Cloaca	—	Serves as common opening of the digestive, reproductive and urinary systems

1.5.3. Ruminant digestive system and digestion

Ruminant (polygastric) (cattle, sheep, goat, etc.) digestive system includes mouth, oesophagus, stomach (rumen, reticulum, omasum and abomasum), small intestine, cecum, large intestine, anus and supportive organs (pancreas, liver and gall bladder). Digestion processes of ruminant are given in table below.

Table 1.3: Digestive processes of ruminant (https://www.intechopen.com/chapters/61960 (Accessed date 29/08/2022)

Organs	Secretion/Enzyme	Function
Mouth	—	Obtains and chews feeds, releases of fermentation gases (mostly CO_2 and CH_4) and ruminates
	Saliva	Moistens feed to aid in swallowing
Oesophagus	—	Transports feed from mouth to rumen
Rumen	Microbial enzymes	Degradation of carbohydrates, protein and lipids, synthesis of microbial protein/lipid and some vitamins (K and B-complex), absorption of VFAs and ammonia, and biohydrogenation
Reticulum	—	Continues ruminal fermentation
Omasum	—	Grinds feeds and absorbs water and VFAs
Abomasum Small intestine	HCL	Decreases pH, denatures protein, activates pepsinogen, kills bacteria
	Pepsins	Hydrolyse microbial and by-pass proteins
	Lipase	Hydrolyses lipid (particularly in milk-fed young ruminant)
	Rennins	Coagulate milk protein (casein) in postnatal period
	Pancreatic amylase and intestinal disaccharidases (maltase, isomaltase, lactase)	Hydrolyse starch escaping ruminal digestion
Abomasum	Bile acids	Emulsify lipid
	Pancreatic lipase, cholesterol esterase,and phospholipase	Hydrolyse lipid
	Pancreatic (trypsin, chymotrypsins, carboxypeptidases, elastase) and intestinal (aminopeptidases, dipeptidases, tripeptidases) proteases	Hydrolyse microbial and by-pass proteins
	Pancreatic and intestinal nucleases	Hydrolyse nucleic acids
	HCL	Decreases pH, denatures protein, activates pepsinogen, kills bacteria
	Pepsins	Hydrolyse microbial and by-pass proteins
Cecum	—	Further microbial fermentation
Large intestine	—	Absorbs water, VFAs and minerals and forms faeces
Anus		Removes faeces

1.5.4. Gastrointestinal hormones and their role in the digestive system

Hormones are chemicals that are produced naturally in the bodies of all animals, including humans. They are chemical messages released into the blood by hormone producing organs that travel to and affect different parts of the body. Hormones may be produced in small amounts, but they control important body functions such as growth, development and reproduction. Hormones can have different chemistry. They can be steroids or proteins. Steroid hormones are active in the body when eaten. For example, insulin is a protein hormone. Diabetic patients need to be injected with insulin for treatment. Some of gastrointestinal hormones used in digestive systems are as follows;

- Gastrin: It affects the motility and trophics of the gastric and intestinal mucosae.
- Cholecystokinin: stimulates the peristalsis of gastric antrum, small and large intestines
- Secretin: It stimulates the secretion of fluid and bicarbonates in pancreas, large intestine, and secretion of pepsin in the stomach. It inhibits the secretion of HCl, motility of the stomach and the tonus of the lower oesophageal sphincter.
- Motilin: It induces the contractile activity of the stomach and intestines.
- Gastrin-releasing peptide: It is a strong stimulator of gastrointestinal peptides
- Neurotensin: It decreases the tonus of oesophageal and intestinal sphincters, peristalsis, the gastric, intestinal and pancreatic secretions and blood perfusion. It stimulates the smooth muscles of the large intestine.
- Gastric inhibitory polypeptide: inhibit the secretion of HCl

Self Check – 1	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer from the given alternatives (2 points each)

1. Depending on its sources or origin animal feed is categorized into _____ classes
   a. 3 b.4. c. 2 d. 6
2. One of the following is not roughage feed sources for animals
   a. legume b. hay c. cereal grains d. straw
3. _____ is the preserved material produced by the controlled fermentation of crop under anaerobic conditions in a structure known as silo
   a. silage b. straw and chaff c. legumes d. bran
4. Sources of plant origin concentrate energy feed consists of;
   a. cerial grain b. milling-byproducts c. molasses d. all
5. Dry matter represents everything contained in a feed sample except_____
   a. carbohydrate b. lipids c. protein d. vitamin e. water

Test II: Short Answer Questions (3 points each)

1. List categories of animal feed based on nutritional values
2. Name the two general classes of roughages.
3. What are the animal origin protein sources?
4. What are concentrates feeds?

Note: **Satisfactory rating - 11 points** **Unsatisfactory - below 11 points**

You can ask your teacher for the copy of the correct answer

LG # 12 LO # 2- Determine Animal Feeding and feed requirement

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Accessing and using PPE
- Tools and equipment for feed preparation
- Follow OHS guidelines and procedures
- Preparing Feed and feed supplements
- Determine Essential requirements for animal nutrition
- Determining economic basis to supplementary feeding system
- Develop and Monitor feeding plan for animal
- Identifying factors that determine animal feed intake
- Identifying the most important elements of feed
- Aligning feed requirement with physiology and production type
- Recording and reporting feeding abnormalities and signs of stress

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to;

- Access and use PPE
- Tools and equipment for feed preparation
- Follow OHS guidelines and procedures
- Prepare Feed and feed supplements
- Determine Essential requirements for animal nutrition

- Determine economic basis to supplementary feeding system
- Develop and Monitor feeding plan for animal
- Identify factors that determine animal feed intake
- Identify the most important elements of feed
- Align feed requirement with physiology and production type
- Record and report feeding abnormalities and signs of stress

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

Information Sheet 2

2.1. Access and use PPE

2.1.1. Introduction

Several kinds of personal protective equipment should be used around livestock. Bump caps or hard hats protect the head around livestock facilities. Respirators should be used around dusty or moldy hay. They should also be used in silos, manure storage areas, and for the use of some pest-control chemicals. Eyes should be protected by goggles from dust, chaff, and chemicals. Glasses should have impact lenses. Protective gloves should be used for certain jobs. Cotton or canvas gloves may be used as hand protection for light work. Leather gloves may be used for heavier work or when working with barbed wire fencing to increase gripping power and protect the hands when handling rough or abrasive materials. Rubber gloves should be worn around sick animals or when assisting a birth. Safety shoes should always be worn on the farm.

There are two kinds of respiratory protection equipment available for use by workers. Air-purifying respirators use filters to remove the contaminants from the air before it is inhaled. One type of purifying respirator removes particles from the air. The other type removes vapor and gas from the air. A combination filter is available for removing both kinds of contaminants from the air before it is inhaled.

2.1.2. PPE used when working in animals

a. Eye and Face Protection; Some of the most common types of eye and face protection include the following:
   - Safety spectacles: These protective eyeglasses have safety frames constructed of metal or plastic and impact-resistant lenses. Side shields are available on some models.
   - Goggles: These are tight-fitting eye protection that completely cover the eyes, eye sockets and the facial area immediately surrounding the eyes and provide protection from impact, dust and splashes. Some goggles will fit over corrective lenses.

- Face shields. These transparent sheets of plastic extend from the eyebrows to below the chin and across the entire width of the employee's head

b. Head Protection: Protective helmets or hard hats should be used when working in animal facilities.

a. Foot and Leg Protection (boots): Steel-toed or hard toed shoes help prevent foot injuries that commonly occur when working with animals and machinery. Make sure footwear is in good working condition by inspecting it regularly. Check to be sure that shoe laces are not fraying and cannot be caught in equipment.

b. Respiratory protections: Moving, handling, and feeding animals creates dust problems. Inadequate or improper ventilation in confinement compounds this problem. Dust masks are good defensives against inhaling the dust in the air. Eg. Face musk is used as respiratory protection.

c. Overall: Overalls are a type of safety clothing made of tough cotton, denim or linen and usually used as protective clothing while working. It is a loose fitting pair of pants with supporting cross-straps, or a full or half sleeve shirt that is worn over regular shirts, vests and trousers to protect them from heat, cold, splashes, sparks, flames and flying debris etc. in the workplace.

d. Gloves: Gloves are necessary to help prevent the spread of harmful bacteria and other harmful chemicals. When working with cows and other livestock, you'll need gloves to help prevent the spread of illness between animals and contamination between humans and animals. Vinyl disposable gloves for this type of task because they are super easy to take on and off, and offer adequate protection. In regards to milking cows, you should be sure that you have well-fitting gloves that are lightly powdered. This will help to milk more efficiently and comfortably for you and the cow.

2.2. Tools and equipment used for animal feed preparation

2.2.1. Introduction

Tools and equipment are two words that are often used synonymously, mainly due to the similarities of their meanings. Because of this factor, they can be used interchangeably in most instances. However, in certain cases, this may not be so. A tool can be any item that is used to achieve a goal. Equipment usually denotes a set of tools that are used to achieve a specific

objective. A tool can be non-mechanical as well. However, when one says equipment, there is a certain mechanical aspect to it that cannot be ignored. Tools are often seen to be used by animals as well. Equipment is only used by human beings. Tools are usually multipurpose. Equipment is designed for a specific task.

2.2.2. Feeding tools and equipment for farm animals

a. **Hay racks;** this is used for feeding farm animals with hay and other forages



Figure 2.1: Hay racks

b. **Feeding troughs;** this is used for feeding farm animals with grain and silage. It is a container were the feed of farm animals placed for them to consume. E.g trays and rubs. Various sizes of feeding troughs are used based on the size, age and types of animals. Feeding troughs are usually made of wood, plastic or aluminium materials.





Figure 2.2: Feeding troughs

c. **Self feeder;** these are mainly used for fattening cattle. The device is equipped with a feed hoper that automatically supplies feed to livestock.
d. **Water troughs;** these are container used for supplying water to farm animals. E.g pails and buckets. The size of troughs varies like feeding troughs depends on the types, age and size of animals. They are made of aluminium materials or polythene materials.
e. **Scoopers/Feed scoops;** this is used for scooping dry feeds



Figure 2.3: Scooper

f. **Spade/shovel;** this is used to mix feed ingredients



Figure 2.4: **Spade versus Shovel**

(Sources for Figure 2.1, 2.2, 2.3 and 2.4: https://www.kofastudy.com/courses/jss1-agricultural-science-2nd-term-2/lessons/feeding-tools-and-equipment-for-farm-animals-week-4/topic/feeding-tools-and-equipment-for-farm-animals/ Accessed date 03/09/2022)

g. Other tools and equipments used for animal feed preparation includes: Knives, knife-sharpening equipment, secateurs, scissors, nutcrackers, blenders and mincers

2.3. Follow OHS guidelines and procedures

2.3.1. Introduction

An OHS policy is a statement of a company's commitment to the health and safety of its employees. Agriculture is one of the most dangerous occupations. Farmers or farm owners who hire labor are required by law to provide safe and healthy workplaces for their employees. They

must inform workers about safety practices. Employees must be told about their rights and responsibilities under the regulations of the Occupational Safety and Health Act (OSHA). Posters have been designed by OSHA for this purpose. OSHA requires farm employers to keep records of work-related injuries and illnesses.

