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Ministry of Labor and Skills

Animal Production

Level IV

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Module Title: Developing Animal Feed Plan and Conducting Ration Formulation

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Introduction to the Module

This module covers the knowledge, skills and attitude required to determine livestock condition and nutritional requirements, determine supplementary feeding program, develop and monitor animal feeding plans**.**

Developing a livestock feeding plan is a crucial aspect of animal husbandry that involves creating a structured approach to meeting the nutritional needs of livestock. A well-designed feeding plan ensures that animals receive balanced diets that promote optimal growth, reproduction, and overall health. It also helps maximize productivity and efficiency while minimizing costs and potential health issues. Livestock feeding plans take into account various factors, including the specific nutritional requirements of the animals, the availability and quality of feed resources, and economic considerations. To begin developing a feeding plan, it's essential to understand the nutritional requirements of the livestock species that is being raised. Different animals have varying needs for energy, protein, vitamins, minerals, and water, depending on factors such as age, weight, stage of production, and environmental conditions. These requirements serve as a foundation for formulating a balanced diet that meets the animals' specific needs.

LG #1	LO #1-Assess livestock condition and nutritional requirements

Instruction sheet

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

- Assessing and recording livestock condition
- Identification of animal production status
- Identification of livestock nutritional requirements
- Analyzing nutritional value of feedstuffs

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 –

- Assess and record livestock condition
- Identify animal production status
- Identify and analyze livestock nutritional requirements
- Analyze nutritional value of feedstuffs

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 sheet
4. Accomplish the “Self-check”
5. Perform the “Operation Sheet
6. Do the Lap test

Information Sheet. 1

1.1. Assessing and recording livestock condition

Assessing and recording livestock condition is an important aspect of livestock management. It involves evaluating the health, body condition, and overall well-being of individual animals or a group of livestock. Here are some points to assess and record livestock condition effectively:

- Visual assessment
- Body condition scoring
- Physical Examination
- Weight Measurement
- Regular Monitoring
- Health and Production Indicators
- Lactation Stage
- Milk Yield
- Record keeping

i. **Visual Observation:** Visual Observation can be performed by:

- Looking for any obvious signs of health issues, such as lameness, abnormal behavior, visible injuries, or signs of disease.
- Assessing their overall appearance, including coat condition, body size, and general alertness.

ii. **Body Condition Scoring:** Body condition scoring (BCS) is a widely used method for assessing the fat cover or body condition of livestock. It involves assigning a numerical score to indicate the amount of fat and muscle on an animal's body. Different livestock species have specific body condition scoring systems tailored to their physiological characteristics. Different authors use different scales in scoring but a scale of 1 to 5 with 0.5 increments is the most common.

Body condition scoring in dairy cows

Score 1 is extremely thin and score 5 is extremely fat. Ideally body condition should be assessed to the nearest half score. Consistency between assessments is vital to the success of the technique. Cows should be handled at the tail head, ribs and loin area. The main assessment is usually based on the tailhead with the fat covering on the loin and ribs used to confirm the body condition score. The operation should be carried out quietly and carefully using the same hand from cow to cow. An overall visual inspection is also important.

- The Tail Head: Assess by standing directly behind the cow. The tailhead is scored by feeling for the amount of fat around the tailhead and the prominence of the pelvic bones.
- Loin and Ribs: Stand to the side of the cow. The loin is scored by feeling the horizontal and vertical projections of the vertebrae and the amount of fat in-between them. The ribs are scored using the flat of the hand and finger-tips to feel the amount of fat over them.

Table 1: Description of Scores

Score	Condition	Detailed Description	Visual Guide
1	Poor (very thin)	**Tail head** – deep cavity with no fatty tissue under skin. Skin fairly supple, coat condition often rough. **Loin** – spine prominent and horizontal processes sharp. **Ribs** – sharp with no fat cover	 
2	Moderate	**Tail head** – shallow cavity but pin bones prominent; some fat under skin. Skin supple. **Loin** – horizontal processes can be identified individually with ends rounded **Ribs** – can be identified individually but feel rounded rather than sharp.	 
2.5			

			
3	Good	**Tail head** – fat cover over whole area and skin smooth but pelvis can be felt, but only with firm pressure. **Loin** – end of horizontal process can only be felt with pressure; only slight depression in loin. **Ribs** – individual ribs can only be felt with firm pressure.	 
4	Fat	Tail head – completely filled and folds and patches of fat evident but soft to touch. Loin – cannot feel processes and have completely rounded appearance. Ribs – folds of fat developing over ribs.	 
5	Grossly fat	Bone structure of the animal no longer noticeable. Tail head – almost buried in fatty tissue. Loin – pelvis impalpable even with firm pressure. Ribs – covered with thick layer of fat.	

Body condition scoring in sheep and goat

Body parts to be examined are the lumbar region, the rib cage and the sternum.

a. Lumbar region

This area contains the loin muscle and is located immediately behind the last rib and before the hip bones. Scoring in this area is based on determining the amount of fat and muscle over and around the vertebrae. Lumbar vertebrae have two protrusions, the vertical protrusion called the spinous process and the two horizontal protrusions called the transverse process. Both processes are used in determining BCS.

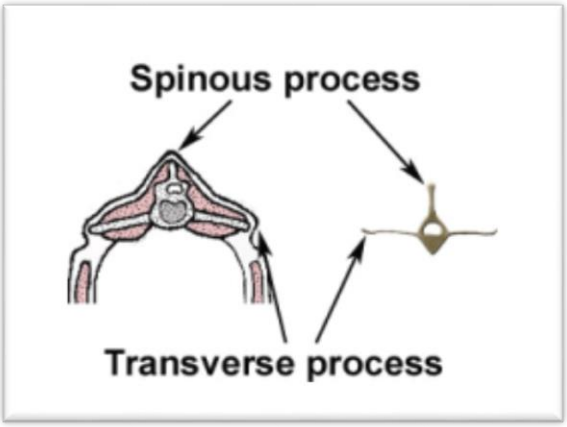


Figure 1: Spinous and transverse processes.

Although the principle of body condition scoring is similar for sheep and goats, it is important to note differences that exist between sheep and goats.

- Compared to sheep, goats have much less subcutaneous fat cover (most of the fat deposition in goats is internal around the intestines and kidneys). In fat-tailed or fat-rumped sheep breeds, the tail could serve as additional measure of body condition. These do not exist in goats.
- The sternum could be used as an additional area to assess condition in goats. This would be difficult in sheep that have a mane.

The following process may be followed during scoring:

- Feeling the spinous process

Feel the spinous process in the center of the sheep/goat back behind the last rib and in front of the hip bone and try to rank the animal based on the answer you give to the question: are the tips sharp or rounded?



Figure 2: . Spinous process.

- Feeling the transverse process

Feel for the tips of the transverse process. Is it sharp or smoothly rounded?

How far will the tips of your finger go under the transverse process?

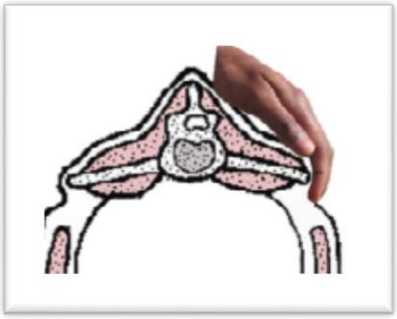


Figure 3: The transverse

You should run your hand over this area and try to grasp these processes with your fingertips and hand as shown in Figures 1 to 3. The degree of sharpness or roundness of the lumbar vertebrae is assessed.

b. The rib cages

The second area to assess is the rib cage and fat cover on the ribs and intercostal (between ribs) spaces. Touch this area and determine if you can feel each of the ribs.



Figure 4: The rib area

c. The sternum area

The sternum is the third part to assess. In goats, it is an important area to assess. The fat cover over the sternum (breast bone) is based upon the amount of fat that can be pinched. In goats and sheep, scores range between 1 and 5 with the lowest-scoring animals being the thinnest and the highest-scoring animals being the fattest. An animal with average body condition would have a score of 2.5 to 3.

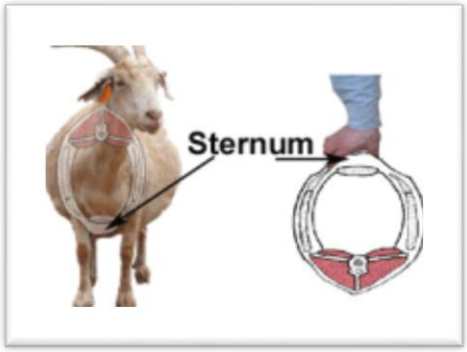


Figure 5: The sternum area.

iii. **Physical Examination:** physical examination of the livestock can be conducted by:

- palpation of joints, body parts, and abdomen.
- Checking for any abnormalities, such as swollen joints, lumps, or signs of discomfort.
- Inspecting their hooves, teeth, and eyes for signs of disease or injury.

iv. **Weight Measurement:** Regularly measure and record the weight of individual animals or a representative sample of the group. This can be done using scales, weighbridges, or weight

estimation methods suitable for your livestock species. Tracking weight changes over time can provide valuable information on growth, feed efficiency, and overall health.

How to estimate the weight of livestock

Estimating the body weight of livestock can be done using various formulas tailored to specific species. Here are a few examples:

a) For Cattle

- Schaeffer's Formula: Estimated body weight (in pounds)
  = (Heart girth x Heart girth x Body length) / 300.

Here's an example of how to apply Schaeffer's formula:

i. Measure the heart girth (circumference) of the animal using a flexible measuring tape. The heart girth is the circumference around the body just behind the shoulder blades and the brisket.
ii. Measure the body length of the animal. The body length is the distance from the point of the shoulder to the point of the buttock.
iii. Plug the values obtained into Schaeffer's formula:
Estimated body weight (in pounds) = (Heart girth x Heart girth x Body length) / 300
iv. Calculate the estimated body weight using the formula. For example, let's say the heart girth is 70 inches and the body length is 80 inches:

Estimated body weight = (60 x 60 x 70) / 300 = 840 pounds(381.018kg)

So, based on Schaeffer's formula, the estimated body weight of the animal would be approximately 840 pounds(381.018kg).

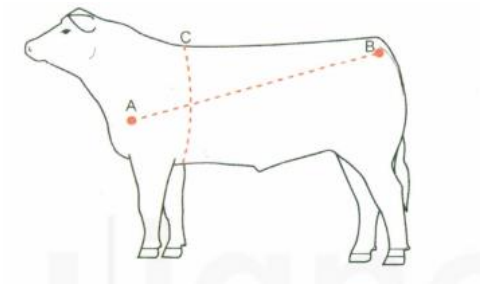


Figure 6: Measuring length and girth in cattle

b) For Horses

- Body Length and Heart Girth Formula:

Estimated body weight (in pounds) = (Heart girth x Heart girth x Body length) / 330.

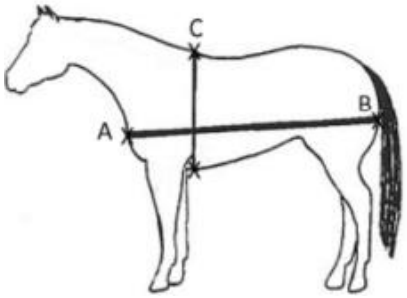


Figure 7: Measuring horse

c) **For Swine**

- Girth and Length Formula:

Estimated body weight (in pounds)
= (Heart Girth(inches) x Heart Girth x Body Length(inches)) / 400.