2.3.2. Physical injuries when working with livestock production

Most of the people injured by animals on the farm are farm family members. The most serious accidents often occur with horses and bulls; however, accidents also happen when working with cows and hogs. People are usually injured by cattle when they kick, step on, or push someone against a hard surface, such as the side of a pen; however, people may also be injured by falling when working with cattle. As people grow older, they tend to lose some of their strength and agility. They may have poorer balance and failing vision, which may cause them to have more accidents around animals. Sometimes, workers are not properly instructed in handling animals. This can also result in accidents involving livestock.

Workers who fail to use personal protective equipment in dangerous environments are more likely to be injured than those who dress correctly. There are many dangerous environments involved in livestock operations. These include slippery floors, manure pits, corrals, dusty feed areas, silos, automatic feeding equipment, and confinement livestock and poultry buildings. Many confinement livestock buildings have a manure storage pit that is cleaned out only a few times each year. If the building is not properly ventilated, the pit gases can kill workers and livestock. Vent pipes must be installed properly. Improperly installed vent pipes may allow gas fumes to be recycled into the building, which can cause illness and possibly death.

Loading and unloading operations are particularly dangerous because the animals are excited and confused by what is happening. It is important to have solid facilities for handling livestock. Temporary or makeshift gates, pens, and chutes increase the chances of a worker being injured. Squeeze chutes and head gates should have solid latches to prevent accidental opening and possible injury to the worker. Floors must not be slippery or cluttered with things that might trip the worker. Sharp corners, pinch points, and protrusions should be eliminated from livestock handling facilities.

Cattle will seldom attack a person. However, sudden noises may startle them. The cattle may then injure a person by crowding him or her against a hard surface. Never approach cattle from the side or rear. Approach the animal from the front while talking to it. This alerts the animal to the presence of the worker. Always wear boots or hard shoes when working around cattle. Tennis shoes should never be worn around livestock. Cattle kick forward and then to the rear. This is a hazard that must be watched for when working with an individual animal. Many of the safety practices outlined for horses also apply to cattle.

The eyes of cattle are located on the sides of their head, which gives them a panoramic view of their surroundings. They have a wider range of peripheral vision than humans. Cattle have limited depth perception and see things in various shades of black and white. As a result, they are sensitive to movement in their field of vision and also react strongly to contrasting patterns of objects around them. The eyes of sheep, goats, horses, and chickens are also located on the sides of their heads. The visual reaction of these animals is very similar to that of cattle. Cattle react negatively to sudden, loud noises, as well as to high-pitched sounds. When moving cattle, do not yell or make other sudden loud noises. This only tends to confuse the animals and will not get them to move in the desired direction. Cattle should be handled calmly and quietly at all times.

People who work with cattle need to be aware of the “flight zone” concept. The flight zone is an imaginary circle around the animal or the herd. The radius of the circle is fairly small for animals that are used to being around people and much bigger for animals that have not been handled much in the past. The flight zone for cattle generally ranges from 5 to 20 feet. However, cattle that are used to being handled, such as dairy cows, may allow a worker to walk up and touch them without moving away. When the worker enters the animal’s or herd’s flight zone, the animal or the herd will move away. If the worker stays on the edge of the flight zone, the animals will move in a calm, steady manner. When moving cattle, the worker should stay in a position where the animal can see the worker. Do not try to head off cattle when they turn and try to go back into an alleyway. A more effective way to handle this situation is to move out of the animal’s flight zone when it starts to turn back.

2.3.3. Hazards of animal diseases

Diseases and parasites that may be transmitted between humans and animals are called zoonoses. Some of the common zoonoses are rabies, brucellosis, bovine tuberculosis, trichinosis, salmonella, leptospirosis, swine erysipelas, ringworm, tapeworm, and spotted fever. Some of these diseases and parasites are very dangerous to humans. Cleanliness, vaccination, quarantine of sick animals, and avoiding exposure are some of the ways to prevent these diseases. Wear rubber gloves when treating sick animals.

2.3.4. Safety solutions

Livestock handling facilities should be well designed and functional for both animal welfare and worker safety. Suggested simple solutions for safe animal handling include:

- planning ahead for any task
- separating people from animals as much as possible
- having water available in yards/shearing sheds to clean up during and after work
- having at least one person on the farm trained in administering first aid
- having a first aid kit close by
- talking about safety issues with family members, workers and other animal handlers.

Procedures to reduce the spread of disease may include, but are not limited to:

- Incident reporting
- Cleaning, removal of waste and spillage, containment or elimination of risk
- The use of PPE and Seeking advice from supervisors.

Protocols for safe work practices may include to:

- Use of PPE clothing and equipment including safety goggles and glasses, protective masks, safety gloves, aprons, appropriate footwear and animal handling gauntlets, hazard identification and risk minimisation
- The handling, use, storage, transport and disposal of chemicals; and
- The handling and disposal of biological wastes.

2.4. Preparing Feed and feed supplements

Feed accounts for approximately 75 percent of the total cost of raising livestock. To feed livestock profitably it is necessary to develop rations that are as economical as possible. The ration must be palatable and meet the nutritional requirements of the animals. Homegrown feeds are used as much as possible because they are generally less expensive than purchased feeds. Commercial feeds are used when homegrown feeds are not available and also to supply nutrients not provided by homegrown feeds. A feed must be palatable, or taste good, in order for the animal to eat it. Moldy feed is often not palatable. Insect and weather damage also lower the palatability of feed. Feed is of no value if the animal will not eat it.

Feeds used in rations must not be harmful to the animal's health or lower the quality of the product. Poisonous plants should not be included in diets for live- stock as these plants may make animals sick. Poisonous plants sometimes grow in hay and pasture fields. Eradicate these plants before harvesting the hay or allowing animals to graze the pasture. Usually, animals will not eat poisonous plants, but if they are in the hay the animals may not sort them out. If the pasture is sparse, animals may eat poisonous plants that are growing there.

It is necessary to balance the intake of roughage and concentrates for the particular species and age of livestock being fed. Ruminants can use more roughage in their diets than non-ruminants. Also, younger animals cannot use as much roughage in their diets as can more mature animals. The purpose for which the animal is being fed must also be considered when including roughage in the diet. For example, fattening animals generally should be fed less roughage than breeding animals.

Adequate animal nutrition is essential for high rates of gain, ample milk production, efficient reproduction, and adequate profits (see sidebar). However, forage quality varies greatly among and within forage crops, and nutritional needs vary among and within animal species and classes. Producing suitable quality forage for a given situation requires knowing the factors that affect forage quality, then exercising management accordingly. Forage quality has a direct effect on animal performance, forage value, and, ultimately, on profits. Analyzing forages for nutrient

content can be used to determine whether quality is adequate and to guide proper ration supplementation.

2.4.1. Factors affecting forage quality

Almost everything can affect forage quality in one way or another. Soil moisture and soil fertility while the forage is growing are important. Generally, the better the growing conditions, the higher the forage quality. With good growing conditions, the most important factor affecting forage quality is growth stage at harvest. More mature forage is less nutritious. Older plants generally have a lower proportion of leaves and a higher proportion of stem material (highly indigestible fiber). Young tender stems, leaves and flowers provide the highest quality forage.

Forage producers and users recognize that quality does not improve after harvesting. The harvesting process can, however, reduce forage quality. Baling hay too wet can cause excessive heating and mold to develop. Forage quality can also be reduced during storage. Uncovered hay stored outside loses nutrients by the leaching action of rain. In summary, high-quality forage is the end product of good growing conditions, correct harvest timing and proper handling and storage from harvesting to utilization. Feed ingredient quality (grains, forages, fat, minerals, and vitamins) is a critical part of animal nutrition. Good storage facilities and conditions are vital. However, the quality of the grains and forages starts with a good initial quality product at harvest.

2.5. Determine Essential requirements for animal nutrition

The animal uses the nutrients obtained from foods for a variety of purposes. Formulation of a ration or diet requires knowledge of the nutrient requirements of the animals and the nutritional value of the foods and, in order to combine these two, the amount of foods the animal can consume. The feed intake capacity (Dry Matter Intake) depends on live weight, production level and quality of feed. The quantity is expressed in terms of dry matter (DM). Essential requirements may vary due to live weight and body condition, mating, lactation and milking, growth, weather conditions/wind chill, sex and age of animal, energy concentration of feeds, distance walked for feed, water or shade, pasture digestibility, and disease/health status. Essential

requirements include Energy, protein, vitamins, water and minerals. Essential nutrients—nutrients required in the diet because they cannot be synthesized within the body in sufficient amounts to satisfy metabolic needs.

a. Energy

The most important item in an animal's diet and over-all feeding standards is based on energy needs. Meeting the energy requirements of an animal can be a major cost in feeding. Animals derive energy from partial or complete oxidation of carbohydrates, fats, and proteins ingested and absorbed from the diet or from breakdown of glycogen, fat, or protein absorbed in the body. Animals require some energy even in a nonproductive state for sustaining the body and maintaining body temperature and muscular activity. Additional energy is required when performing work and for growth and fattening, pregnancy, and lactation. Younger animals require more protein and energy to maintain condition and growth. The energy requirement of male animal is higher than female animals. This is due to the basal metabolism rate is higher for males than it is for non-pregnant females of the same age and size.

b. Protein

Protein is required by rumen micro-organisms to digest forages; therefore, if protein is inadequate, intake will be reduced. Proteins are the principal constituents of the organs and muscles. Protein deficiency is also a major problem. If an animal has an energy deficiency, a lack of protein in his diet aggravates the condition. Protein supplement is often mistakenly advocated when total energy (carbohydrates and fats) intake should be increased. In many range-land areas in fair to excellent range condition, and where adequate dry roughage is available, protein supplement is the only winter supplement needed.

The qualitative protein requirement is greater for growth than for maintenance and is affected by sex, species, and genetic makeup within species. Most animals tend to eat to satisfy energy requirements. A shortage of protein or energy in the diet prevents the animal from using fully their potential for growth. As the growth rate of muscles and bones is limited, excessive energy intake is converted to fat. Protein is diverted to energy only when it is provided in excess of the metabolic requirement or calorie intake is sufficient.

c. Carbohydrates

The primary function of carbohydrates and fats in animal nutrition is to serve as a source of energy for normal life processes. The dry matter in plants consists of 75 to 80 percent carbohydrates. Carbohydrates are the major constituents of plant tissues, and the energy in most plants is available largely as carbohydrates. This energy provides the animal the nutrition for growth, maintenance, and production. Energy deficiency is a major problem and usually occurs when animals do not get enough to eat. Increasing the animals' total feed intake can bring about dramatic recovery from many so-called minor element deficiencies and diseases. Maintenance requirements for dry animals are significantly less than those for lactating animals. About 20 days after an animal gives birth, the megacalories of energy required are 150 percent of those required before parturition. The needs of mother and offspring immediately before weaning are 200 percent of those of the dry mother.

d. Vitamins and minor elements

In addition to carbohydrates, proteins, fats, minerals, and water, vitamins (organic compounds) are required by animals in small amounts for normal body functions, maintenance, growth, health, and production, and they regulate the use of major nutrients. Vitamins must be provided to animals for many metabolic reactions within cells. If the vitamins are not available, biochemical reactions cannot take place and such symptoms as loss of appetite, poor appearance, reduced growth, and feed utilization may occur.

e. Minerals

Minerals have three functions:

- Calcium and phosphorous are the main constituents of bones, teeth, and other organs.
- Present as electrolytes in body fluids and soft tissues.
- Trace elements are integral components of certain enzymes and other important compounds. These trace elements serve as activators of enzymes.

Animals derive most of their mineral nutrients from forages and concentrate feeds they consume.

f. Water

Water is a major component of the animal's body and is influenced by several such factors as species, age, and dietary conditions that effect the amount in the body. Animals are more sensitive to the lack of water than food. If water intake is limited, the first indication is feed intake is reduced. As water intake becomes severely limited, weight loss is rapid and the body dehydrates. Dehydration with a loss of 10 percent is considered severe, and a 20 percent water loss results in death. Insufficient or poor-quality water causes poor livestock performance. Water requirements are influenced by diet and environmental factors. Water consumption is generally related to dry matter intake and rising temperature. As the temperature increases, water consumption increases and feed intake decreases. The three sources of water are:

- drinking water
- water contained in foods
- metabolic water

2.6. Determining economic basis to supplementary feeding system

2.6.1. Types of cattle feeding systems

There are two types of cattle feeding system. These are outdoor feeding and indoor feeding systems

a. **Indoor feeding**: feed bunks or mangers. Several different types of feed are fed to livestock including hay, silage, grain and prepared rations. Special equipment is required to make, store and deliver each type of feed.
b. **Outdoor feeding**: Pasture and rangeland grazing in open fields. Seasonal feeding on the ground.

2.6.2. Supplementary feedings to animals

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

- **Energy Supplements**

Many energy-rich feeds are by-products of cereal grain milling. These by-product feeds usually come from various layers of the seed covering, which, along with being higher in fibre, are higher in protein and minerals than the seed itself, which is mainly starch. The most common milling by-products are from wheat with lesser amounts derived from corn. Molasses is the major by-product of sugar production, coming mainly from sugar cane but also from sugar beets. Most molasses in commercial use is adjusted to contain 25% water. It may also be dried so that it may be added to dry diets, but this is a much more expensive product. While molasses is a good source of trace minerals, the protein and vitamin level is quite low. It is used often to stimulate eating, to reduce dustiness in feeds, as a pellet binder, and when fortified with an N source, as a ruminant feed known as a liquid protein supplement.

- **Protein Supplements**

These may originate from either plant or animal sources, or in the case of ruminants, from non-protein Nitrogen Sources. A protein supplement is a feed which has more than 20% crude protein. These are usually the most expensive constituents in animal rations so their selection is affected by cost and availability. The content and availability of amino acids for monogastric species, the presence of undesirable or toxic substances and the content of other nutrients should also be considered. Soybean meal, Cottonseed meal and linseed meal are the most common plant protein supplement. Animal protein supplements (meat meal, blood meal, bone meal) are usually by-products of the meat-packing industry. Since these are animal tissues, the amino acid distribution is usually similar to the animals' requirements, although quality may be quite variable.

- **Minerals supplement**

Numerous minerals are essential for proper animal nutrition. In addition to their metabolic functions, the macro-minerals are necessary for tissue structure (e.g. calcium and phosphorous in bone or egg shells) and for milk secretion. Plant tissues obviously contain considerable mineral but the actual content can vary with stage of maturity and soil conditions. Feed analysis is necessary to indicate the actual composition so that diets can be fortified as required. Bone meal, limestone and many mineral supplements are available from commercial feed suppliers.

- **Vitamins supplements**

Vitamins function as cofactors or enzyme activators in metabolic processes so are necessary for all general body functions and maintenance of health. All green, growing plants contain carotene which animals can convert into vitamin A. Supplemental vitamin A may be necessary to ensure an adequate supply whenever herbivores are not grazing on good quality pasture and for omnivores and carnivores. The rumen micro-organisms produce B vitamins so these are unlikely to be deficient in matures ruminants. In contrast, diets for very young calves and all non-ruminants may require some supplementation with B vitamins. Animal diets usually contain sufficient vitamins E and K but deficiencies can occur. As with all other nutrients, diets should be designed to meet individual requirements and fortified to provide a slight excess of any vitamins that could be deficient under natural conditions.

Supplementary feeding is often used in grazing systems to help meet production requirements. This may be a regular part of the production cycle to help match feed demand to feed supply or reserved for times of drought. The extent to which supplementary feeding is used depends on the business objective and seasonal conditions. Important considerations in supplementary feeding include:

- Animal health: Animal health must be considered foremost. In a drought feeding situation, if supplementary feeding is determined to be necessary through feed budgeting, but is not possible due to financial or labour constraints, livestock should be sold or adjustment options sought when stock begin to fall below a condition score of 2. Where supplementary feeding is being undertaken to achieve a particular production objective, the nutritional requirements of the animal as a ruminant must be considered and an appropriate ration devised accordingly.

- Feed budgeting: Feed budgeting is the method of predicting whether the feed available to the herd or flock is sufficient to meet requirements. This requires an understanding of pasture growth rates throughout the year for a particular location and can be accessed via farm planning tools such as the feed demand calculator if on-farm records are not available.

- Production objectives: It is important to consider the enterprise's production objectives eg if the enterprise's production objective is to maximise weight gain, then a high energy supplement may be appropriate, such as grain. If the production objective is to wean more animals and supplementary feeding is required to minimise disease associated with nutritional deficiencies during late pregnancy, such as grass tetany or pregnancy toxaemia, hay may be a better option.

Both approaches will require an increased labour commitment and the economic and social impact of this will also have to be considered. By identifying the need for supplementary feeding and aligning feed requirements with production objectives, the most suitable feed source can be identified and the impact of supplementation on the operating margin minimised.

The ultimate supplementation strategy adopted will depend on class of animal being fed, the timing of the intended market and the impact of compensatory gain. E.g benefits of supplementary feed growing cattle over the dry season can be almost completely eroded by compensatory gain if they are not sold until the following year. To be effective, the supplement you choose must make up for the main nutrient deficiencies in the paddock feed. Dry feed is often deficient in protein and sulphur. In cases where the feed is green but very short, it is the low energy intake which limits production. The following principles for efficient use of supplements should be followed.

- Identify the most limiting components, usually protein, sulphur and/or metabolisable energy.
- Select supplements containing high levels of the identified limiting components.
- Balance the supplement to ensure efficient rumen function
- Young and lactating animals have a greater need for protein.
- Choose feeding techniques which minimise disruption to the animals' digestive system.
- Cost out the program, taking into account alternative measures.
- Start feeding those animals with the greatest needs, for example pregnant cows of low fat score, or weaners below critical liveweights.
- Monitor feed consumption, liveweight and condition, so that you can confirm that your strategy is working.

2.7. Develop and Monitor feeding plan for animal

Recommended feed management practices for a particular operation may include considering processing options, implementation of grouping strategies, including grouping by gender and increasing the number of production groups, appropriately adjusting diets based on climatic factors, and minimizing feed wastage.

- Grouping: Place animals of similar ages, weights, and production levels together so that more specific rations can be developed with a minimal chance of overfeeding nutrients.
- Phase feeding: Use multiphase feeding versus minimal-phase feeding. Phase feeding provides a series of diets that are formulated to more closely meet the nutrient needs of the animal at a particular stage of growth or production. Dividing the growth period into several periods with a smaller spread in body weight, milk production, or egg production status allows producers to provide diets that more closely meet the animal's nutrient requirements and significantly reduces nutrient excretion and wastage.
- Gender (split-sex) feeding: Place animals of the same gender together. Split-sex feeding divides the animals by gender so that diets can be formulated to meet the special nutrient needs of each sex.
- Climate: Adjust diet to meet specific climatic conditions, i.e., temperature, wind, precipitation, or adjust the building climate to optimize nutrient utilization.

2.8. Identifying factors that determine animal feed intake

2.8.1. Introduction

The maximum dry mater intake is about 3 - 3.5% of a cows live weight and can be estimated with the formula kg Dry mater/cow/day = 0.025*live-weight + 0.1*kg milk.

In general, daily dry matter intake of the anima is calculated by the following formula

Dry Matter intake (DM) = 0.025 x Body weight x 0.1 x kg of milk yield
Concentrate feed = $^{2}/_{3}$ x DM
Roughage = $^{1}/_{3}\,x$ DM

Source: https://assets.accessagriculture.org/s3fs-public/Animal_nutrition_and_feed_rations_infonet_biovision.pdf (Accessed on 04/09/2022)

2.8.2. Major drivers of feed intake

- Feed availability: The amount of feed on offer must be sufficient to satisfy appetite and meet production targets. Provide equal access to feed for all cows, particularly at troughs or on a feedpad.
- Feed quality: Optimise nutrient content in the diet for intake and milk production (e.g. energy, protein and fibre). Feed quality and the palatability of a particular feed are affected by:
  - ✓ Freshness
  - ✓ Mould
  - ✓ Spoilage
  - ✓ Taste
  - ✓ Moisture
  - ✓ Temperature
  - ✓ High neutral detergent fibre (NDF) in individual feeds and the total diet will restrict the cow's ability to consume a high intake.
- Feeding management: Provide feeds and total diets that are easy to eat and digest. Consider the:
  - ✓ chop length
  - ✓ degree and type of grain processing
  - ✓ amount of green leaf available in pastures
  - ✓ Ensure mixed rations are mixed thoroughly

It is important to note that a lack of water in the diet results in a reduced appetite: a cow will eat less

Neutral detergent fibre (NDF) content: NDF in forages and the total diet determines dry matter (DM) intake. Diets need to be balanced to contain sufficient and effective NDF for healthy rumen function while not providing too much fibre, as this slows down digestion and limits intake.