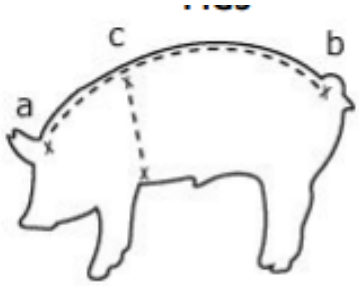


Figure 8: Measuring swine

Remember that this is just an estimation, and actual body weight may vary. It's always advisable to use multiple methods, such as weighing scales or weight tapes, for more accurate measurements of livestock body weight.

v. **Regular Monitoring:** Establish a schedule for regular livestock condition assessments. The frequency of assessments may vary based on factors such as livestock species, production stage, and management goals. Regular monitoring allows for early detection of health issues, timely interventions, and the ability to track changes in livestock condition over time.

vi. **Health and Production Indicators:** In addition to body condition scoring and weight measurement, consider other health and production indicators specific to your livestock species. This may include milk production in dairy cows, average daily gain in growing animals, reproductive performance, or any specific performance metrics relevant to your management objectives. Regularly monitor and record these indicators to assess the overall health and productivity of your livestock.

vii. **Lactation Stage:** The lactation stage refers to the phase of the reproductive cycle in which a female animal (e.g., cow, goat, or sheep) is actively producing milk. The lactation stage provides valuable information about the animal's physiological condition and nutritional needs. The lactation stage affects the nutritional requirements of the animal. Lactating animals have higher energy, protein, and mineral requirements to support milk production. By identifying the lactation stage, nutritionists and farmers can adjust the animal's diet to meet its specific requirements, ensuring optimal health and productivity.

viii. **Milk Yield:** Milk yield refers to the amount of milk produced by a lactating animal over a specific period, usually measured in liters or pounds per day. Milk yield is a crucial parameter for assessing the productivity and condition of dairy animals. Here's how it is used in livestock condition assessment:

- Milk yield is an indicator of the animal's productivity and milk-producing capacity. Higher milk yields generally indicate better health and nutritional status. Monitoring milk yield helps identify any changes in production patterns, such as sudden drops in milk production, which may indicate health issues or inadequate nutrition.
- Milk yield data can be used to evaluate the effectiveness of the animal's diet and nutritional management practices. If milk yield is below expected levels, it may indicate a need for dietary adjustments or improved feeding practices to optimize productivity and maintain animal condition.

ix. **Record Keeping:** Maintain accurate and organized records of livestock condition assessments. Create a system to record and track individual animal identification, dates of assessment, body condition scores, weight measurements, and any relevant observations or treatments. Utilize spreadsheets, software, or dedicated livestock management tools to facilitate record keeping.

1.2. Identification of animal production status

Identification of animal production status involves determining the stage or phase of production that individual animals or a group of livestock are in. Here are some common production statuses to consider:

Growing/Pre-weaning: This production status refers to young animals that are still growing and dependent on their mother's milk or supplemental feeding. They have not reached sexual maturity or started producing for commercial purposes.

Breeding/Reproductive: Animals in the breeding or reproductive phase are sexually mature and capable of mating. They are managed for the purpose of reproduction and producing offspring. This status includes both males and females that are actively involved in breeding activities.

Pregnant: Animals that are pregnant have conceived and are carrying offspring in their uterus. The pregnancy status may vary in duration depending on the species. It is important to identify pregnant animals to provide appropriate care and monitor their health during gestation.

Lactating: Lactating animals have given birth and are currently producing milk for their young. This status is particularly relevant for dairy animals but can also apply to other livestock species. Lactating animals require specialized nutrition and management practices to support milk production.

Finishing/Market-Ready: This status applies to animals that have reached the desired weight and condition for market or slaughter. They have completed the growth phase and are ready to be sold or processed for meat production.

Dry/Non-lactating: Dry or non-lactating animals are not currently producing milk. This status typically applies to dairy animals between lactation cycles or animals that are not actively producing for commercial milk purposes.

Post-breeding/Post-calving: Animals that have completed the breeding or calving process but are not yet pregnant again fall under this status. It is a transitional phase in reproductive cycles.

Non-productive/Maintenance: Some animals may be in a non-productive or maintenance phase. They are not actively involved in reproduction, growth, or milk production. This status may apply to animals that have reached the end of their productive life or are temporarily resting between production cycles.

Identifying the production status of animals is crucial for appropriate management decisions. It helps guide nutrition, breeding programs, healthcare interventions, and overall herd or flock management strategies. By understanding the specific production status of animals, producers can optimize their care, productivity, and welfare.

1.3. Identification of livestock nutritional requirements

Identifying the nutritional requirements of livestock is essential for maintaining their health, productivity, and overall well-being. Here are the key steps involved in identifying livestock nutritional requirements:

- **Determine the Livestock Species and Breed**: Different species and breeds of livestock have varying nutritional requirements. Understand the specific species and breed you are working with, as their genetic makeup can influence their nutritional needs.
- **Consider the Animal's Life Stage:** The nutritional requirements of livestock change throughout their life stages. Consider whether the animals are in the growth phase, gestation, lactation, or maintenance. Each stage has specific nutrient requirements to support optimal growth, reproduction, and maintenance.
- **Assess Body Weight and Body Condition:** Determine the body weight and body condition score of the animals. Body weight is crucial for calculating nutrient requirements accurately. Body condition scoring helps evaluate the animal's fat cover, which can affect their energy requirements.
- **Consider Environmental Factors:** Environmental factors, such as temperature, humidity, and stress, can impact the nutritional requirements of livestock. Extreme weather conditions or high-stress environments may require adjustments to the animals' diet to meet their increased energy or nutrient demands.

1.3.1. Nutrient requirements of cattle

Cattle are natural grazers with the ability to digest plant carbohydrates that are indigestible for most other mammals. They require a consistent supply of energy, protein, minerals, vitamins, and water to maintain productivity and health. The nutrient requirements of cattle can be categorized into maintenance, lactation, growth, and reproduction.

Maintenance: This component includes the nutrients needed for breathing, digestion, movement, tissue repair, and maintaining body weight. The energy requirements for maintenance are divided into maintenance and non-maintenance portions. Generally, cattle require 7-14% crude protein in their daily dry matter intake.

Lactation: Nutrient requirements for lactation are determined by the amount of milk produced and its composition. Cows that produce more milk with higher fat and protein content have higher nutrient requirements.

Growth: The requirements for growth depend on the actual weight, average daily gain, weight at maturity, and composition of gain.

Reproduction: Adjustments to requirements for reproduction are based on the expected calf birth weight and stage of gestation. Pregnancy does not significantly affect requirements until the last three months when the fetus is growing rapidly.

Here are some specific numerical values for feed requirements for lactating cows:

- Energy: 18-20 megajoules (MJ) per kilogram of dry matter (DM)
- Protein: 16-18% crude protein (CP) in the diet
- Fiber: 25-30% neutral detergent fiber (NDF) in the diet

These values can serve as guidelines for formulating diets for lactating cows to meet their specific nutritional needs.

1.3.2. Nutrient requirements of sheep

Sheep require a well-balanced diet to support optimal growth and production. This diet should include energy (carbohydrates and fats), proteins, minerals, vitamins, and water. In certain stressful field conditions, additional nutrients may be necessary. Providing adequate energy is particularly crucial as a significant portion of sheep feed consists of grass and forage, which can be sparse or of poor quality.

Here are some specific nutritional requirements and recommendations for sheep:

Energy: The energy requirements of ewes are highest during the first 8-10 weeks of lactation when milk production is at its peak. After this period, as lambs start foraging, the energy requirements of the ewe decrease to pre-lambing levels.

Protein: Good-quality forage and pasture generally provide sufficient protein for mature sheep. However, sheep do not efficiently digest poor-quality protein compared to cattle. In such cases, a

protein supplement should be fed along with mature grass and hay, especially during the dry season. A minimum of 7% dietary crude protein is needed for maintenance in most sheep. Protein requirements vary depending on the stage of production (growth, gestation, lactation) and the presence of certain diseases.

Minerals: Sheep require various major minerals such as sodium, chlorine, calcium, phosphorus, magnesium, sulfur, potassium, as well as trace minerals including cobalt, copper, iodine, iron, manganese, molybdenum, zinc, and selenium. Trace mineralized salt can help prevent deficiencies in sodium, chlorine, iodine, manganese, cobalt, copper, iron, and zinc. Selenium should be included in rations, mineral mixtures, or other supplements in deficient areas. Sheep diets usually contain sufficient potassium, iron, magnesium, sulfur, and manganese. Adequate levels of calcium, iodine, and cobalt are also necessary.

Vitamins: Sheep diets typically provide ample amounts of vitamins A (provitamin A), D, and E. However, under certain circumstances, supplementation may be required. The B vitamins and vitamin K are synthesized by rumen microorganisms, so supplements are generally unnecessary. Vitamin A can be stored in the liver when sheep consume diets rich in carotene (e.g., high-quality pasture or green hays). Vitamin D can be derived from sun-cured forage, and vitamin D3 can be synthesized when the skin is exposed to ultraviolet light. Vitamin E supplementation may be beneficial when ewes are fed poor-quality hay or forage.

Water: Adequate water intake is essential for sheep, as it participates in nearly all body functions. Sheep can consume anywhere from ½ to 4 gallons of water per day, depending on their physiological state and environmental conditions. Water intake increases with high-protein and high-salt diets. Reduced water intake can negatively impact milk production in ewes and growth rates in lambs. Clean, fresh, and easily accessible water should be available at all times.

Table 2: Daily maintenance requirement estimates for energy and digestible crude protein (DCP) for sheep and goat.

Live weight (kg)	ME (MJ/kg dry matter)		DCP (g/day)	
	Confined	Extensive	Maintenance	Pregnancy
10	2.32	3.25	15	30
20	3.91	5.47	26	50
30	5.30	7.42	35	67
40	6.58	9.21	43	83
50	7.78	10.89	51	99
60	8.92	12.49	59	113

1.3.3. Nutrient requirements of goats

Goats prefer browsing on bushy plants and woody shrubs. Their nutrient requirements depend on factors such as age, sex, breed, production system, body size, climate, and physiological stage. Feed intake is usually 3-4% of body weight in kg of dry matter per head per day. Carbohydrates from sugars, starches, and fiber are converted into energy by rumen flora. Goats need at least 12% crude fiber in their diet, and energy requirements vary during different physiological stages.

Fats can serve as an energy source for goats, but excessive fat intake is not cost-effective. Proteins are broken down into amino acids and are important for growth, milk synthesis, and mohair growth. Mineral requirements for goats are not definitively established, but adding specific minerals to salt can prevent deficiencies. Macro-minerals like calcium, phosphorus, magnesium, sodium, potassium, sulfur, and chlorides are needed. Micro-minerals include iron, copper, cobalt, manganese, zinc, iodine, selenium, molybdenum, and others.

Calcium is necessary for lactating goats to prevent milk fever. Phosphorus deficiency can impact growth and milk production. The calcium-phosphorus ratio should be maintained between 1:1 and 2:1. Goats may consume excess salt when offered freely, which can affect feed and water intake. Vitamins A, D, E, K, and C are important for goat health and functioning. Water intake is crucial,

and goats should have unlimited access to fresh, clean water. Water requirements vary based on factors like lactation, temperature, forage water content, exercise, and diet composition.

Ensuring adequate water intake is vital for goat performance, and water quality is important too.

1.3.4. Nutrient requirements of poultry

Poultry require the presence of at least 38 dietary nutrients in appropriate concentrations and balance. Criteria used to determine the requirement for a given nutrient include

- growth
- feed efficiency
- egg production
- prevention of deficiency symptoms, and
- quality of poultry products.

These requirements assume the nutrients are in a highly bio-available form, and they do not include a margin of safety. Consequently, adjustments should be made based on bio-availability of nutrients in various feed-stuffs. A margin of safety should be added based on the length of time the diet will be stored before feeding, changes in rates of feed intake due to environmental temperature or dietary energy content, genetic strain, husbandry conditions (especially the level of sanitation), and the presence of stressors (such as diseases or mycotoxins).

Poultry can adjust their feed intake over a considerable range of feed energy levels to meet their daily energy needs. Energy needs and, consequently, feed intake also varies considerably with environmental temperature and amount of physical activity.

A bird's daily need for amino acids, vitamins, and minerals are mostly independent of these factors. If a bird consumes a diet that has a higher energy content, it will decrease its feed intake; consequently, that diet must contain a proportionally higher amount of amino acids, vitamins, and minerals. Thus, nutrient density in the ration should be adjusted to provide appropriate nutrient intake based on requirements and the actual feed intake. It is impossible to set the energy requirements in terms of unit/kg diet because birds adjust their feed intake to achieve their daily energy intake.

Poultry, like all animals, synthesize proteins that contain 20 amino acids. Birds are unable to synthesize 9 of these amino acids because of the lack of specific enzymes: arginine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. Histidine, glycine,

and proline can be synthesized by birds, but the rate is usually insufficient to meet metabolic needs, hence a dietary source is required. These 12 amino acids are referred to as the essential amino acids. Tyrosine and cysteine can be synthesized from phenylalanine and methionine, respectively, and are referred to as being conditionally essential because they must be in the diet if phenylalanine or methionine levels are inadequate. The diet must also supply sufficient amounts of nitrogen to allow the synthesis of non-essential amino acids. Essential amino acids are often added to the diet in purified form (eg, methionine and lysine) to minimize the total protein level as well as the cost of the diet. This has the added advantage of minimizing nitrogen excretion.