Other factors that influence DM intake include:

- ✓ cow size
- ✓ rumen health
- ✓ stage of lactation (in early-lactation cows require higher DM intake)

- ✓ water quality and accessibility
- ✓ heat stress
- ✓ overall animal health
- ✓ nutrient supply (should be constant and consistent to maximise rumen microbial activity and DM intake).

2.9. Identifying the most important elements of animal feed

2.9.1. Classification of basic nutrients

Nutrient is any substance absorbed by an organism from its external environment and used in the metabolism. Essential requirements may vary due to live weight and body condition, mating, lactation and milking, growth, weather conditions/wind chill, sex and age of animal, energy concentration of feeds, distance walked for feed water or shade, pasture digestibility, and disease/health status. It is source of materials needed for growth, maintenance, and reproduction and production purpose. It includes: Water, Carbohydrate, Proteins, Lipids, Minerals and Vitamin.

i. Water

Water – Often overlooked and not considered as a nutrient when formulating diets for animals, but extremely important. It is vital to the life of the organism that the water content of the body be maintained. An animal will die more rapidly if deprived of water than if deprived of food. The water content of foods is variable and can range from as little as 60 g/kg in concentrates to over 900 g/kg in some root crops. Water quality may affect feed consumption directly because low quality water normally will result in reduced water consumption and, hence, lower feed consumption and production.

ii. Carbohydrates

Carbohydrates defined as hydrates of carbon formed by combining CO_2 & H_2O (photosynthesis). The primary component found in animal feeds. Carbohydrates consumed by animals serves as source of energy, as a reserve in the form of fat mainly, and also glycogen into which it is readily transformed.

Functions of Carbohydrates in general

a. Carbohydrates are the main sources of energy in the body.
b. Store energy (starch and glycogen).
c. Excess carbohydrate is converted to fat.
d. Carbohydrates are linked to many proteins and lipids, where they play key roles in mediating interactions among cells and interactions between cells and other elements in the cellular environment.
e. Structural basis of many organisms: Cellulose of plants; exoskeleton of insects, cell wall of microorganisms, mucopolysaccharides as ground substance in higher organisms.

iii. Proteins

Proteins are complex organic compounds of high molecular weight. Proteins are found in all living cells, where they are intimately connected with all phases of activity that constitute the life of the cell. Each species has its own specific proteins, and a single organism has many different proteins in its cells and tissues. It follows therefore that a large number of proteins occur in nature. Proteins are mainly found in active tissues in plants and animals like leaves, shoots, and muscle. In common with carbohydrates proteins contain carbon, hydrogen and oxygen but in addition they also contain nitrogen. Most proteins also contain sulfur and a few contains phosphorous and iron. Functions of protein are;

- Peptides derived from casein are involved in calcium flow in tissues and modification of the immune system response
- Other milk peptides stimulate growth of desirable bacteria and suppress harmful bacteria, and some act as growth factors for intestinal cells.
- Peptides, including bombesin, enterostatin, glucagon and leptin, are important in the control of food intake.
- Peptides play an important role in the flavour and sensory properties of foods such as yeast extract, cheese and fruit juices.

iv. Lipids

Lipids are group of substances found in plant and animal tissues, insoluble in water but soluble in common organic solvents such as benzene, ether, chloroform, ethanol which is the specific character of lipids. These are basically made up of the elements carbon, hydrogen and oxygen,

but quantity of oxygen found in basic lipid structures is lower than that found in carbohydrates. Lipids play different roles in the animal body. They act as electron carriers, substrate carriers in enzymatic reaction, as components of biological membranes & stores of energy. Additional Functions of Lipids are:

- As an energy source, lipids provide 9 kcal of energy per gram
- Source of steroid hormones are critical intercellular messengers
- Helps in absorption of lipid-soluble vitamins (A, D,E, K)
- Adds taste & palatability to foods.
- Acts as surfactant, detergent & emulsifying agent.
- Give shape to the body

v. Vitamins

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

- Development healthy skin and nerve tissue.
- Aids in building up resistance to infection.
- Functions in eyesight and bone formation.
- It is important in the ration of pregnant females.
- Normal reproduction
- Essential for the proper utilization of calcium and phosphorus to produce normal, healthy bones.
- Necessary for the maintenance of normal blood coagulation.

vi. Minerals

These are inorganic nutrients necessary in serving the animal body in many different ways. Minerals have many roles in addition to their catalytic role by activation of many enzymes. Other roles of minerals include:

- They are building blocks of animal tissues such as constituents of bones and teeth (structural role), and also essential for synthesis of structural proteins like the mineral sulphur.
- Minerals are components of organic compounds like iron haemoglobin, cobalt is vitamin B12.
- Minerals serve a variety of functions as soluble salts in blood and other body fluids playing role in maintenance of osmotic relations and acid base equilibrium (elector chemical function).

Essential minerals are classified into two depending upon their concentration in the animal or up on the quantity animals require these elements.

1. Major element: are elements required in relatively larger quantities
2. Minor elements (trace elements) - are elements required is relatively less quantities.

vii. Essential and non-essential nutrient

In animal nutrition, essential means ‘essential in the diet’, i.e. the nutrient must be supplied in the animal’s feed. A nutrient is essential when either:

- It cannot be made at all within the animal’s cells, e.g. the essential amino acids listed in α-linolenic and linoleic fatty acids, all the minerals needed by animals and almost all vitamins (there are some individual species differences); or
- It can be made but not rapidly enough to meet the animal’s current need for it, e.g. in some circumstances, the amino acid arginine.

Nutrients which can be synthesized within animal body cells are called non-essential nutrients. This does not mean that they are not needed in the animal’s metabolism; just that they do not have to be provided in the animal’s feed. However, the feed must supply those substances which the animal needs as starting points to synthesize non-essential nutrients.

2.10. Aligning feed requirement with physiology and production type

Feeding standards are based on the nutrient requirements of a specific species at a specific physiological state. The nutrient requirement for each nutrient is the total amount of each nutrient required to perform the various physiological functions. Dietary nutrients should be supplied at the required levels; both nutrient deficiencies and excesses have the potential to have detrimental effects on the animal. Nutrient requirements are either expressed as the total amount required each day or the concentration required in the diet. It is important to emphasize the animal requires an amount of a specific nutrient versus a concentration of a specific nutrient. However, rations offered ad-libitum or free-choice are formulated based on nutrient concentration. Accurate ration formulation for ad-libitum, also referred to as ad-lib, intake requires an accurate estimation of intake to ensure the animal will consume the required amount of the nutrient.

The first category is nutrients required for maintenance. All animals have a maintenance requirement. Maintenance is defined as the state in which an animal is neither gaining nor losing nutrients. Formulating rations to include only the maintenance requirement is rare. Generally, rations also include nutrients for additional functions such as growth or lactation. Therefore, during ration formulation the maintenance requirements are used as an initial reference point and additional requirements are added depending on the animal's specific physiological state.

The second category is growth and development. In animals, growth and development is measured by determining the animal's weight. Growth rate is determined by the weight change over time. Relative growth rates in life are represented by growth curves. Average growth curves are available for all species. Figure below illustrates an average growth curve for an animal with a mature body weight of 500 kg or approximately 1,200 pounds.

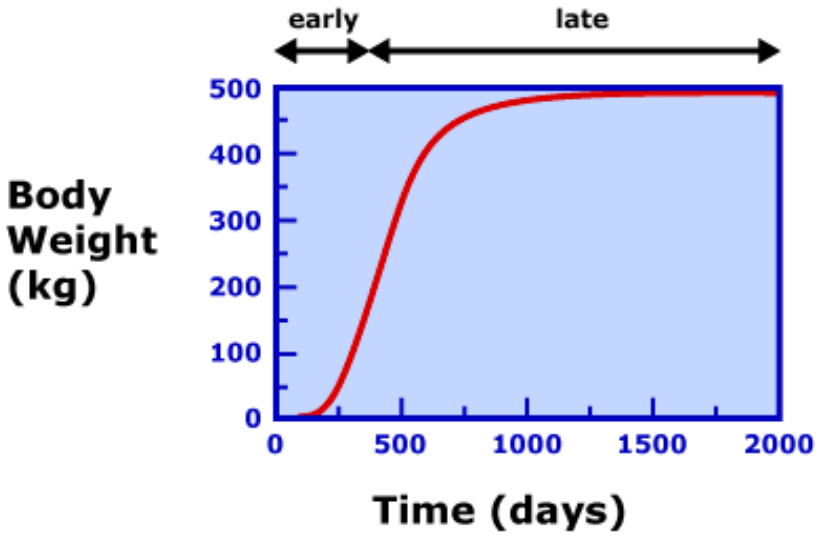


Figure 2.5: Illustrates an average growth curve for an animal

Although it is essential to provide nutrients to achieve adequate growth rates, economics of growth is important to consider. Gross efficiency, defined as total production divided by total consumption, is greatest for young animals because a greater portion of the total nutrients are going towards productive growth versus maintenance. However, if maximal growth rate is not required to achieve a set growth point in a set period of time, it may be economically advantageous to feed a lower quantity and/or quality of nutrients over time and achieve the same total growth at a lower cost.

Lactating animals with high milk production have an extremely high nutrient requirement. The primary nutrients in milk are water, lactose, lipids, protein, and a variety of minerals especially Ca and P. Nutrient requirement is directly related to level of production. As production increases, nutrient requirements increase. Milk production will vary between and within species. A lactating animal has two sources to fulfill her nutrient requirements, dietary nutrients and nutrients from tissue mobilization. The main source of nutrients such as water will come from the diet and limiting the dietary source will limit milk production. A lactating animal does have the ability to mobilize specific nutrients for a period of time without significantly limiting lactation. However, if the metabolized nutrients are not replenished from dietary sources, subsequent production will be limited.

Nutrient requirements for reproduction can be divided into three time periods, prior to breeding, the initial two-thirds of gestation, and the final one-third of gestation. Nutrient balance prior to breeding can influence conception, establishment of pregnancy, and maintenance of pregnancy. The magnitude of the increase in nutrients is the greatest during the final one-third of gestation in comparison to the initial two-thirds of gestation. During the final one-third of pregnancy, in addition to supporting the growth of fetal tissues and associated fluids, the dam's metabolic rate also increases. Limiting nutrients required during gestation will limit subsequent health and productivity of the dam and the offspring. Severe limitation of nutrients can result in death of the offspring and/or the dam.