Dietary energy content must be specified to maintain the proper ratio of protein to energy so that birds can consume an adequate amount of protein. The protein requirement or amino acid requirements can be defined accurately only in relation to the energy density. Also, the degree of fat deposition in meat producing birds can be affected by this relationship.

Methionine would be the first limiting amino acid in grain and soybean meal diets, but lysine is likely to become the first limiting amino acid if soybean meal is replaced by another plant protein supplement such as cotton-seed meal. Much of the phosphorus in feedstuffs of plant origin is complexes by phytate which is not absorbed efficiently by poultry. Consequently, it is critical that only the available phosphorus and not the total phosphorus levels that are considered in poultry feed formulation. Appropriate calcium nutrition depends on both the level of calcium and its ratio to that of available phosphorus. For growing poultry, this ratio should not deviate substantially from 2:1. The calcium requirement of laying hens is very high and increases with the rate of egg production and age of the hen.

Although it is not easy to ascertain the exact calcium requirements for poultry, care should be taken to avoid adding a generous amount because excess calcium interferes with utilization of potassium, magnesium, manganese, and zinc which can reduce the palatability of the diet. Requirements for vitamins A, D, and E are expressed in IU. For chickens, 1 IU of vitamin A activity is equivalent to 0.3 mcg of pure retinol, 0.344 mcg of retinyl acetate, or 0.6 mcg of β-carotene. However, young chicks use β-carotene less efficiently. One IU of vitamin D is equal to 0.025 mcg of cholecalciferol

(vitamin D3). Ergocalciferol (vitamin D2) is used with an efficiency of <10% of vitamin D3 in poultry.

Vitamin E requirements vary with the type and level of fat in the diet, the levels of selenium and traceI apologize for any confusion caused. Here are the revised paragraphs with the numerical values included:

The nutrient requirements of poultry are determined based on factors like growth, feed efficiency, egg production, and quality of poultry products. Adjustments should be made for nutrient bioavailability and factors such as storage time, temperature, energy content, genetic strain, sanitation, and stressors. Poultry can adjust their feed intake to meet energy needs, but amino acid, vitamin, and mineral requirements remain constant.

Essential amino acids must be provided in the diet, and nitrogen is needed for non-essential amino acid synthesis. Protein-to-energy ratio affects fat deposition. Methionine and lysine are important limiting amino acids. Calcium and phosphorus levels, along with their ratio, are crucial for bone health and egg production. Excess calcium can interfere with mineral utilization. Vitamin requirements are expressed in International Units (IU), and vitamin E levels may need to be increased with specific dietary conditions. Water intake varies depending on factors such as temperature, humidity, diet composition, and bird productivity. Water deprivation has negative effects on growth, egg production, and mortality. Access to clean water is essential.

1.4. Analyzing nutritional value of pasture and feedstuffs

Animal feedstuffs are natural or artificial material, which when included in the diet serve as a nutrient source or have other useful functions. Animal feedstuffs are classified into either roughage or concentrates. Roughage includes pastures, forage, hay, silage, and crop by-products that contain a high percentage of fibre. Concentrates are low in fibre and high in energy or protein. During commercial feed making, raw materials consist almost entirely of concentrates.

Concentrates can be classified based on their nutrient contribution to the ration: as a source of energy, protein, minerals,

or vitamins. The use of a given concentrate in a livestock feed depends on the following factors:

- Availability. This is the first major consideration and largely depends on location and season.
- Cost. As livestock are kept for profit, the prevailing price of a feedstuff is a key consideration for its inclusion. The price will depend on ease of availability, especially for plant-based material, which may be seasonal.
- Competition with human consumption. Several cereal grains used as feedstuffs in developing countries are primarily grown for human consumption, with the excess sold for livestock use. During times of scarcity, some of these materials may not be available.
- Acceptability/utilization. The acceptability and ability of the animal to utilize (digest) a feedstuff is important. Some feedstuffs can only be fed to certain species of animals due to the nature of their digestive systems.
- Nutritional value. The choice of feedstuff can be dictated by its nutrient content. During costing, the nutritional value should be considered, and the purchase price based on quality. Handling properties. Some feedstuffs require processing prior to mixing (e.g. for size reduction) and their usage will depend on the capacity to process (e.g. milling of cottonseed cake [CSC]). Presence of anti-nutritive factors. Some feedstuffs contain factors that are harmful to some classes of livestock and are unsuitable.

Energy feedstuffs

Energy feedstuffs have a high energy content per unit weight and are normally mixed with other feedstuffs (which are concentrated sources of other specific nutrients) to provide additional energy to help complete a balanced diet. They normally comprise less than 18% crude fibre, less than 20% crude protein (CP), and mineral and vitamins to a small extent. Cereal grains, cereal milling by-products, molasses and fats are all energy feedstuffs.

a) Cereal-based concentrates

In developed countries, some cereal grains are grown exclusively for animal feed. In developing countries, their milled by-products are a major ingredient due to a significant competition for grain used for human consumption.

The most commonly used cereal grains have some similarities:

- Dry matter content 85–90%. Low dry matter content is a sign of poor drying and makes grains susceptible to mould growth and aflatoxin contamination.

- ME of approximately 3,000 kcal/kg. Mostly in the form of starch
- CP 8–12%. Most protein is found in the outer parts of grain.
- Lysine and methionine levels are usually low; digestibility of the protein is 75–80%.
- Crude fat 2–5%. High in mono- and poly-unsaturated fatty acids (oleic, linoleic and linolenic acids).
- Crude fibre 6–18%. Crude fibre is high in grains which have a husk (oats, rice, barley) and low in naked grains (wheat, maize).
- Calcium: (<0.15%). Ca content is low in cereal grains.
- Phosphorous (0.30–0.5%). P level is high in cereal grains. About 50% of phosphorous in the feeds of plant origin is bound and unavailable to non-ruminants

Nutritive values of commonly used cereal grains and their by-products

Maize

Maize is the most important cereal in East Africa and is a staple for humans. The common variety has a white grain, but it can be yellow, which contains beta carotene, a precursor of vitamin A. Inclusion of yellow maize can give broiler carcasses and egg yolks a deep yellow colour, which is desirable to consumers. Maize is an excellent source of digestible energy for both ruminants and non-ruminants. It is low in the amino acids tryptophan and lysine, which require supplementation in non-ruminant rations. Whole maize is included in poultry and swine rations. When maize is dry milled for human consumption, several by-products are obtained.

Table 3:The nutrient content of the maize grain

ME (poultry)	DE (pigs)	CP	CF	EE	Ca	TP	AP
Kcal/kg	Kcal/kg	%	%	%	%	%	%
3,300	3400	8-12	3.0	3-6	0.02-0.05	0.24-0.33	0.1

EE: oil content, Ca: Calcium, TP: Total phosphorous, AP: Available phosphorous

Source: Charles and Ben, 2021

Maize by-products

Maize undergoes dry milling to produce flour from the endosperm for human consumption. In the process, the hull, germ, and endosperm are separated before milling. The main by-products of maize milling are maize bran and maize germ.

- Maize bran: Maize bran consists of the outer coating of the maize kernel (hull) with little or no starchy part and germ.
- Maize germ: The maize germ consists of an oil-rich (high energy) embryo and protein. After the oil is mechanically extracted from the germ, the residue is maize germ cake. The residue after solvent extraction is called maize germ meal. Cake has high oil content and is higher in energy, while meal is low in oil and is considered a protein supplement.

Wheat

Wheat is grown primarily for human consumption and is rarely used for animal feed due to its high cost. Several by-products of milled wheat are used for livestock feeding.

The proteins found in wheat are prolamin and glutelin (both referred as wheat gluten). Wheat gluten is elastic and forms a sticky mass when chewed, reducing palatability in livestock. Wheat has higher protein content than maize and provides only slightly less energy.

Wheat contains 5–8% indigestible pentosans (non-starch polysaccharides) leading to reduced diet digestibility and wet faeces. The main pentosans are arabinoxylans which absorb up to 10 times their weight in water. Poultry do not have adequate enzymes to digest these polysaccharides which lead to an increased digesta viscosity and reduction of 10–15% ME utilization. This problem can be solved by adding an exogenous xylanase enzyme to feed.

Table 4: Nutrient content of wheat

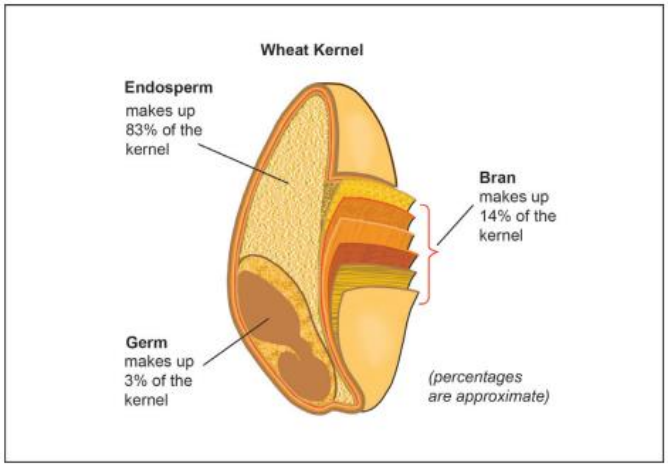
ME(poultry)	DE (pigs)	CP	CF	EE	Ca	TP	AP
Kcal/kg	Kcal/kg	%	%	%	%	%	%
3000	3450	13	3.0	2.0	0.06	0.35	0.15

EE: oil content, Ca: Calcium, TP: Total phosphorous, AP: Available phosphorous

Source: Charles and Ben, 2021

Wheat grain comprises 83% endosperm, 14% bran and 3% germ. During milling for human consumption, the endosperm is separated from the bran and germ.

Figure 9: : Parts of wheat grain.



Source: Source: Simon Ndonye.

Wheat bran

Wheat bran consists of the coarse outer covering of the wheat grain. It is made up of the husk and some adhering endosperm. It has a low energy value (for non-ruminants) and high fibre content, making it highly suitable as cattle and horse feed, as the fibre is readily digestible (Table 5). It can be used for feeding pigs and poultry in limited amounts due to high fibre and low ME.

Table 5: Nutrient content of wheat bran

ME(poultry)	DE (pigs)	CP	CF	EE	Ca	TP	AP
Kcal/kg	Kcal/kg	%	%	%	%	%	%
1500	2500	16	12	3	0.15	1.3	0.5

EE: oil content, Ca: Calcium, TP: Total phosphorous, AP: Available phosphorous

Source: Charles and Ben, 2021

The protein content of wheat bran is higher compared to whole wheat grain because the bran is the outer layer of the wheat kernel, which contains a higher concentration of protein.

When wheat is processed to produce refined flour, the bran and germ portions are removed, leaving behind the starchy endosperm. The bran, which is the outermost layer, is rich in fiber, minerals, and protein. On the other hand, the endosperm, which is used to make white flour, contains mostly carbohydrates with a lower protein content.

b) Non-cereal-based concentrates

Cane molasses

Molasses is a by-product of the manufacture of refined sugar from beet and sugar cane containing sucrose and other soluble sugars. It can be used for distilling industrial alcohol and livestock feed. Animals like to eat molasses but levels beyond 25% can cause digestive disturbances (diarrhoea) and reduced feed efficiency. Molasses has been used to induce animals to eat poor quality roughage by mixing with water and sprinkling on feedstuffs). Cane molasses is fed mainly to dairy cows, beef, sheep, and horses, and rarely to pigs and poultry. Fed at low levels, molasses is a good source of energy and can replace some grain content.

Molasses helps to reduce dust in feed, as a pellet binder, or liquid protein supplement when mixed with urea. Due to its milling properties (sticky consistency), the use of molasses in feed manufacturing is limited as its high viscosity will not allow it to circulate easily from storage tanks to feed mixers.