2.11. Recording and reporting feeding abnormalities and signs of stress

2.11.1. Introduction

Cattle may consume feeds normally, but there can be negative symptoms shown as result of the consumption of certain feeds. These may include diarrhea, abnormal water intake, bloat, poor appetite, non-typical or unpleasant smells in products (e.g. milk) and excreta and of discomfort. Appropriate action must be to ascertain the quality aspects of the feed concerned when such negative effects are noted. Animal health is critical to performance and business success; unhealthy animals will not generate efficient production or profits.

The negative effect of stress on feed intake has long been recognized, although the precise pathways involved are still debated. It is likely, however, that the inhibitory effect of stress on appetite results from a complex interplay among leptin and glucocorticoids. There is some evidence suggesting that stress may have an inhibitory effect on rumination and this in turn may reduce feed digestibility and therefore performance, and may also increase the risk of ruminal acidosis.

2.11.2. Signs of stress and its influence on farm animals

The stress response includes several changes that may have negative effects on the performance of farm animals. These effects include changes in the immune function and increased susceptibility to disease, decreased feed intake and rumination, inhibition of oxytocin release,

and reduced fertility, among others. Stressors can be conveniently divided into physical stressors, social stressors resulting from the interactions with individuals of the same species and stressors related to handling by humans. Stressors have additive effects. This means that when several stressors impinge upon the animal at the same time, the resulting stress response will be much higher than if the animal was exposed to one stressor only. Therefore, circumstances such as weaning and transport can be particularly difficult for the animals.

The stress response includes several changes that may have negative effects on the performance of farm animals. These effects include changes in the immune function and increased susceptibility to disease, decreased feed intake and rumination, inhibition of oxytocin release, and reduced fertility, among others. In this fact sheet we will address the effect of stress on susceptibility to disease, feed intake and rumination.

The negative effect of stress on feed intake has long been recognized, although the precise pathways involved are still debated. It is likely, however, that the inhibitory effect of stress on appetite results from a complex interplay among leptin and glucocorticoids. There is some evidence suggesting that stress may have an inhibitory effect on rumination and this in turn may reduce feed digestibility and therefore performance, and may also increase the risk of ruminal acidosis. The precise mechanism underlying the effect of stress on rumination is not know, but it is interesting to highlight that brain activity during rumination is similar to that during sleep, and stress is known to interfere with sleep.

Self-check 2	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer from the given alternatives (2 points each)

1. Based on its component livestock feeds are classified as _____:
   a. roughages b. concentrates c. crude fiber d. A and B
2. Factors that determine animal feed intake are;
   a. weather condition b. animal health condition c. live body weight d. all
3. One of following animal feed nutrient is not the most important
   a. protein b. energy c. supplementary feed d. water
4. Animal need nutrients for the purpose of: a. maintenance b. reproduction
   c. production d. growth e. all

Test II: Short Answer Questions (3 points each)

1. Write the difference between feed supplements and feed additives
2. Explain advantages of aligning feed requirement with physiology and production type of an animals
3. Explain tools and equipments used for preparing and providing animal feed
4. What are the types of cattle feeding systems?
5. List PPE used in animal production facilities
6. Describe the influence of stress on the production performance of animals?

Note: **Satisfactory rating - 12points** **Unsatisfactory - below 12 points**

You can ask your teacher for the copy of the correct answers

LG # 13 LO # 3- Feed Ration Formulation

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Preparing and monitoring feeding plan to livestock farming
- Selecting feeding method and amount of feed
- Determining feed types and feed budget
- Feeding costs and benefit analysis
- Recording feed related data
- Performing animal feed content evaluation
- Calculating animal feed requirement for specific animal
- Applying basic ration formulation steps for animals

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to;

- Prepare and monitor feeding plan to livestock farming
- Select feeding method and amount of feed
- Determine feed types and feed budget
- Feed costs and benefit analysis
- Record feed related data
- Perform animal feed content evaluation
- Calculate animal feed requirement for specific animal
- Apply basic ration formulation steps for animals

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet 3

3.1. Prepare and monitor feeding plan to livestock farming

A feeding plan is designed to provide information on the requirements of an individual to ensure they are fed in a way that promotes good health and prevents negative effects. A feeding plan can be given to someone who is looking after an animal to ensure they feed the animal in a suitable manner.

3.1.1. Check list for successful feeding planning

a. Take a broad look at your system
   - Is the feeding system right?
   - Is waste minimized?
   - Are there any big changes that could be made to improve performance eg, contracting out heifer rearing, changing grazing or winter feeding system?

b. Work out the energy requirements of all stock over a year of production

c. Work out the current feed conversion efficiency

d. . Know the nutritional content of the grass, silage, forages and bought-in feeds
   - Energy content
   - Protein content
   - Digestibility
   - Minerals

e. Monitor stock performance to make sure the feeding regime is right for the system
   - Milk record
   - Measure liveweight and weight gain against targets
   - Body condition score and Blood profiles

f. Work out a whole-farm feed plan
   - STEP 1 – Work out annual energy demand

- STEP 2 – Work out annual energy supply from grazed grass, conserved forages, bought-in concentrates and straights
- STEP 3 – Subtract Step 1 from Step 2 and assess where the energy balance lies

g. Set targets for improvement

- Is more production from grazed grass and conserved home-grown feeds possible?
- Use bought-in feeds as efficiently as possible
- Focus on attention to detail

h. Consider other factors

- Animal health
- Protecting the environment

3.1.2. Whole-farm feed planning

- **Balancing energy demand and supply**

Step 1: Work out the animals' annual demand for energy

A. Annual energy requirements for dairy stock

Table 3.1: Maintenance energy for cows (per cow) (Source: https://www.nutrientmanagement.org/assets/12028 Accessed on 02/09/2022)

Cow weight (Kg)	Annual maintenance energy requirement in Megajulies metabolizable energy (MJ ME)
550	25.550
600	27.27.350
650	29.200

Table 3.2: Energy required for milk production (per cow) (Source: https://www.nutrientmanagement.org/assets/12028 Accessed on 02/09/2022)

Annual milk yield (litres)	**Annual energy required (MJ ME)**
4500	23,850
5000	26,500
5500	29,150
6000	31,800
6500	34,450

7000	37,100
7500	39,750

Note: milk with very high or very low butterfat content will increase/decrease energy requirements.

B. Annual energy requirements for beef stock

Table 3.3: Annual growing and finishing heifers and steer energy requirements (Source: https://www.nutrientmanagement.org/assets/12028 Accessed on 02/09/2022)

Stock	Annual energy requirement (MJ ME per animal)		
	12 month system	18 month system	
		1st year	2nd year
Small heifer	22,800	10,300	16,300
Medium heifer/ small steer	25,600	11,400	17,500
Large heifer/medium steer	25,800	13,600	18,700
Large steer	28,300	14,500	19,200

Table 3.4: Growing and finishing bulls ((Source: https://www.nutrientmanagement.org/assets/12028 Accessed on 02/09/2022)

Breed size	Annual energy requirement on a 12 month system (MJ ME per bull)
Small	22,200
Medium	27,000
Large	29,800

Step 2: Work out the energy supplied by feed each year

- Now calculate the energy supply from the farm. Work out how much grass and forage DM is produced each year and its energy content. If these figures are not known, they can be worked out roughly. Much of the information needed is contained in the analysis of bought-in feeds and forages that have been sampled. It is best to make these calculations

on DM value – this keeps everything on the same basis and means the energy needed and supplied can be compared.

Step 2a: Work out the energy supplied from grazed grass

- Unless a platemeter is used to monitor grass growth and utilisation, it is difficult to estimate the energy supplied into the system from grazed grass. Yet this is a significant and cheap source.

Step 2b: Work out the energy supplied by conserved forages

- If conserved forages are sampled and tested the feed analysis will indicate their DM and energy contents. These can be used to work out how much energy is being produced and used from these silages. Subtract any wastage in storage and feeding out from the total produced. Typical clamp losses range from 10–15% of the DM, but can be as high as 30% in poorly managed feeding systems

Step 2c: Work out the energy supplied by concentrates and straight feeds

- This is the relatively easy part! The amount bought in is known and the ingredients label gives information on energy density on a DM basis.

Step 3: Subtract the total energy demand from the total energy supply to find the whole farm annual energy balance.

Fresh look when preparing and monitoring feeding plan

- Measure
  - ✓ Nutrients in soils, manures
  - ✓ Nutrients in grass, forage crops, silages, bought-in feeds
  - ✓ Grazed grass and silage yields
  - ✓ Animal performance – milk yields, growth rates, dry matter intakes, health and fertility
  - ✓ Feed conversion efficiency
- Think
  - ✓ About the strategic objectives of the enterprise.
  - ✓ Set targets for production, feed efficiency, financial returns, environmental impact and marketing of the end product
- Plan

- ✓ How to achieve the objectives. Draw up:
  - ✓ A soil management plan
  - ✓ A crop nutrient management plan
  - ✓ Feed plans for feeding grazed grass in summer and conserved forages in winter
  - ✓ Targeted performance programmes for each livestock enterprise
  - ✓ An animal health plan

- Act
  - ✓ Make changes that will make the business more efficient and protect the environment, eg
    - Ration stock separately according to level of performance
    - Reduce wastage at feeding out
    - Change calving period
    - Introduce red clover
    - Contract out heifer rearing
    - Target manure applications to meet grass and crop requirements

There is a real win: win to be gained by balancing nutrient input to nutrient use on-farm; costs can be reduced and gains made from improving efficiency. Taking action to achieve these will reduce the over-supply of nutrients to the system.

3.2. Selecting feeding method and amount of feed

There are different methods of feeding cattle in animal husbandry.

a. Traditional feeding methods

At some farms concentrates are fed to cows individually according to milk production. The roughages and concentrates are generally fed free choice but are fed separately. Roughages are usually fed free choice in feed bunks to the entire herd or in mangers in stanchion barns traditionally, concentrate mix is fed individually in mangers in stanchion barns or in the milking

parlor during milking. Modern farms are getting away from this and are feeding free choice, which saves milking time and labor.

Disadvantages of traditional feeding include the following:

- It is hard to measure the amount of forage (roughage) each cow eats; therefore, it is hard to balance the ration with the right amount of concentrate for each cow
- Low-producing cows are often overfed concentrates
- High-producing cows are often underfed concentrates
- Grain-feeding facilities are required in the milking parlor
- The level of dust in the milking parlor increases
- Cleanup of uneaten grain in the milking parlor is required
- There is less control over the total feeding program

Advantages of traditional feeding include the following:

- Less specialized equipment is needed
- Theoretically, each cow feeds according to individual needs based on production
- It permits adjusting concentrate feeding to the stage of lactation
- It permits challenge feeding of each cow

b. Challenge or Lead Feeding methods

The practice of feeding higher levels of concentrate to challenge the cow to reach her maximum potential milk production is called challenge (lead) feeding. Challenge feeding gives more concentrates to the cow early in the lactation period and less later in lactation. Continue to increase the level of concentrate feeding until milk production levels off. At maximum milk production, hold the level of concentrate feeding constant. This practice is best used on small, high-producing farms. It would require immense labor and time to perform this on large farms.

c. Feeding Total Mixed Rations

A method of feeding that is becoming more popular with modern dairy producers is feeding a total mixed ration. A total mixed ration is one that has all or almost all of the ingredients blended together. This ration is then fed free choice to all the cows in a group. In large herds, the cows are usually divided into several groups. The total mixed ration contains roughages and concentrates combined to meet the energy, protein, mineral, vitamin, and crude fiber needs of the

cows. When feeding a total mixed ration free choice, no concentrates are fed in the milking parlor.

For pastured animals, grass is usually the forage that composes the majority of their diet. Cattle reared in feedlots are fed hay supplemented with grain, soy and other ingredients to increase the energy density of the feed.

An animal must receive the proper amounts of nutrients in the right proportion to efficiently produce meat, milk, eggs, wool, work, etc. Feeding a balanced diet, avoiding overfeeding, and providing abundant supplies of cool, clean, and pure water will help to optimize feed and nutrient use on an animal farm. It is impossible for all nutrients to be in a perfect balance in commercial or practical diets, but we want to come close to meeting an animal's nutrient requirements. If the diet is balanced except for one underfed nutrient, then the entire production of the animal will be limited to the level of that "limiting nutrient" and all other nutrients will be wasted. Overfeeding can be harmful to animals and to the environment. Animals that become over conditioned or obese may be unproductive and at greater risk of health problems. Excess feed is often wasted and may remain in the feeding area, become contaminated, and end up in the manure pile.

Matching the amount and quality of home-grown forages and concentrate feeds with animal production requirements is central to running a successful livestock business. Getting the balance right is crucial for generating an efficient system that has minimal detrimental impact on the environment while optimizing animal performance. Livestock should be fed rations that have been properly balanced for energy, protein, minerals, and vitamins. This will ensure their nutrient requirements are met and not exceeded which would lead to waste and inefficiency. Taking a bottom-up approach to feed planning, starting by calculating the amount of nutrients the animals need to perform to expected levels, calculating what can be grown on-farm, then filling any gaps with purchased feeds, provides an opportunity for farmers and industry to enhance profitability whilst protecting our surroundings.

3.3. Determining feed types and feed budget

Feed budgeting is a farm assessment to identify feed requirements based on the number and class of livestock to be fed and the production levels that are targeted. A feed budget is generally used as an outline of the feed supply and demand over a 12-month period a feed year plan.

3.3.1. The feed budgeting process

Predicting pasture availability and comparing it with stock requirements

- Estimate or measure the amount and quality of pasture currently available.
- Estimate the number of days that pasture is required for current livestock classes, numbers and the targets set for their production performance.
- Compare the number of days that pasture is required with the number of predicted days available for various weather patterns. Choose the pattern that is most suitable for the predicted circumstances

Taking corrective action based on an assessment of the benefits and costs:

- If the number of days of available feed exceeds that required, options for utilising the extra feed include increasing stock numbers on pasture or conserving the excess pasture by making silage or hay.
- If the number of days of available feed is less than required to meet targets, decrease stock numbers on pasture or be prepared to supplementary feed.

Feed budgeting is a useful tool in avoiding over and under grazing and optimising the conversion of quality feed into product. Overgrazing reduces plant leaf area and carbohydrate stores in the roots, thereby reducing production. Under grazing reduces pasture quality and quantity and misses production and profit opportunities.

3.4. Feed costs and benefit analysis

The main factor producers should consider when using by-product feeds is economics. Producers should check with several brokers to determine the market price and nutrient profile of each by-product feed considered. Prices vary throughout the year.

Cost of feed have the highest share in animal farming. Farmers/cattle owner feed different feed types for their dairy cows. Hay, concentrates, grasses and others are common feed types the farmers used to feed their cows. High share of feed cost goes to concentrates followed by green grass and hay for small dairy farms. Although the supply of feed is progressing, the cost of feed is increasing from time to time. Specially, the price of some concentrates such as oil seed cake is highly inflating. The reason for this could the existence of only few companies that produce limited feed concentrates who fix the price by themselves.

3.5. Recording feed related data

Record is information that has been systematically and carefully collected and appropriately stored for intended use. To be able to run any economic enterprise successfully, carefully thought out, properly collected and kept records are a must. For the purpose of keeping track and decision making in any economic enterprise, comprehensive and well kept records must be kept. The records will:

- Be used in determining profitability of various techniques of production or systems
- Be used to compare the efficiency of use of inputs, such as land, labour and capital, with that of alternative production activities
- Help the investor in improving the efficiency of farm's operations
- Be used to preserve institutional memory of the enterprise for future reference
- Records should be used for decision making on a farm/ranch and should be interpreted in the right way, otherwise there will be a waste of time, money and energy.
- Adequate and correct record keeping is also a valuable tool for assessing the performance of your herd or flock and making good management decisions.
- The records should be simple, easy and quick to interpret.
- In all records, there should be a 'Remarks' column/entry explaining the reasons behind any unusual observation. This is very essential in interpreting the implications of the records, particularly for a third party who may have not been directly involved in taking the records, but needs to make informed/accurate decisions.

3.5.1. Record keeping for Cattle production

Excellent records are the cornerstone of building a financially successful beef/Dairy enterprise and they will be of great help in the development of the Beef/dairy husbandry and beef/dairy industry of any country. In summary, the importance of good record keeping includes:

- Aids in efficient management of the herd Improves bargaining power on products Evaluation of livestock for selection Adding value to livestock
- Control of inbreeding and aid in breeding planning Aid in culling low performers
- To assess profitability/losses
- Aid in gross margin analysis Credit/loan access
- To rationalize labour
- Aids in disease management
- Aids in feed planning and management

Types of Records

The major types of records are:

- Physical (identification) Breeding
- Production (Performance) Feeding
- Health and Financial records

3.5.2. Feeding Records

These should indicate the amount of feeding given as well as the type of feed. Feeding records should be used the most for day-to-day management, evaluating pasture management practices and for planning of activities in the future. The day to day management decisions which are to be made are for instance, which cows need concentrates and how much, cows to be culled and why etc. Thus the important records are:

- Available fodder on farm
- Quantity fed
- Concentrate supplemented
- Minerals
- Left-over (per head and per feed, if possible)
- Spoilage (per batch)

3.6. Performing animal feed content evaluation

A person must know the nutrient composition of the feeds used to properly balance a ration. Average nutrient composition values can be found in nutrient composition tables. However, some feed, especially forages, can vary considerably from these average values. To get the maximum benefit from the ration, it is wise to have the feeds used analyzed for nutrient content.

Milk cows, beef cows that are nursing calves, and young growing animals require high nutrient levels. Forages fed to these animals should be analyzed for nutrient content. Haylage, silage, and high-moisture grains may vary greatly in moisture and nutrient content. Better rations can be developed if these feeds are also analyzed for moisture and nutrient content.

Growing conditions, such as excessive rainfall or drought, can affect the nutrient content of feeds, especially forages. When unusual growing conditions occur, it is a good idea to have these feeds analyzed. Other indications that a feed should be analyzed include musty odor, unusual amounts of foreign material or pests present in the feed, and a high level of leaf shattering on forages.

The most important tests to be done on feed grains are moisture, protein, and energy content. Forages should be tested for moisture, protein, acid detergent fiber, and neutral detergent fiber. It seldom pays to test for major or trace mineral content. Under some growing conditions, it is wise to check forages for nitrate and prussic acid content. Excessive amounts of these substances can be harmful to animals.

The chemical composition of feed analysis begins with measuring the feed’s water and dry matter (DM) contents. Within the DM we have the organic matter (OM) and minerals; and the OM can be further divided into fibre, non-fibrous (non-structural) carbohydrates, protein, fat, vitamins and non-nutrient substances. The basic method used is the proximate analysis (developed in the latter part of the 19th century) which identifies DM, crude protein, crude fibre, crude fat (ether extract) and crude minerals (ash). The proximate analysis is now supported by newer methods, including detergent extraction for measuring fibre, atomic absorption

spectroscopy for the individual minerals and chromatography for measuring fatty acids, amino acids and vitamins.

Table 3.5: Methods of measuring the nutritionally important constituents of feeds (**source:** Gordon McL. Dryden, 2021)

Food constituent	**Analytical method**
Dry matter (DM)	Measured by heating the feed, usually at 100°C for several hours; fresh forages may be dried at 50–60°C to avoid heat damage to proteins and loss of carbohydrates and other constituents
Organic matter (OM)	Determined as the loss of mass after ashing (see below)
Fibre (acid detergent fibre, ADF; neutral detergent fibre, NDF; and crude fibre, CF)	ADF and NDF are the residues which are resistant to the actions of either acid detergent (cetyltrimethylammonium bromide in sulphuric acid) or neutral detergent (sodium dodecyl sulphate in a pH 7 solution). Early methods of fibre analysis used a sequential extraction with acid and alkali to give a residue called CF. This analysis is now not often used and has been replaced with the more reliable detergent methods
Protein (crude) (CP)	Determined by measuring the total Nitrogen content and multiplying this by 6.25. This method assumes that all the feed N is from protein, and that all proteins contain 16% Nitrogen.
Non-structural carbohydrates	These are carbohydrates which are not part of the plant cell wall. These compounds are measured by polarimetry, ethanol extraction, and enzymatic methods
Fat (crude) (EE, for ‘ether extract’)	Diethyl ether, petroleum ether, or hexanes are used to extract fats and other substances such as phospholipids, waxes, fat-soluble vitamins, and pigments. This constituent is also called ‘ether extract’. Individual fatty acids are measured by chromatography
Minerals (ash)	Ash is measured by burning a sample at 500°C or more for several hours. The ash contains most of the minerals although some are lost by volatilization; this analysis is now more used for determining the organic matter content

Vitamins	Measured by chromatography, microbial bioassays, and other methods

Take representative samples of the feed to be analyzed. Take random samples of hay from at least 20 bales. Insert the sampling tube into the center of the bale. About 15 samples from silage and 5 from grain will usually give enough to be representative of the entire lot. Samples of silage or total mixed rations should be taken from the silage feeder or feed mixer as it is being fed. Avoid the top of the feed be- cause it is drier than the entire batch. Mix the samples from one type of feed and take a subsample from the mixture for analysis. Seal the samples in polyethylene freezer bags. Store dry samples in a cool area and freeze samples that contain more than 15 percent moisture. Send the samples to a testing laboratory as soon as possible. Use a laboratory that is certified by the National Forage Testing Association to ensure the highest accuracy of the test.