Table 6: Nutrient content of cane molasses

Dry matter	ME (poultry)	ME (cattle)	CP (%)	Ca	TP
%	Kcal/kg	kcal/kg	%	%	%
75	2,400	2,650	6	1	0.1

TP: total phosphorous

Source: Charles and Ben, 2021

Protein concentrates

Protein concentrates contain 20% or more CP and are used in feed formulations to increase the protein levels of the feed mix. It should be noted that most energy sources (except fat and starch)

supply protein, but usually not in enough quantities to meet the animal's requirements. Unlike energy, protein is defined in terms of both quality and quantity, and as such, some supplements may contain the same amount of protein but differ markedly in quality and price. The quality is dependent on the presence of essential amino acids.

The protein requirements for livestock can be met from several sources, including:

- Plants (high protein legume fodder, oilseed meals and cakes)
- By-products from the wet milling of maize
- Brewery and distillery by-products (yeast)
- Animal, avian, or marine
- NPN (urea)

The choice of the source to use is dependent on several factors as shown in Table 7.

Table 7: Factors determining inclusion of protein concentrate in rations

Factor	Description
Availability	Varies from location to location
Cost factor	Cost of protein supplement.
Quality	Content and availability of essential amino acids.
Nutritional value	Choice of feedstuff can be dictated by nutrient content. Nutritional value should be considered during costing, and purchase price based on quality. Presence of minerals and vitamins may be a decisive factor as proteins sources may resemble each other but may different mineral and vitamin levels.
Undesirable and anti-nutritive fact	The presence of trypsin inhibitors in soybean, gossypol in CSC and odors in products such as fishmeal.

i. Plant protein sources

The most common plant protein sources used in feed mixing are oilseed meals and cakes. Other sources include maize gluten feed and meal, germ meal (maize), copra meal (coconut), canola meal, and peanut meal.

In general, plant proteins are:

- Low in lysine, methionine and cysteine (Soybean is an exception with high lysine)

- High in true protein (Plant proteins have about 90% true protein and 10%NPN)
- Dependent on the method of fat extraction which affects the energy content of oilseed meals
- High in phosphorous, although most is bound by phytic acid.

a) Oilseed cakes and meals

These are by-products of fat extraction from seeds high in oil content. The oil can be extracted mechanically through a press or extracted using organic solvents. Mechanically extracted oil is normally in cake form, while solvent extracted oil is in meal form**.**



Figure 10: : Cottonseed cake (A), Cottonseed meal (B).

Mechanically extracted cakes are high in residue fat and low in protein, while the opposite applies to solvent extracted meal.

Soybean meal

Whole soya bean is low in CP (38%) and rich in oil (18–21%) and is extracted to make soybean meal. After the extraction of oil (soybean meal through solvent extraction), the protein content of the meal increases to 46–50%, becoming palatable and highly digestible. Soybean meal is high in lysine but low in methionine. It is the best plant protein source and should be a standard ingredient in poultry diets when available. Raw soybeans have a lower nutritive value than roasted beans or soybean meal due to the presence of toxic substances. The anti-nutritive factors in raw soybean include trypsin inhibitors that impede the activity of the enzymes trypsin and chymotrypsin in the gut, thus preventing protein digestion and increasing nitrogen and sulphur losses in faeces. This leads to poor growth, and poor feather production in poultry.

These toxins are especially harmful to young animals (calves, chicks and piglets). Laying chicken fed raw beans will lay eggs normally, but with blood spots in the yolk.

The toxin is destroyed through extrusion, as the inhibitor is thermally labile. Under small-scale conditions, the trypsin inhibitor can be controlled by simply germinating or fermenting the bean for 48 hours. Small quantities of soya bean can be roasted at a homestead level, before being crushed and fed to livestock.

Table 8: Nutrient content of soybean meal

DM	ME poultry	DE pigs	CP	EE	CF	Ca	TP	AP	Lys	Met
%	Kcal/kg	Kcal/kg	%	%	%	%	%	%	%	%
90	2,300	3200	45	1	7	0.3	0.58	0.3	2.69	0.62

DM: dry matter, CP: crude protein, CF: crude fibre, EE: oil content, Ca: Calcium, TP: total phosphorous, AP: available phosphorous, Lys: Lysine, Met: Methionine.

Source: Charles and Ben, 2021

Cottonseed cake

The cake is obtained after oil has been pressed from the cottonseeds either mechanically (CSC) or by solvents (cottonseed meal). Whole cottonseed is high in energy and low in protein. Its use in feeding early lactating cows has met with good results, due to a high energy (fat) content and highly digestible fibre.

The protein is of good quality, but the content is variable due to processing techniques, as the fibre levels are highly dependent on the efficiency of the ginnery. The energy content is dependent on the method and efficiency of fat extraction. As a result, cakes have a high variability in content of energy, fibre, and protein. A cake with a high protein content is considered to be of good quality.

The use of CSC in livestock feed is limited by anti-nutritional factors. It contains gossypol, a yellow pigment toxic to young chicks and piglets. The high fibre content, presence of gossypol, low levels cysteine, methionine and lysine limit its use in poultry diets. It is very palatable to ruminant animals but less liked by poultry and swine.

The use of cottonseed in animal feed can be increased through breeding plant types with lower levels of gossypol, removing gossypol by physical extraction, or deactivating it with iron salts.

Low gossypol meals that give a good performance in both poultry and swine are available but are more expensive.

The use of CSC in the rations of laying hens is not recommended, as gossypol affects egg quality, causing a green-brownblack discoloration in the yolk, depending on the level of gossypol and length of storage. It causes yolks to be viscous. Some fatty acids in residual cotton oil cause egg whites to turn pink during storage.

Table 9: : Nutrient content of cottonseed cake

DM	ME poultry	ME ruminants	DE pigs	CP	EE	CF	Ca	TP	AP	Lys	Met
%	Kcal/kg	Kcal/kg	Kcal/kg	%	%	%	%	%	%	%	%
90	2,200	2,700	2,690	34	2	16	0.25	1.0	0.3	1.3	0.7

DM: dry matter, CP: crude protein, CF: crude fibre, EE: oil content, Ca: Calcium, TP: total phosphorous, AP: available phosphorous, Lys: Lysine, Met: Methionine

Source: Charles and Ben, 2021

Sunflower seed cake

Sunflower seed is grown for its polyunsaturated fatty acids and has a typical oil content of 46% and protein content of 16%. The cake is obtained after mechanical expulsion of fat from sunflower seeds, with the quality (energy and protein content) of the cake dependent on the extent and efficiency of fat extraction. The nutrient content of the cake varies considerably due to differences in the efficiency of extraction. Sunflower cake is lower in protein and higher in fibre (due to a thick seed coat) when compared with CSC. It is deficient in lysine and methionine. The high fibre content discourages its use in swine and poultry diets, but in ruminants the performance is similar to CSC.

Table 10: Nutrient content of sunflower seed cake

DM	ME poultry	ME ruminants	DE pigs	CP	EE	CF	Ca	TP	AP	Lys	Met
%	Kcal/kg	Kcal/kg	Kcal/kg	%	%	%	%	%	%	%	%
90	1,700	2,300	2,470	28	2	23	0.3	1.2	0.35	1.0	1.0

CP: crude protein, CF: crude fibre, EE: oil content, Ca: Calcium, TP: total phosphorous, AP: available phosphorous

Source: Charles and Ben, 2021.

b) Maize gluten meal

Maize gluten meal is the principal protein of maize endosperm and consists mainly of zein and glutelin. The dried residue is obtained after the separation with bran followed by removal of starch and germ, during wet milling. It is normally available at two levels of protein (40% and 60%). It is low in lysine and tryptophan. Gluten meal is used in rations for all livestock, and due to high levels of xanthophylls is a good feed for poultry, especially due to deeper egg yolk and broiler skins yellow color.

ii. Protein supplements of animal origin

Meat and bone meal

Meat and bone meal (MBM) is prepared from the wastes associated with slaughtering and rendering operations. These include carcass trimmings, condemned carcasses, inedible offal, and bones. Material such as hair, hoof, horn, hide, manure, or stomach contents are not included. The ash content is high (because of bone) at up to 28–36%. 8–11% of this is calcium, and 4–5% is phosphorous (Table 11). It is not considered especially palatable and should be introduced into a ration gradually. The protein in meat and bone meal is degraded relatively slowly in the rumen and is therefore a good source of bypass protein. MBM is high in fat which increases its energy content. Feeding MBM to cattle is thought to have been responsible for the spread of bovine spongiform encephalopathy (BSE, or mad cow disease). As such, MBM is no longer allowed in feed for ruminant animals.

Table 11: : Nutrient content of meat and bone meal

DM	CP	EE	Ash	Ca	AP
%	%	%	%	%	%
94	46	10	30	11.8	5.6

DM: dry matter, CP: crude protein, EE: oil content, Ca: Calcium, AP: available phosphorous

Source: Charles and Ben, 2021.

Nutritive value of Roughage feeds

Pasture forage

- Metabolizable Energy (ME): Approximately 2,000-2,500 kcal/kg of dry matter (DM)

- Crude Protein: 10-20% crude protein on a dry matter basis
- Calcium: Approximately 0.3-0.6% calcium on a dry matter basis
- Phosphorus: Approximately 0.2-0.4% phosphorus on a dry matter basis

Hay

- Dry Matter: Dry matter content can vary but typically ranges from 85-95% on an as-fed basis.
- Metabolizable Energy (ME): Approximately 1,800-2,500 kcal/kg of dry matter (DM).
- Crude Protein: Generally, ranges from 8-20% crude protein.
    - ✓ 8 to 14 percent in grass hays
    - ✓ 14 to 17 percent in legume-grass mixed hays.
- Calcium: Approximately 0.3-1.0% calcium
- Phosphorus: Approximately 0.1-0.4% phosphorus

Please note that these values are approximate and can vary depending on the specific type of hay, stage of growth, and storage conditions.

Self-Check 1.	Written Test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer (3 point)

1. How is body condition scoring typically performed in dairy cows?
   a) By assessing the tailhead, ribs, and loin area
   b) By measuring the weight of the cow
   c) By monitoring milk production levels
   d) By conducting regular physical examinations
2. What is one of the limitations of using cottonseed cake (CSC) in poultry diets?
   a) High variability in energy, fiber, and protein content
   b) Presence of gossypol, a toxic pigment
   c) Low levels of essential amino acids like cysteine, methionine, and lysine
   d) Limited availability and high cost compared to other feed ingredients
3. What are the anti-nutritive factors in raw soybeans that can negatively impact poultry growth and feather production?
   a) High levels of trypsin and chymotrypsin enzymes
   b) Presence of gossypol
   c) Low levels of lysine and methionine
   d) Toxic substances that impede protein digestion

Test II: Short Answer Questions(11pts).

1. What are some factors that influence the nutrient requirements of cattle? (2)
2. How does the energy requirement of sheep change throughout the lactation period? (3)
3. What are some specific feeding strategies that can be employed to meet the nutritional needs of goats? (3)

4. How does the daily feed intake of goats vary based on their physiological stage? (3)

Note: Satisfactory rating - 14 points **Unsatisfactory - below 14 points**

You can ask you teacher for the copy of the correct answers.

Operation Sheet -1

1.1.Perform body condition scoring in dairy cows

A. Materials, tools and equipment

- Personal Protective Equipment (PPE)
- Reference Material
- Record-Keeping Materials

B. Procedures

a) Wear appropriate personal protective equipment (PPE)

b) Approach the cattle calmly and gently to minimize stress and ensure safety.

c) Start by visually assessing the overall appearance and condition of the animal.

d) Look for indicators such as the fat cover over the animal's body and the prominence of skeletal features.

e) Begin the assessment by observing the backbone and loin area.

f) Run your hand gently along the backbone and loin to feel for the amount of fat cover.

g) Note how easily the backbone can be felt and the presence of muscle definition.

h) Move to the ribs and assess the fat cover over the ribcage.

i) Again, use your hand to feel the amount of fat and muscle covering the ribs.

j) Note any visible or easily palpable ribs.

k) Assess the fat cover over the tailhead and the prominence of the hip bones.

l) Feel for fat deposition around the tailhead and notice any muscle definition.

m) Continue to evaluate the area behind the shoulder (thoracic region) for fat cover and muscle definition.

n) Assess the presence of a crease or depression along the back of the animal.

o) Observe the shape and fullness of the hindquarters, including the presence of a well-rounded appearance or excessive fat deposits.

p) Based on the observations and evaluations, assign a body condition score to the animal using the 1 to 5 scale.

q) Record the body condition score for each individual animal for future reference or management decisions.

1.2. Body weight estimation in cattle

A. Materials, tools and equipment

- Measuring Tape or Flexible Measuring Tape
- Chute or Restraining Device
- Calculator
- PPE
- Heart girth meter

B. Procedure

a) Wear PPE

b) Gather the necessary materials and tools

c) Secure the animal in a chute or suitable restraining device

d) Locate the Heart Girth.

e) Measure the Body Length

f) Calculate the Estimated Body Weight

g) Interpret the estimated body weight based on the specific weight estimation formula.

h) Record the result

LAP test-1	Performance Test

Name…… ID…… Date……

Time started: _____ Time finished: _____

Instructions: With the provided templates, tools, and materials, you are required to perform the following tasks within a 1hour minute timeframe. It is expected that each student completes the project.

1. Visually assess the overall appearance and condition of a dairy cow

2. Based on your visual assessment, what indicators can you identify to determine the fat cover and prominence of skeletal features?
3. What specific observations can you make about the backbone and loin area, considering the ease of feeling the backbone and the presence of muscle definition?
4. Measure the heart girth and body length of a mature cow and estimate its body weight.

LG #2	LO #2- Assess pasture feed

Instruction sheet

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

- Determining grazing management strategy
- Monitoring quantity and quality of pasture

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:

- Determine grazing management strategy
- Monitor quantity and quality of pasture

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 sheet
4. Accomplish the “Self-check”
5. Perform the “Operation Sheet”
6. Do the Lap test

Information Sheet. 2

2.1. Determining grazing management strategy

To ensure a sustainable stocking capacity of pasture, you can implement the following grazing management strategies:

a) Rotational Grazing:

Dividing pasture into smaller paddocks or pastures and rotating livestock between them. This allows forage in one area to recover while animals graze in another. Rotational grazing prevents overgrazing and promotes the growth and health of forage plants(https://www.youtube.com/watch?v=wsVeUl9zJ8I).

How to develop rotation schedule

Creating and implementing rotation schedules for grazing management involves dividing pasture or grazing area into smaller paddocks and rotating livestock through them. Here's a step-by-step guide on how to develop rotation schedules:

- **Assessing the Pasture**: Evaluating the size, condition, and carrying capacity of pasture. Consider factors such as forage production, soil fertility, water availability, and topography. This assessment will help you determine the number of paddocks needed and the appropriate stocking rates.
- **Determining Grazing Periods:** Decide on the duration of time livestock will spend in each paddock. This can vary depending on factors such as forage growth rate, plant recovery period, and desired residual forage height. The length of grazing periods could range from a few days to several weeks.
- **Calculating Rest Periods:** Determine the rest or recovery period for each paddock. Rest periods allow forage plants to regrow, replenish energy reserves, and promote overall pasture health. The duration of rest periods depends on factors such as forage growth rate,

plant species, and environmental conditions. It can range from a few weeks to several months.

- **Dividing Pasture into Paddocks:** Divide your pasture into smaller paddocks or grazing areas. The number of paddocks needed will depend on factors such as pasture size, carrying capacity, and the desired duration of grazing and rest periods. Aim for a sufficient number of paddocks to allow for proper rotation without overgrazing or underutilization of any area.
- **Plan the Rotation Sequence:** Determine the order in which livestock will move through the paddocks. Consider factors such as forage quality, accessibility to water sources, topography, and ease of livestock movement. The rotation sequence should ensure that each paddock receives adequate rest before being grazed again.



Figure 11: Rotational grazing

- **Establish Fencing and Water Infrastructure:** Install appropriate fencing to separate the paddocks and contain the livestock. Ensure that there is access to water sources in each paddock or plan for portable water troughs to be moved as livestock rotate through the areas.
- **Monitor and Adjust:** Regularly monitor the condition of the pasture, including forage growth, livestock performance, and pasture health indicators. Assess the effectiveness of the rotation schedule and make adjustments as needed. This may involve modifying

grazing periods, rest periods, or paddock sizes based on observed conditions and livestock needs.

- **Record Keeping:** Maintain records of the rotation schedule, including grazing periods, rest periods, and any observations or management actions taken. This information will help you track the effectiveness of the rotation system, evaluate its impact on pasture health and livestock performance, and guide future adjustments.

b) Rest and Recovery Periods: Provide adequate rest periods for each paddock or pasture to allow forage to regrow and replenish its energy reserves. The duration of rest periods will depend on forage growth rates, plant species, and environmental conditions. Rest periods promote sustainable forage production and maintain the long-term productivity of the pasture.

c) Stocking Rates: Determine the appropriate number of animals that your pasture can support without causing overgrazing or degradation. Consider factors such as forage availability, growth rates, and the desired residual forage height. Adjust stocking rates based on the carrying capacity of your pasture and monitor animal performance and pasture condition regularly.

d) Grazing Intensity and Duration: Control the intensity and duration of grazing in each paddock to avoid excessive forage removal. Avoid allowing animals to graze too long or too heavily in one area, as it can lead to overgrazing and reduce the pasture's carrying capacity.

e) Targeted Grazing: Targeted grazing refers to the deliberate use of livestock to manage specific vegetation types or achieve specific vegetation management goals within a pasture or rangeland. It involves strategically grazing certain areas or plant species to achieve desired outcomes. Targeted grazing is a flexible and ecologically friendly approach that can be integrated into overall grazing management strategies. It provides a natural and cost-effective method for vegetation management, particularly for controlling invasive species or promoting desired plant communities within a pasture or rangeland.

f) Water Management: Ensure proper water distribution throughout the pasture to encourage even utilization and prevent overgrazing around water sources. Consider installing additional watering points or implementing rotational grazing around existing water sources to promote more uniform grazing.

g) Monitoring and Adaptation: Regularly monitor the condition of your pasture, including forage availability, plant species composition, and soil health. Adjust your grazing

management strategies as needed based on these assessments. This includes making changes to stocking rates, rotation schedules, and rest periods to maintain a sustainable stocking capacity.

h) **Soil Health Management:** Implement practices that enhance soil health, such as maintaining proper soil fertility, managing soil erosion, and minimizing soil compaction. Healthy soils support the growth of nutritious forage and contribute to the long-term sustainability of the pasture.

i) **Seasonal Adjustments:** Adapt your grazing management strategies to account for seasonal variations in forage growth and climate conditions. Adjust stocking rates, rotation schedules, or implement supplemental feeding during periods of forage scarcity to ensure sustainable grazing.

2.2. Monitor Quantity and quality of pasture

Monitoring the quantity and quality of pasture is crucial for ensuring a continual and consistent supply of nutrients to livestock. Here are some practices to help you monitor and manage pasture quantity and quality effectively:

Visual Assessment: Conduct regular visual assessments of your pasture to observe the overall condition, forage growth, and any issues such as overgrazing or underutilization. Look for signs of healthy vegetation, including vigorous growth, desirable plant species, and appropriate ground cover.

Forage Sampling: Take forage samples from representative areas of your pasture to determine its nutritional value. This can be done by hand-plucking or using specialized tools like a grazing stick or pasture probe. Analyze the samples in a laboratory to obtain information on key parameters such as dry matter content, protein content, fiber content, and mineral composition.

Pasture Measurement Tools: Utilize tools and technologies such as pasture measurement devices or satellite imagery to assess pasture growth and monitor changes over time. These tools can provide objective data on pasture quantity, allowing you to make informed decisions about grazing management.

Grazing Records: Keep records of stocking rates, grazing duration, and rest periods for each pasture or paddock. This information helps you track the utilization of the pasture and identify

trends or patterns that may affect its quantity and quality. By maintaining grazing records, you can adjust management practices based on historical data and observations.

Nutrient Analysis: Conduct regular soil testing to assess the nutrient status of your pasture. Soil tests provide valuable insights into soil fertility and nutrient deficiencies, allowing you to apply appropriate fertilizers or soil amendments to ensure optimal forage growth and nutrient availability for livestock.

Animal Performance Monitoring: Monitor the performance and health of your livestock, including weight gain, body condition score, and overall productivity. Animal performance can serve as an indicator of whether the pasture is providing adequate nutrition. Regular assessments can help you identify any deficiencies or imbalances in the pasture's nutrient supply.

Seasonal Adjustments: Recognize that pasture quantity and quality can vary throughout the year due to seasonal changes in weather and forage growth. Adjust your grazing management practices, such as stocking rates or supplemental feeding, to accommodate these seasonal fluctuations and maintain consistent nutrient supply to livestock.

Grazing Management Adjustments: Based on the monitoring data and assessments, make necessary adjustments to your grazing management strategy. This may include altering stocking rates, adjusting rotation schedules, or implementing supplementary feeding to ensure adequate nutrient supply to livestock while preserving pasture health.

Self-Check 2.	Written Test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer (3 points)

1. What is the purpose of rotational grazing?
   a. To promote the growth and health of forage plants
   b. To control invasive species within a pasture
   c. To ensure proper water distribution throughout the pasture
   d. To enhance soil fertility and minimize soil compaction
2. How can you determine the appropriate number of animals your pasture can support?
   a. By assessing the condition of the pasture and considering factors
   b. By implementing targeted grazing practices
   c. By adjusting the timing and intensity of grazing
   d. By dividing the pasture into smaller paddocks and rotating livestock between them
3. What is targeted grazing?
   a. What is the importance of rest and recovery periods in grazing management?
   a. They allow forage to regrow and replenish energy reserves
   b. They prevent overgrazing and reduce the carrying capacity of the pasture
   c. They promote the growth of desired plant species
   d. They ensure proper water distribution throughout the pasture

Test II: Short Answer Questions (10pts)

1. What are some practices you can implement to monitor and assess the quantity and quality of pasture? (4pts).
2. How can forage sampling and analysis help in determining the nutritional value of pasture? (3pts)
3. Why is it important to keep grazing records and how can they assist in managing pasture quantity and quality? (3ps)

Note: Satisfactory rating - 13 points **Unsatisfactory - below 13 points**

You can ask you teacher for the copy of the correct answers.

Operation Sheet -2

2.1. Develop grazing management plan using rotational grazing system

A. Materials, tools and equipment:

- Maps and Aerial Imagery
- Soil Reports
- Nutrient composition table
- Fencing materials
- Grazing Record Sheets
- Management Guides and Publications

B. Procedure

a) Clearly identify your goals and objectives for grazing management.
b) Conduct a thorough assessment of your grazing resources.
c) Evaluate the condition of your pasture or range
d) Assess the carrying capacity of your land
e) Determine Stocking Rate and Grazing Pressure
f) Ensure that the stocking rate aligns with the carrying capacity of your land.
g) Adjust the stocking rate as needed to avoid overgrazing or underutilization of forage resources.
h) Create a grazing schedule that outlines when and how long livestock will be allocated to each paddock or pasture.
i) Establish a system for monitoring and evaluating the grazing management plan.
j) Use this information to make informed decisions and adjust the grazing management plan as needed.
k) Implement appropriate herd or flock management practices that complement the grazing management plan.
l) Integrate environmental stewardship practices into your grazing management plan.

m) Keep records

LAP test-2	

Name…… ID…… Date……

Time started: _____ Time finished: _____

Instructions: Given the necessary templates, tools, and materials, you are required to perform the following tasks within 12 hours. Each student is expected to complete the project.

Task 1: Develop pasture grazing management plan

LG #3	LO #3: Determine supplementary feeding program

Instruction sheet

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

- Identifying and determining types of supplementary feed
- Determining economic basis to supplementary feeding system
- Determining supplementary feeding program
- Providing supplementary feeding

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:

- Identify and determine types of supplementary feed
- Determine Economic basis to supplementary feeding system
- Determine supplementary feeding program
- Provide supplementary feeding

Learning Instructions:

7. Read the specific objectives of this Learning Guide.
8. Follow the instructions described below
9. Read the information written in the information sheet
10. Accomplish the “Self-check”
11. Perform the “Operation Sheet”
1. Do the Lap test

Information Sheet. 3

3.1. Identifying and determining types of supplementary feed

Identifying and determining the types of supplementary feed for livestock involves considering several factors, including the nutritional requirements of the animals, the availability of feed ingredients, and the specific goals of the feeding program.

Supplementary feeds, also known as supplemental feeds or concentrates, are additional feed sources provided to livestock to meet their nutritional requirements alongside their primary forage or grazing.