A feed analysis report will generally include the following measures:

- Dry matter (DM): the mass of a material when the moisture content is removed
- Crude protein (CP): the total of both true protein and non-protein nitrogen insoluble crude
- Protein (ICP): the amount of indigestible crude protein in the feed resulting from overheating
- Neutral detergent fiber (NDF): relatively insoluble material found in the cell wall of plants, which may be used to predict feed intake. A low NDF is desirable
- Acid detergent fiber (ADF): measures the least digestible part of the feed; includes cellulose, lignin, silica, insoluble crude protein, and ash. A low ADF is desirable
- Digestible dry matter (DDM): percent of forage that is digestible
- Net energy (NE): an indicator of the true value of a feed. It is the energy left after determining the energy lost through the feces, urine, gas, and heat gen- erated by metabolism
- Total digestible nutrients (TDN): the total of the digestible parts of crude fiber, protein, fat, and nitrogen-free extract
- Dry-matter intake (DMI): estimated maximum consumption of forage dry matter by the animal. It is shown as a percentage of body weight

- Relative feed value (RFV): an evaluation of the quality of hay and haylage by combining into one number digestibility and feed intake

The energy value of forage can also be estimated by plant maturity at harvest and the amount of weather damage to the feed. Late-cut, mature plants are lower in energy than early-cut, immature plants. Weather damage lowers the energy content of forages regardless of the stage of maturity when cut.

3.7. Calculating animal feed requirement for specific animal

3.7.1. Rules of Thumb for Balancing Rations

a. Beef

A maintenance ration for beef cows is primarily roughage. Some supplement may be required, depending on the quality of the roughage fed. The amount of air-dry roughage to feed should equal about 2 percent of the body weight of the animal. For example, if the beef cow weighs 1,213 pounds the amount of air-dry roughage to feed for maintenance would be about 24 pounds. If the ration is being calculated on a 100 percent dry-matter basis, 1.8 percent of the animal's body weight is used as the rule of thumb. For a 1,213-pound cow, this would be about 22 pounds of 100 percent dry-matter roughage.

Cows nursing calves in drylot should be fed about 50 percent more than dry cows. Silage is substituted at the rate of three parts silage for each one part of dry roughage. Vitamin A supplement may be needed if the roughage is of poor quality. Fattening rations for beef should be about 2 to 2.5 percent of the animal's body weight, fed as air-dry grain and protein supplement. If the ration is calculated on a 100 percent dry-matter basis, use 1.8 to 2.25 percent of the animal's body weight. About 0.5 to 1.0 percent of body weight should be fed as air-dry roughage. On a 100 percent dry-matter basis, use 0.45 to 0.9 percent of the animal's body weight. About one part of protein supplement should be fed to each 8 to 12 parts of grain. The total ration should have about 10 to 15 percent air-dry roughage. On a 100 percent dry-matter basis, about 9 to 13.5 percent of the total ration should be roughage. Rations with high grain content give the fastest and most efficient weight gains.

Fattening cattle must be fed a mineral supplement. If a high-concentrate (grain) ration is fed, a mineral supplement consisting of two parts dicalcium phosphate, two parts limestone, and six parts trace mineralized salt should be fed free choice. Free choice means that the supplement is available at all times to the animal. When feeding a high roughage ration, a mineral supplement consisting of two parts trace mineralized salt and one part dicalcium phosphate should be fed free choice.

b. Sheep

Sheep maintenance rations should have about 3 percent of body weight as air-dry roughage (2.7 percent on a 100 percent dry-matter basis). Supplement may be needed to balance the ration. In fattening rations for sheep, about 0.5 to 1 percent of body weight should be fed as air-dry roughage (0.45 to 0.9 percent on a 100 per- cent dry-matter basis). The ration should have about 2 to 3 percent of body weight fed as air-dry grain and protein supplement (1.8 to 2.7 percent on a 100 percent dry-matter basis). **Rules of thumb for goats are similar to those for sheep**.

c. Poultry

Poultry rations are made up almost entirely of grain and protein supplements. Laying hens need a great deal of calcium for forming the egg shell. A ration for poultry is about 10 percent of body weight, fed as air-dry feed (9 percent if ration is calculated on a 100 percent dry-matter basis).

d. Dairy

Dairy farming is a serious business and therefore farmers need to make profit in order to meet family needs. Feed rations fed to dairy cattle either originate from the farm or are purchased. In order to minimize feed wastage and to overcome the problem of low levels of production, dairy rations need to be efficiently utilized by the animal. A cow fed on balanced ration will utilize the feed more efficiently and hence it production will be better than a cow fed on imbalanced rations. Feed rations that are offered to dairy cows are considered balanced if they provide adequate nutrients (Carbohydrates, protein and minerals) to meet the animal requirements for maintenance, reproduction, growth and milk production.

3.8. Applying basic ration formulation steps for animals

A ration is the amount of feed an animal is given during a 24-hour period. It is balanced if it provides all the nutrients the animal needs for good growth, gain, or production. In addition, the ration must taste good to the animal and it must be economical. The right balance of roughages and concentrates must be in the ration.

3.8.1. General Steps in Balancing a Ration

Step 1: Identify the kind, age, weight, and function of the animal(s) for which the ration is being formulated. In this text, suggested rations and feeding programs are found in the units referring to specific species of animals. These may be used as general guides in formulating rations.

Step 2: Consult a table of nutrient requirements to determine the nutrient needs of the animal(s). These requirements are called feeding standards. Feeding standards are based on average requirements and may not meet the needs under specific feeding conditions. If unusual conditions such as weather stress are present, adjustments in the diet may be needed.

Step 3: Choose the feeds to be used in the ration and consult a feed composition table to determine the nutrient content of the selected feeds. Note that the nutrient content of a feed may be different for different species. Values given in a feed composition table are average values and may not represent the actual composition values of the feeds being used. An analysis of feeds being used is a more accurate method of determining feed composition.

Step 4: Calculate the amounts of each feed to use in the ration. Several methods may be used to do this. The Pearson Square or algebraic equations may be used to balance a ration using two or more feeds. Computer programs may also be used to balance rations.

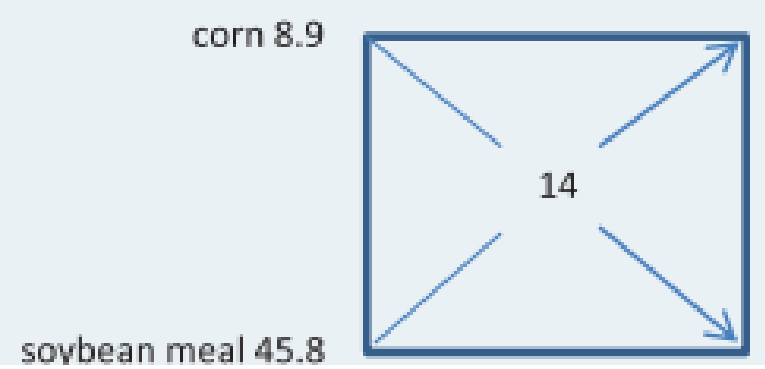
Step 5: Check the ration formulated against the needs of the animal(s). Be sure it meets the requirements for minerals and vitamins. If there is an excessive amount of a nutrient present, it may be necessary to recalculate the ration to bring it more closely in line with the requirements.

A. Use of the Pearson Square

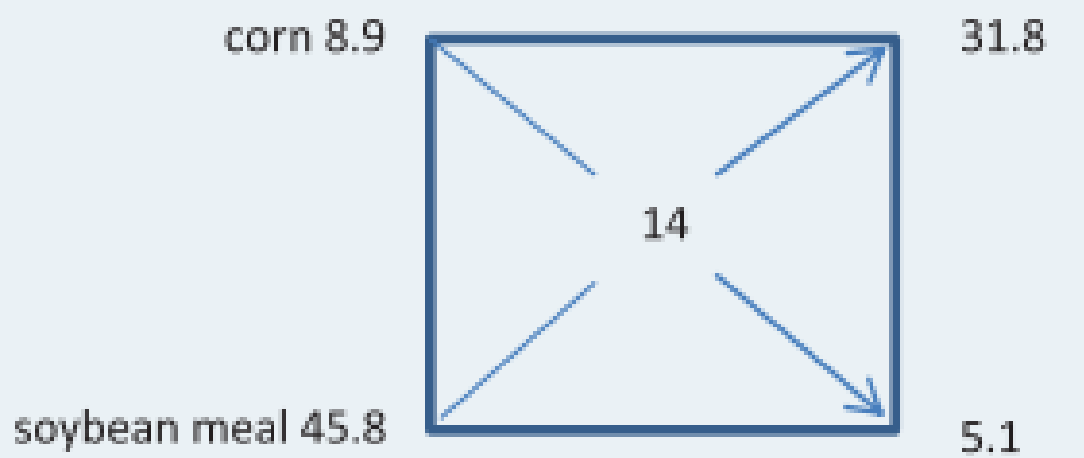
It is difficult to balance a ration by trial and error. The Pearson Square is a useful tool for simplifying the balancing of rations. It shows the proportions or percentages of two feeds to be mixed together to give a percent of the needed nutrient. The Pearson Square can be used to find out how much of two grains should be mixed with a supplement. The proportions of each grain to be used must be known or decided upon first. The same method is also used to mix two protein supplements with one grain and to mix two grains and two protein supplements. In each case, the proportions of like feeds to each other (such as the two grains) must be decided upon in advance. The weighted average percent of protein is then found. Finally, the Pearson Square is used to balance the mix.

Example: 2000 pounds of feed are needed to feed a 100 pound bull. A 14% crude protein ration is needed. Corn and soybean meal are selected as feeds. The corn has 8.9% and soybean meal has 45.8% crude protein. How much corn and soybean meal need to be mixed together for 200 pounds of feed?

Step 1: Draw a square with lines connecting the opposite corners. Write the percent of crude protein needed (14) in the center of the square where the lines cross. Write the feeds to be used and their crude protein percentages at the left hand corners of the square.