Here are some common types of supplementary feeds:

Grain

Grains such as corn, barley, wheat, oats, and sorghum are commonly used as supplementary feeds for livestock. They are dense in energy and can provide carbohydrates and some protein. Grains can be fed whole, cracked, rolled, or processed into pellets or cubes.

Protein Supplements

Protein supplements are used to augment the protein content in the animal's diet. Examples include soybean meal, cottonseed meal, canola meal, sunflower meal, and distillers' grains. These supplements provide essential amino acids and help meet the protein requirements of animals, particularly when the forage or pasture is deficient in protein.

Oilseed Meals

Oilseed meals, such as soybean meal, linseed meal, and rapeseed meal, are rich in protein and fat. They can serve as valuable protein sources and contribute to the overall energy density of the diet.

Forage Supplements

Forage supplements are typically preserved forages, such as hay, haylage, or silage, that are provided as additional fiber and nutrients. They can be used when there is limited access to fresh pasture or to balance the nutrient composition of the diet.

By-Products

By-products from various industries, such as brewers' grains, distillers' grains, sugar beet pulp, and citrus pulp, can be used as supplementary feeds. These by-products are often rich in nutrients and can provide energy, protein, and fiber to the animal's diet.

Mineral and Vitamin Supplements

Mineral and vitamin supplements are used to ensure animals receive appropriate levels of essential minerals and vitamins. These supplements can be in the form of blocks, loose minerals, or premixed concentrates.

Feed Additives

Feed additives are substances added to animal feeds to enhance performance, health, or digestion. Examples include probiotics, prebiotics, enzymes, and direct-fed microbials. These additives can improve feed efficiency, gut health, nutrient utilization, and overall animal well-being.

It's important to note that the selection of supplementary feeds should be based on the specific nutritional requirements of the animal species, their stage of production (such as growth, lactation, or maintenance), and the availability and cost of feed ingredients.

3.2. Determining economic basis to supplementary feeding system

The economic basis of a supplementary feeding system for livestock involves assessing the cost-effectiveness and financial implications of implementing such a system. Here are some key economic considerations:

Cost of Feed Ingredients:

Evaluate the cost of various feed ingredients required for the supplementary feeding system. Compare prices and availability from different suppliers or sources. Consider both the upfront cost and the ongoing costs associated with maintaining a consistent supply of feed ingredients.

Nutrient Density and Efficiency:

Assess the nutrient density of the supplementary feeds in relation to their cost. Compare the cost per unit of specific nutrients (e.g., cost per unit of protein or energy) to determine the most cost-effective options. Consider the digestibility and utilization of nutrients by the animals to ensure efficient conversion of feed into desired production outcomes.

Feed Conversion Efficiency:

Evaluate the feed conversion efficiency of the supplementary feeding system. This refers to the ability of animals to convert feed into desired outputs, such as weight gain or milk production. Efficient feed conversion can help optimize the economic returns from the supplementary feeding program by minimizing feed wastage.

Production and Performance Benefits:

Consider the potential production and performance benefits resulting from the supplementary feeding system. Assess how the system can enhance growth rates, improve body condition, increase milk yields, or enhance reproductive performance. These benefits can directly or indirectly contribute to economic returns through improved livestock productivity.

Health and Disease Management:

Evaluate the impact of the supplementary feeding system on animal health and disease management. A well-balanced and properly supplemented diet can support overall animal health, reduce the risk of nutrient deficiencies or metabolic disorders, and minimize veterinary costs. Consider the potential cost savings associated with reduced health issues or improved herd/flock immunity.

Market Value and Profitability:

Assess how the supplementary feeding system may impact the market value and profitability of the livestock enterprise. Consider factors such as improved product quality, market demand for higher-quality products, and potential price premiums for well-fed animals. Evaluate how the system may enhance the profitability of the operation by increasing output value or reducing production costs.

Feasibility and Return on Investment:

Conduct a feasibility analysis and calculate the potential return on investment (ROI) of implementing the supplementary feeding system. Consider the initial investment required for infrastructure, equipment, and feed inventory. Estimate the expected benefits and compare them to the costs over a defined time period to determine the financial viability and potential ROI.

It's important to note that the economic considerations of a supplementary feeding system will vary based on factors such as the type of livestock, production goals, local market conditions, and available resources. Conducting a thorough economic analysis and consulting with agricultural economists or industry professionals can help in making informed decisions regarding the implementation of a cost-effective supplementary feeding system.

3.3. Determining supplementary feeding program to satisfy deficiencies in pasture feed or animal condition.

A supplementary feeding program can be implemented to address deficiencies in pasture feed or improve animal condition. Here's a suggested approach to designing such a program:

Identify Nutritional Deficiencies

Assess the specific nutritional deficiencies in the pasture feed or animal condition. This can be done through forage analysis, veterinary examination, and observation of body condition scores. Identify the nutrients that are lacking or insufficient, such as energy, protein, minerals, or vitamins.

Set Feeding Objectives:

Determine the objectives of the supplementary feeding program. This could include improving body condition, supporting growth or weight gain, enhancing milk production, or addressing specific nutrient deficiencies. Establish clear goals to guide the selection and implementation of the program.

Select Appropriate Supplementary Feeds:

Choose supplementary feeds that are rich in the nutrients lacking in the pasture feed or required to improve animal condition. Consider feed ingredients such as grains, protein supplements, oilseed meals, mineral supplements, or forage substitutes. Ensure that the selected feeds are cost-effective and readily available.

Determine Feeding Methods:

Determine the feeding methods that best suit the needs of your livestock and the available resources. This can include offering supplementary feeds in troughs, feeding stations, or as part of a total mixed ration (TMR). Consider factors such as feed accessibility, feeding frequency, and the ability to monitor individual feed intake.

Calculate Feed Requirements:

Calculate the appropriate amount of supplementary feed required to meet the nutritional needs of the animals. This calculation should consider factors such as animal weight, desired nutrient intake, and the nutrient composition of the supplementary feeds. Work with a nutritionist or use appropriate software tools to determine the precise feed quantities.

Monitor and Adjust:

Monitor the animals' response to the supplementary feeding program, including changes in body condition, weight gain, milk production, or other relevant parameters. Regularly assess the pastures and adjust the feeding program as needed to ensure that the animals' nutritional requirements are being met effectively.

Cost-Benefit Analysis

Conduct a cost-benefit analysis of the supplementary feeding program to evaluate its economic feasibility and impact on profitability. Consider the cost of feed ingredients, labor, and any associated infrastructure or equipment investment. Compare these costs to the expected benefits, such as improved animal performance, enhanced market value, or reduced veterinary expenses.

3.4. Providing supplementary feeding to maintain livestock body weights, condition or lactation requirement

Supplementary feeding can be employed to maintain livestock body weights, condition, or meet lactation requirements. Here's a suggested approach for each scenario:

Maintaining Body Weights

Assess the current body weights of the livestock and determine the desired target weights.

Calculate the appropriate amount of supplementary feed required to maintain the desired weights. Consider the animals' energy requirements and the nutrient composition of the supplementary feeds.

Select supplementary feeds that are high in energy, such as grains or energy-dense concentrates, to provide the necessary calories.

Monitor the animals' body weights regularly and adjust the feeding program as needed to ensure they are maintaining the desired weights.

Maintaining Body Condition

Evaluate the body condition scores of the livestock. Body condition scoring assesses the amount of body fat and muscle cover and provides an indication of overall body condition.

Determine the target body condition score and the desired changes, if any.

Choose supplementary feeds that are appropriate for improving body condition. This may include feeds with higher protein content or feeds that are specifically formulated for body condition improvement.

Adjust the feeding program to provide the necessary nutrients and calories to support body condition improvement. Monitor the animals' body condition scores regularly and adjust the feeding program accordingly.

Meeting Lactation Requirements:

Assess the nutritional requirements for lactating animals, considering their stage of lactation, milk production levels, and the nutrient composition of the primary forage or grazing.

Calculate the additional nutrient and energy requirements for lactation.

Select supplementary feeds that are high in energy and protein to meet the increased demands of milk production. Protein supplements, oilseed meals, or specialized lactation feeds may be appropriate options.

Determine the quantity and frequency of supplementary feed required to meet the lactation requirements, based on the specific nutrient needs and the milk production levels.

Regularly monitor the animals' milk production, body condition, and overall health to ensure they are adequately supported during lactation. Adjust the feeding program if necessary.

In all cases, consider the economic feasibility and cost-effectiveness of the supplementary feeding program. Conduct regular assessments of animal performance, monitor feed consumption, and adjust the program as needed to optimize livestock condition, production, and overall profitability.

Self-Check 3.	Written Test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer (4 points)

1. . What are some common types of supplementary feeds for livestock?
   a) Fresh pasture and forage
   b) Minerals and vitamins
   c) Fertilizers and soil amendments
   d) Grains and protein supplements
2. Which type of supplementary feed is typically used to augment the protein content in the animal's diet?
   a) Oilseed meals
   b) Forage supplements
   c) Grain supplements
   d) Protein supplements
3. When determining the economic basis of a supplementary feeding system, which factor should be considered to assess the cost-effectiveness of feed ingredients?
   a) Nutrient density and efficiency
   b) Feed conversion efficiency
   c) Production and performance benefits
   d) Market value and profitability
4. What is the purpose of conducting a feasibility analysis and calculating the potential return on investment (ROI) for implementing a supplementary feeding system?
   a) To assess the impact on animal health and disease management
   b) To determine the cost of feed ingredients
   c) To evaluate the feed conversion efficiency
   d) To determine the financial viability and potential profitability

Test II: Fill in the blank space (6pts)

1. _____ can be done through forage analysis, veterinary examination, and observation of body condition scores to identify nutritional deficiencies in the pasture feed or animal condition. (2pts).
2. The selection of supplementary feeds should consider the nutrient composition of the feeds and their _____ and availability. (2pts)
3. It is important to regularly _____ the animals' response to the supplementary feeding program and make adjustments as needed to ensure their nutritional requirements are being effectively met. (2pts)

Note: Satisfactory rating - 10 points **Unsatisfactory - below 10 points**

You can ask you teacher for the copy of the correct answers.

Operation Sheet -3

3.1. Developing supplementary feeding program

A. Materials tools and equipment

- Feed Ingredients
- Storage Facilities
- Feeders
- Watering Equipment
- Weighing Scales
- Feeding Equipment
- Feed analysis Laboratory
- Monitoring and Record-Keeping Tools
- Personal Protective Equipment (PPE)

B. Procedure

a) Identify the species and type of livestock
b) Determine the specific nutritional requirements of the livestock species and the stage of production
c) Evaluate the available feed resources
d) Conduct a forage laboratory analysis
e) Identify the nutrients that are lacking or insufficient

f) Select appropriate supplementary feeds that can address the identified nutritional deficiencies.
g) Select feeds that are cost-effective, readily available, and compatible with the livestock's dietary needs.
h) Calculate the quantity of supplementary feeds required to meet the nutritional needs of the livestock.
i) Determine the feeding methods that best suit the livestock species, their management system, and the available resources.
j) Conduct a cost-benefit analysis of the supplementary feeding program.
k) Record the progress

LAP TEST-3	**Performance Test**

Name…… ID…… Date……

Time started: _____ Time finished: _____

Instructions: Given the necessary templates, tools, and materials, you are required to perform the following tasks within 12 hours. Each student is expected to complete the project.

Task 1: Develop supplementary feeding program for 5 lactating dairy cows

LG #4	LO #4- Develop animal feeding plans

Instruction sheet

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

- Developing and reviewing feeding plan
- Identifying and carrying out feed conservation methods
- Selecting a system of livestock feeding options
- Preparing feed budget according to the selected system of feeding
- Feed plan data documentation

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:

- Develop and review feeding plan
- Identify and carry out feed conservation methods
- Select a system of livestock feeding options
- Prepare feed budget according to the selected system of feeding
- Document feed plan data

Learning Instructions:

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

Information Sheet. 4

4.1. Developing and reviewing feeding plan

A livestock feeding plan is a comprehensive strategy that outlines the specific nutritional needs of livestock and provides guidelines for feeding them in a systematic and efficient manner. It considers the type of livestock, their age, weight, production stage, and any specific requirements related to their health, growth, reproduction, or production goals.

4.1.1. Developing feeding plan

Basic data or information on your livestock need to be well documented periodically to properly plan the management of the farm such as the feed requirements for a given period of time. Planning on feed requirements could be done at different levels, from national, village and individual farm level. It could also be planned annually, biannually or on quarterly basis. The most common and effective is planning at individual farm levels on annual basis. Feed planning or sometimes called feed budgeting in a given farm has the following purposes.

- It ensures animals are fed properly, so we can reach the set production targets.
- It ensures minimization of feed wastage.
- It helps to predict feed surpluses and deficits and act accordingly.
- It helps to design a strategy of acquiring the required feed including roughages in time
- The supplement feed requirements can be foreseen a long way in advance and therefore purchased at the lowest possible price.

In planning the feed requirements of a given farm or herd, one has to critically look in to three major components.

i. The animals

In planning feed requirement, the first thing to know the details of animals in the farm.

- Which type and number of animals are in the farm? (Cattle, Goats, Sheep, mixed, etc)
- What is the main purpose of the animals (milk, meat, power)
- How many are there in the different categories (milking cows, growing animals, heifers, steers, bulls, calves, etc).
- Good if one has individual liveweights periodically.

Knowing the details of the herd structure will help the feed requirements for a given period of time. Feed requirements could be expressed in many ways, in terms of total dry matter, or in terms of roughages, concentrate supplements, and total mixed rations (TMR) or all details of nutrients (protein, energy, vitamins, minerals and water) based on the level of intensification of the farm. Feed and nutrient requirements of individual animals could also further disaggregate as for maintenance, production (milk, growth/meat, power/traction, etc) and pregnancy. This makes estimation and planning of feed requirement precise and increase productivity and profitability of the farm.

ii. The management of the animals

The management of the animals could be classified in different ways. One can broadly categorize as:

- pastoral,
- agropastoral and
- sedentary (crop-livestock mixed systems in Ethiopia) production systems.

The other classification could be the

- extensive,
- semi-intensive and
- intensive systems.

It could also be classified as

- traditional and
- commercial production systems.

In dairy it could also be categorized as

- rural
- peri-urban and
- urban systems.

Most of these classifications are based on the level of feed availability and feeding systems. Hence, if a farm has clear farm management practice one can have a practical plan of the annual feed requirement. In all the management systems the main challenge is lack of uniform supply of feed over the seasons. Seasonality of feed availability is very crucial in the tropical livestock production systems. It is severed in the pastoral and agropastoral systems. This seasonality of feed supply has

also a huge influence on feed and products (like milk) price-variability over the seasons. It is important to look months of peak feed supplies, times of feed scarcity and associated feed related matters.

Therefore, in planning we may need to clearly identify which months have critical feed scarcity, or good supply, in which seasons are feeds cheaper and the supply is good. This helps the farm to maintain production levels consistent throughout the year and makes it more profitable.

iii. The available feeds

The other side in planning feed requirements is looking the feeds required and available for livestock. Therefore, one has to clearly list out the feed available around the area and the additional feeds to be purchased or produced. These includes:

- The area and expected grazing land and estimated productivity. In countries like Ethiopia where communal grazing practiced, it might be very difficult to estimate for individual farmer or animal.
- The estimated feed from the crop aftermath grazing.
- The amount of hay produced and conserved annually.
- The amount of crop residues produced annually by crop type.
- The area and total production of cultivated forages (either in cut and carry systems, conserved hay or silage).
- The concentrate feeds (formulated feed, grains, agro-industrial by products, etc) available or to be purchased.
- Prices of roughages and concentrate supplements over the months of the year.
- Any other feed available that could be quantifiable or estimated.
- Average quality profiles of the feeds for major nutrients like protein, energy, digestibility, etc.

Steps of developing feeding plan

a) Estimating feed requirements of animals in a given farm

Based on the information provided above, annual feed requirements of a given farm will be the sum of daily feed requirements of all the animals in the farm multiplied by the 365 days. Hence, first determine or estimate the weight of each animal. Under smallholder farmers conditions, getting liveweights of animals specially for large animals is very difficult or not usually available.

More precise estimate of feed requirements is normally derived from a good estimation of liveweights of animals. There are different alternatives to estimate liveweight of animals as follows. However, their level of precision is different.

- Using appropriate balances to weigh animals.
- Estimating weight through body heart girth measurements.
- Estimating using conversions factors as tropical livestock units (TLU) which is about 250 kgs.

The use of TLU is mostly applicable for most smallholder farmers as weighing and measuring facilities are not available. The conversion factors are indicated in Table 12. But still close supervision and use of the proper conversion factor makes the estimation mor precise.

Table 12: – Conversion factors of different livestock groups into Tropical Livestock Units (TLU)

No	Description of animals	Conversion factor to TLU*	No	Description of animals	Conversion factor to TLU*
1	Calf	0.20 - 0.25	10	Sheep Young	0.06
2	Crossbred calves	0.40	11	Goats Young	0.06
3	Weaned calf	0.34	12	Sheep mature	0.10 - 0.13
4	Heifer	0.50- 0.75	13	Goat mature	0.10 - 0.13
5	Local cow	0.8 - 1.00	14	Donkey Young	0.35
6	Local oxen	1.00 – 1.10	15	Donkey mature	0.50 - 0.70
7	Crossbred cows	1.80	16	Camel	1.25
8	Crossbred oxen /bulls	1.9	17	Chicken	0.013
9	Crossbred Heifers	0.70	18	Horse	0.8- 1.10

TLU – Tropical livestock unit which is equivalent to 250kg;

Sources: Storck et al, 1991 and Greyseels, 1988

Example:

If a farmer has 2 crossbred cows, 3 local oxen, 2 crossbred calves, one crossbred heifer, 1 mature donkey and 15 sheep. The total TLU the farmer has will be calculated as follows:

Table 13: Example on how to convert the type and number of animals a farmer has to TLU

No	Description of animals	Number of animals	Conversion factor to TLU*	Estimated TLU
1.	Crossbred calves	2	0.40	0.80
2.	Donkey mature	1	0.50 - 0.70	0.60
3.	Local oxen	3	1.00	3
4.	Crossbred cows	2	1.80	3.60
5.	Crossbred Heifers	1	0.70	0.70
6.	Sheep	15	0.10 - 0.13	1.73
	Total			10.43

As indicated in Table 13, the farmer has about 10.43 TLU animals, which is equivalent to

10.43 TLU X 250 kgs = 2,606 kgs.

Therefore, the farmer requires for his all animals (herd), which totally weighs about 2606 kgs for a given period of time. Note that if the actual weights of individual animals are available feed requirements are calculated for each animal and sum up to estimate for the farm.

- **Estimating feed requirement of animals in terms of dry matter and nutrients**

Once you know the total number of animals and their live weight estimates, the next step is to assess the daily feed requirements. Feed requirements could be expressed in terms of total dry matter (TDM) or in terms of nutrients including, crude protein (CP), energy, minerals, vitamins and water. Detailed feed requirements could be planned for specialized farms, however for smallholder farmers like in Ethiopia requirements in terms of TDM, CP and energy is usually doing well for planning. The very crude estimate of daily TDM requirement is just using established multiplication factors. Normally an animal will consume about 1 to 4% of the live weight. Large animals like cattle consume about 2.5 to 3% while small ruminants like sheep and goats can

consume 3 to 4% of their live weight. The level of intake is also highly determined by the quality of the feed. Based on this intake estimation factor; A farmer who has 10.43 TLU = 2606 kg liveweight will require as follows:

- ✓ Daily feed requirement (TDM) = 2606 kg liveweight X 3% = 78.2 kg

Here if we know the daily feed requirement, we can calculate for any length of time required.
If it is a fattening, we can calculate 3 or 6 months as planned or if it is dairy, we can plan for a year.

- ✓ Annual feed requirement (TDM) = 78.2 X 365 = 28,543 kg = 28.5 tons of TDM
- ✓ Add about 20 % allowance for feeds that may be wasted as refusal and others.
- ✓ Total annual feed requirement = 28.5 tons + (28.5x20%) = 34.2 tons TDM

b) Estimating feeds which are available or to be purchased based on the plan

According to the above example the total feed required is 34.2 tons TDM. This total dry matter feed could come from different feed sources available including from grazing, crop residues, hay, cultivated forage crops, agro-industrial by products, formulated concentrates and others. Therefore, the next step is to determine the proportion of the total estimated annual total dry matter (TDM) in terms of the different feed components.

When one calculates or estimate the proportion of these feed components it is essential to consider the following.

- Availability of feeds in the area
- Nutritional value of the feed in relation to the nutrient requirement and targeted product
- Price of the feed if it is to be purchased
- Ease of production and its productivity and quality if it is to be produced

The required feed types usually determined based on the livestock production systems There are three major husbandry practices in the crop livestock mixed systems in Ethiopia. The feed resources for these systems are basically different. These systems are:

- Livestock under grazing systems – such production system under Ethiopia condition is very extensive. It is usually traditional and not market oriented.
- Semi intensive in which animals are partly grazing but supplemented at home
- Indoor feeding

Hence the proportion of feeds for the annual TDM estimated for the farms will be disaggregated depending on the above broad livestock production practices.

Livestock based on entirely on grazing

In this system animals allow to graze on natural pasture, browse in forest areas, graze after maths and on threshing grounds. Animals do not provide with any supplement feed at home or around the barn. One of the big challenges for farmers is to estimate the amount of feed the animals consumed from these feed source. Moreover, in areas where communal grazing is practiced, estimation of consumed feed from such grazing systems is very difficult. The question here is, do the animals fed adequately and produce according to the expectations. Do animals fed to their requirements in the different seasons. Such systems require close supervision and check if the grazing is adequate or additional feed is required or not. In most parts of the country animals are suffered from feed shortage in some months of the year specially during the dry season. Therefore, interventions on efficient feed utilization and introduction of additional feeds should be looked to meet requirements and improve productivity. The available feed should be estimated in terms of quantity and quality and the deficits need to be fulfilled from other sources. This is crucially important in most farming systems.

Livestock partly grazing and complimented with additional feed.

In the crop livestock mixed systems, the majority of livestock production is based on grazing and supplemented with different feed resources available. The amount and quality of additional feed required depends on the amount of grazing feed available, season and productivity level of the farm. If the grazing lands are good the additional feed is low. In many parts of Ethiopia, the grazing lands are highly degraded and the area is small relative to the number of animals and its contribution is seasonal and limited in amount and poor in quality. There are techniques to estimate the productivity of a given grazing lands and the amount of feed daily consumed by animals. But this is not an activity that could be done as a routine. Moreover, the grazing lands in many parts of Ethiopia are communal, which makes estimation very complicated and very difficult. Therefore, the recommended way is to roughly estimate the proportion of feed a given livestock farm obtained from grazing. The best estimation is obtained from experience. Though productivity of the grazing lands varies over the different years, those experienced farmers know how much the grazing contribute to the annual feed budget. In addition, it is also very important to consider the quality

of the feed from grazing lands. In most parts of the crop-livestock mixed systems in Ethiopia, grazing lands contribution is estimated up to 50% of the annual feed supply. If the farmer estimates 50% of the feed budget from grazing, then the next step is what would be the rest of the feed resources to full fill the annual feed requirement. Here one has to consider critical facts.

- Crop residues are very poor in quality especially the cereal crop residues which are the major feed sources available. If the farmer has only these feed resources, it might be very difficult to expect products like milk and meat.
- If the farmer is producing milk or fattening animals. Then he/she needs to have quality feed sources like cultivated forage crops, agro-industrial by products or formulated concentrates in addition to the poor roughages (grazing and crop residues).

The quantity of crop residues available or produced from the farmers' fields could be estimated from the grain yield by established conversion factors as indicated in Table 14.

Example:

If a farmer producers 10 quintals of tef from his farm, the total amount of straw he can obtain is 10 x1.5=15 quintals = 1.5 tons of tef straw.

Hay produced from the protected pasture lands will be estimated either from quadrats or number of bales produced (usually a bale of hay ways 15 kg in Ethiopia) or directly weight the total yield or estimate in different established systems like a bundle of donkey loads, cart loads, piles etc.

Purchased hay, concentrates, grains, agro-industrial by products are usually purchased based on weights and could be easily quantified. Yield of cultivated forage yields will be calculated by measuring the area cultivated and its average forage yield (or reported yields for the area).

Note that perennial forage crops like elephant grass could be harvested 2 to 4 times under rainfed conditions and up to 6 times when irrigated. Annual yields will be the sum of the total cuts in a year.