Step 2: Subtract the smaller number from the larger along the diagonal lines. Write the difference at the opposite end of the diagonals. (14-8.9 = 5.1 and 14.8-14 = 31.8).



Step 3: Add the parts corn to the parts soybean meal to determine the total parts ration (36.9). Divide the parts of each feed by the total parts to find the percentage of each feed in the ration

(31.8 ÷ 36.9) x 100 = 86.2% corn

(5.1 ÷ 36.9) x 100 = 13.8% soybean meal

Step 4: It is known that 2000 pounds of the mixture is need. Multiplying the percent of corn in the mix by the total pounds of the mix

2000 x 0.862 = 1724 pounds of corn

Multiplying the percent of soybean meal in the mix by the total pounds of the mix

2000 x 0.138 = 276 pounds of soybean meal

- **Person square Method: Mixing two grains with a supplement**

Example: Assume that a 2000 pound mix of corn, oats, and soybean meal is needed. The mix is to contain 16% digestible protein. A decision is made to use 75% corn and 25% oats in the mix. Thus, the proportion of corn to oats is 3 to 1. How many pounds of corn, oats and soybean meal are needed?

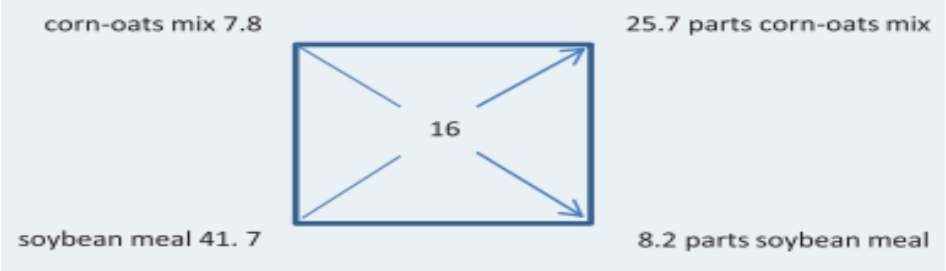
Step 1: The weighted average percent of protein in the corn and oats is found first. Multiply the proportion of corn (30) by the percent digestible protein in corn (7.1). Do the same for oats (digestible protein 9.9). Add the two answers together and divide by the total parts (4). The answer is the weighted average percent of digestible protein in the corn-oats mix.

3 x 7 = 21.3

1 x 9.9 = $\frac{9.9}{31.2}$

31.2 ÷ 4 = 7.8% digestible protein in the corn-oats mix

Step 2: Draw the Pearson square and use it to find the pounds of the corn-oats mix and the soybean meal needed.



Step 3: Add the parts corn-oats and the parts soybean meal to determine the total parts ration

25.7 + 8.2 = 33.9 total parts

Step 4: Divide the parts of each feed by the total parts to find the percent of each feed in the ration

(25.7 ÷ 33.9) x 100 = 75.8% corn-oats mix

(8.2 ÷ 33.9) x 100 = 24.2% soybean meal

Step 5: It is known that 2000 pounds of the mixtures is needed. Multiply the percent of each component of the mixture by 2000 to find the number of pounds needed

0.758 x 2000 = 1516 pounds corn-oats mix

1516 x 0.75 = 1137 pounds corn needed

1516 x 0.25 = 379 pounds oats needed

0.242 x 2000 = 484 pound of soybean meal needed

B. Using Algebraic Equations to Balance Rations

Algebraic equations may be used instead of the Pearson Square to balance rations. Letters are used as a means of representation in mathematical statements. For example, let “x” represent corn and “y” represent soybean meal. A mathematical statement describing the relationship between x and y can then be set up and used to solve for an unknown.

Example: 2000 pounds of a 14% protein feed is needed using corn and soybean meal. This ration is to be balanced for protein using two feeds. The basic equations are;

Equation 1: X = pounds of corn needed

Y = pounds of soybean meal needed

X+ Y= Total pounds of mix are needed

Equation 2: (% protein in corn) x (X) + (% protein in soybean meal) x (Y) = pounds of protein desired mix

Step 1: Find the pounds of protein desired in mix by multiplying the quantity of feed by the percent (or amount/lb) of the nutrient desired.

2000 x 0.14= 280

Step 2: Place the desired values in equation 2. Express all percents as decimals. Protein in corn is 8.9% and protein in soybean meal is 45.8%

0.089X + 0.458Y = 280

Step 3: Either X or Y must be cancelled by the multiplication of equation 1 by the percentage of nutrient for either X or Y, and the resulting equation 3 is subtracted from equation 2. This example uses the percentage crude protein for corn (0.089). The value 178 is found by multiplying 0.089 times 2000 lb. equation 3 is:

0.089X + 0.089Y = 178

Step 4: Subtract equation 3 from equation 2:

0.089X + 0.458Y = 280

- 0.089X – 0.089Y = - 178

0.369Y = 102

Y = 102/0.369

Y = 276 Pounds of soybean meal

Step 5: The value of X may be found by substituting the value of Y in equation 1 and solving for X

X + 276 = 2000

X= 2000 -276

X= 1724 pounds of corn

C. Formulation of rations using computer software

Feeding standards are considered as minimum; hence the final mix should have at least the stated amounts. The Pearson square and the alternative method cannot give a least cost formulation.

Where more than two feed ingredients are available and more than two nutrients must be balanced and costs must be considered then linear programming (LP) must be used. The technique allows for simultaneous consideration of economical and nutritional parameters. The formulator must have a good understanding of the specifications and the techniques of formulation so as to enable interpretation of results.

Advantages of least cost formulation

- Avail cheap supply of nutrients
- Avoid unnecessary costs when one ingredient's price increases
- Determines critical price ranges before reworking the problems

Self-check 3	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer from the given alternatives (2 points each)

1. Which one of the following is techniques used for feed ration formulation
   a. using computer software b. Using Algebraic Equations
   c. Person square Method d. all
2. Feeding records include the following except one
   a. Quantity fed b. Concentrate supplemented c. Minerals d. breed
3. When determining a ration, the _____ must be considered when determining the nutrient requirements. a. weight of the ration b. size of the ration
   c. type of the ration d. functions of the ration
4. A criteria used to evaluate animal feed content evaluation
   a. moisture content b. energy content c. protein content d. all
5. _____ is generally used as an outline of the feed supply and demand over a 12-month period a feed year plan
   a. ration b. feed budget c. feed-coast benefit analysis d. feeding system
6. Cost of feed have the highest share in animal farming. a. true b. false

Test II: Short Answer Questions (3 points each)

1. Write the definition of ration
2. List the importance of good animal feed record keeping
3. _____ is designed to provide information on the requirements of an individual animal to ensure they are fed in a way that promotes good health and prevents negative effects.
4. Explain points to be known when preparing animal feeding plan

Note: **Satisfactory rating - 12 points** **Unsatisfactory - below 12 points**

You can ask your teacher for the copy of the correct answers

Operation Sheet – 3

3.1. Procedure for preparing livestock feed planning

A. Tools and equipments used

i. Pen or permanent marker
ii. Philipp Chart
iii. Feed (forage and concentrate feed)
iv. Lactating dairy cow

B. **Procedures for preparing livestock feed planning**

Step 1: Work out the animals' annual demand for energy

Step 2: Work out the energy supplied by feed each year

Step 2a: Work out the energy supplied from grazed grass

Step 2b: Work out the energy supplied by conserved forages

Step 2c: Work out the energy supplied by concentrates and straight feeds

Step 3: Subtract the total energy demand from the total energy supply to find the whole farm annual energy balance.

LAP TEST-3	**Performance Test**

Name……. ID……..

Date…….

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 40 minutes. The project is expected from each student to do it.

Assume that the annual milk yield of a lactating dairy cow is 4500 litres and annual energy required for production of this milk is 23,850 Mega Julies Metabolizable Energy (MJ ME). The energy content of available forage feed energy content is 40MJ ME and concentrate feed 110 MJ ME.

Task 1- Prepare six month feed planning for lactating five dairy cows

3.2. Techniques of feed ration formulation by using the Pearson Square methods

A. Tools and equipments used

i. A4 paper

ii. Pen

iii. Calculator

iv. Cotton seed cake and maize germ

v. Weight Balance

B. **Procedures of Pearson Square methods**

Step 1: Draw a square with lines connecting the opposite corners

Step 2: Subtract the smaller number from the larger along the diagonal lines

Step 3: Add the parts on the left upper side and lower side, and the right upper and lower side together to determine the total parts ration

Step 4: Multiplying the percent of corn in the mix by the total pounds of the mix

LAP TEST-3.2	**Performance Test**

Name……. ID……..

Date…….

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 45 minutes. The project is expected from each student to do it.

Assume you want to make a dairy meal with 16% crude protein (CP) using cotton seed cake (CSC) and maize germ (MG). The CSC provides 35 % CP while MG provides 10.6 % CP.

Task 1- Perform Pearson Square methods for calculating the above feed ration formulation

References

Book and Journal References

Yavuz Gurbuz (2017): Heat Applications In Feed And Food Processing; Proceedings of 72nd The IRES International Conference, Mecca, Saudi Arabia

Frank B. Flanders and James R. Gillespie (2016): Modern Livestock and Poultry Production, 9th Edition.

P McDonald, R A Edwards, J F D Greenhalgh, C A Morgan, L A Sinclair and R G Wilkinson (2012): Animal Nutrition, 7th Edition.

Philip I Hynd (2019): Animal Nutrition from Theory to Practice

Gordon McL. Dryden (2021). Fundamentals of Applied Animal Nutrition

Website references

1. https://www.intechopen.com/chapters/61960 (Accessed date 29/08/2022)
2. https://www.researchgate.net/publication/321361777_Heat_Applications_In_Feed_And_Food_Processing [accessed 08/ 29 2022].
3. https://www.daf.qld.gov.au/business-priorities/agriculture/animals/dairy/nutrition-lactating-cows/affecting-feed-intake (Accessed date 30/08/2022)
4. https://www.mla.com.au/research-and-development/livestock-production/livestock-nutrition/supplementary-feeding/ (Accessed date 30/08/2022)
5. https://courses.ecampus.oregonstate.edu/ans312/one/nutrient_functions_story.htm (Accessed date 31/08/2022)
6. Information of www.infonet-biovision.org (Accessed on 01/09/2022)
7. https://www.fawec.org/en/technical-documents-general-concepts/107-stress-in-farm-animals#:~:text=The%20stress%20response%20includes%20several,and%20reduced%20fertility%2C%20among%20others. (Accessed on 03/09/2022)

AKNOWLEDGEMENT

Ministry of Labor and Skills wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

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