Table 14: Multipliers used to estimate crop residue from grain yields of different crops

No	Crop type	Multiplier
1	Tef	1.5
2	Wheat	1.5
3	Barley	1.5
4	Oats	1.7
5	Rice	1.3
6	Maize	2.0
7	Sorghum	2.5
8	Millet	2.2
9	Faba Bean	1.2
10	Field Pea	1.2
11	Chickpea	1.0

Sources: FAO, 1987

Livestock husbandry in indoor feeding systems

Indoor feeding is generally a practice of market oriented commercial farms under intensive management. Such feeding systems in dairy production, fattening (cattle and small ruminants) and poultry production. In Intensive systems of livestock production more than 70% of the cost is incurred for feed. The implication is that any effort for efficient use of feed makes the farm more profitable. In Ethiopia most urban and peri-urban dairy production and fattening activities and in some rural area's farmers follow indoor feeding practices. Now a days such feeding systems with improved dairy breeds becomes popular in many parts of the country. In such production practice planning annual feed requirements is not as such complicated, it only needs to follow the basic principles of diet formulation. However, unlike other countries, the productivity level is still far below, moreover we don't have our own established feeding standards and the ration formulation is less efficient.

c) Balancing the feed requirement and available feed (produced plus purchased feed)

By balancing the feed requirement and produced feed, one can crudely see if the feed is adequate, deficit or extra. Based on these findings the feed plan will be developed. If it is deficit, feed may be purchased, cultivated or other actions will be considered.

4.1.2. Reviewing feeding plan

Reviewing a feeding plan involves critically examining and evaluating the existing or proposed livestock feeding plan to assess its effectiveness, accuracy, and suitability for meeting the nutritional needs of the animals. It is a process of analyzing the plan to identify any areas that may need improvement, adjustment, or optimization.

When reviewing a livestock feeding plan, here are some general guidelines to consider:

Nutrient Requirements: Assess whether the feeding plan meets the specific nutrient requirements of the livestock based on their age, production stage, and physiological needs. Ensure that the plan provides adequate protein, energy, vitamins, minerals, and other essential nutrients.

Feed Composition: Examine the composition of the feed, including the types and proportions of ingredients used. Evaluate the balance of different feed components, such as grains, forages, protein sources, and supplements, to ensure they meet the nutritional needs of the animals.

Feed Quality: Consider the quality of the feed being provided. Check for signs of spoilage, mold, or mycotoxin contamination that could negatively impact animal health and performance. Assess the feed's nutritional value, such as its protein and energy content, to ensure it meets the desired standards.

Feeding Management: Evaluate the feeding management practices outlined in the plan. This includes factors such as feeding frequency, feeding methods, access to clean water, and any special considerations for specific animal groups or production systems.

Production Goals: Consider the specific goals of the livestock operation and assess whether the feeding plan aligns with those objectives. For example, if the goal is to maximize growth or milk production, ensure that the feed plan supports those targets.

Cost-effectiveness: Analyze the cost-effectiveness of the feeding plan. Assess the availability and affordability of feed ingredients, as well as the overall economic viability of the plan.

Health and Safety: Consider any health or safety concerns related to the feeding plan. Evaluate potential risks, such as the presence of toxins, allergens, or feed additives that could pose a threat to animal health or food safety.

4.2. Identifying and carrying out feed conservation methods

Conserving forage is an essential practice for livestock farmers and can help ensure a sufficient supply of high-quality feed during periods of scarcity or unfavorable weather conditions. Here are some common methods for conserving forage:

Haymaking: Haymaking involves cutting forage, allowing it to dry, and then baling it for storage. Here are the steps involved in making hay:

i. **Timing:** Cut the forage when it is at the appropriate growth stage, usually during the late vegetative or early reproductive stage.
ii. **Drying:** Lay the cut forage in the field in rows or spread it thinly to allow air circulation for drying. Regularly turn the forage to promote even drying.
iii. **Baling:** Once the forage has reached the desired moisture content (around 15-20% for small square bales and 12-18% for large round bales), bale it using a baler.
iv. **Storage:** Store the bales in a dry, well-ventilated area to prevent moisture absorption and mold growth.

Factors affecting hay quality

Several factors can influence the quality of hay. Here are some key factors that can affect hay quality:

Stage of Maturity: The stage at which the forage is harvested significantly impacts hay quality. Forage cut at early growth stages generally has higher nutrient content, digestibility, and palatability compared to mature forage. As plants mature, they tend to accumulate more fiber and lignin, which reduces digestibility and nutrient availability.

Timing of Harvest: The timing of hay harvest is crucial. Optimal timing depends on the forage species and desired nutrient composition. Harvesting too early can result in low yields and insufficient drying, while harvesting too late can result in nutrient loss and reduced forage quality due to increased lignification.

Moisture Content: Proper moisture content is crucial for hay quality. Hay should be dried to a moisture level that prevents mold, yeast, and bacterial growth but doesn't lead to excessive nutrient loss. For small square bales, the recommended moisture content is around 15-20%, while for large round bales, it is around 12-18%.

Drying Conditions: Adequate drying conditions are necessary to prevent hay spoilage. Factors such as weather (temperature, humidity, and rainfall), air circulation, and field conditions can impact drying rates. Properly timed cutting, conditioning (crushing or crimping stems), and tedding (flipping the forage) can help speed up drying.

Leaf-to-stem Ratio: Leaves generally contain higher nutrient content compared to stems. Preserving a higher leaf-to-stem ratio during harvest and drying processes contributes to improved hay quality. Minimizing leaf shattering during cutting, handling, and raking is essential.

Weed and Contaminant Control: Weeds and contaminants in the hay can reduce its quality. Controlling weeds in the field and avoiding contamination during harvest, baling, and storage is important. This includes minimizing soil, dust, foreign materials, and toxic plants in the hay.

Nutrient Loss during Storage: Proper storage is crucial to preserve hay quality. Exposure to moisture, sunlight, and air can lead to nutrient loss and mold development. Bales should be stored in a dry, well-ventilated area, protected from rain, and stacked properly to prevent spoilage.

Baling Density: Proper baling density helps reduce air penetration and preserves hay quality. Dense bales have reduced air circulation, which minimizes the risk of mold growth and maintains nutritive value.

Nutrient Composition: The nutrient composition of hay depends on factors such as the forage species, soil fertility, fertilization practices, and environmental conditions. Balanced soil fertility and appropriate fertilization can contribute to higher-quality hay with improved nutrient content.

Storage Duration: Hay quality can decline over time. Extended storage periods can result in nutrient degradation, color changes, and potential mold growth. Proper inventory management and rotation of older hay can help maintain overall quality.

It's important to note that different livestock have varying nutritional requirements, so hay quality should align with the specific needs of the animals being fed. Regular hay testing can provide valuable insights into the nutrient content and guide appropriate supplementation if necessary.

Silage making

Silage making is a process of preserving forage crops, such as grasses or corn, under anaerobic conditions to create a fermented feed known as silage. Silage is a valuable feed source for

livestock, particularly during periods of limited forage availability or when the nutritional quality of fresh forage is low.

Here are the key steps involved in silage making:

i. **Crop Selection and Harvest:** The forage crop selected for silage making should be at the appropriate stage of growth when it has the desired moisture and nutrient content. Common forage crops used for silage include grasses (such as ryegrass, Timothy grass) and corn.
ii. **Crop Preparation:** The forage crop is typically chopped into small pieces using a forage harvester or chopper. Chopping increases the surface area of the crop, facilitating better compaction and fermentation.
iii. **Packing:** The chopped forage is packed tightly into a storage structure, such as a silo or bunker. Adequate packing is crucial to remove excess air and create an anaerobic (oxygen-free) environment, which promotes fermentation.
iv. **Sealing:** Once the forage is packed, the storage structure is sealed to prevent the entry of oxygen. This can be done using plastic sheeting, oxygen barrier films, or tires. A proper seal helps maintain anaerobic conditions for fermentation.
v. **Fermentation:** Fermentation is a natural process that occurs in the absence of oxygen. Lactic acid bacteria, naturally present on the forage and introduced during packing, convert sugars in the forage into lactic acid. The lactic acid lowers the pH of the silage, preserving the nutrients and inhibiting the growth of spoilage-causing bacteria.
vi. **Fermentation Period:** The fermentation process typically takes a few weeks to complete. During this time, the silage undergoes a transition from aerobic (initial stage) to anaerobic conditions as the oxygen is consumed. The temperature of the silage may rise initially but should stabilize as fermentation progresses.
vii. **Feedout:** Once the fermentation period is complete, the silage is ready for feeding. During feedout, the silage is removed from the storage structure as needed. It's important to maintain a smooth, compact face on the silage surface to minimize exposure to air and prevent spoilage. Covering the exposed surface with plastic can help preserve the quality of the remaining silage.

Silage making provides several benefits, including the preservation of nutrients, increased palatability, reduced losses due to weathering, and the ability to store forage for extended periods.

Proper management throughout the silage-making process, from crop selection to feedout, is crucial to produce high-quality silage that meets the nutritional needs of livestock.

Methods of silage making

There are several methods of silage making, each suited to different circumstances and available resources.

Here are some common methods:

Bunker Silo: In this method, the forage is packed and stored in a bunker or trench silo. The bunker is typically constructed with concrete walls and a plastic or rubber lining to prevent seepage. The forage is chopped, packed tightly into the bunker, and then covered with plastic sheeting and weighted down to create an airtight seal.

Tower Silo: Tower silos are tall, cylindrical structures made of concrete or steel. Chopped forage is blown or conveyed up into the silo using a blower or conveyor system. The forage is packed to remove air pockets and then covered with plastic and airtight caps to seal the silo.

Bag Silo: Bag silage involves packing chopped forage into long plastic bags made of specialized silage film. The forage is packed tightly into the bag, and the bag is sealed at both ends to create an airtight environment. The bag is then rolled up and tied off. Bag silos can be a flexible and cost-effective option for small-scale operations or temporary storage needs.

Pit silo: A pit is an excavated storage space in the ground used for storing silage or other agricultural materials. It is a rectangular or trapezoidal-shaped structure created by digging into the soil. The pit provides a large capacity for storing chopped forage and is often used in larger-scale operations. Pit silos offer advantages such as lower construction costs compared to tower silos, flexibility in size and shape, and the ability to accommodate large-scale operations. However, they require careful management to ensure proper packing and sealing to achieve optimal fermentation and minimize spoilage.

Factors affecting the quality of silage

Several factors can significantly influence the quality of silage. These include:

Moisture Content

The moisture content of the forage at the time of ensiling is crucial. Forage that is too dry may not ferment properly, leading to reduced nutrient preservation and increased spoilage. Conversely, forage that is too wet can lead to excessive seepage, nutrient losses, and the risk of undesirable

fermentation. The ideal moisture content varies depending on the type of forage but generally falls between 60% and 70%.

Chop Length

The length at which the forage is chopped affects packing density and fermentation. An optimal chop length promotes better compaction, reduces oxygen penetration, and enhances fermentation. The appropriate chop length varies based on the forage type and the desired particle size for effective packing.

Packing Density

Achieving a high packing density is essential for minimizing oxygen presence and ensuring a successful fermentation process. Proper packing removes air pockets and creates an anaerobic environment. Insufficient packing density can result in increased air infiltration, leading to mold growth and nutrient losses.

Fermentation and pH

Fermentation is a critical process in silage making. Lactic acid bacteria naturally present on the forage convert sugars into lactic acid, lowering the pH and preserving the forage. The pH of well-fermented silage typically ranges between 3.8 and 4.5. Proper fermentation inhibits the growth of spoilage-causing bacteria and molds, preserving the nutritional value of the silage.

Oxygen Exclusion

The exclusion of oxygen is vital to create an anaerobic environment for fermentation. Effective sealing and covering of the silage storage structure, such as using plastic sheeting or oxygen barrier films, are essential to prevent air infiltration during storage and feedout.

Silage Additives

Additives can be used to enhance the fermentation process and improve silage quality. These additives may include inoculants containing specific strains of lactic acid bacteria or enzymes that aid in the breakdown of complex carbohydrates. The selection and use of additives should be based on specific forage characteristics and objectives.

Temperature and Moisture Management

Proper temperature and moisture management during the fermentation and storage period are critical. Temperature fluctuations and excessive moisture can promote undesirable microbial

activity and spoilage. Adequate ventilation and drainage in storage structures are important to prevent moisture buildup and maintain optimal conditions.

Harvest Timing

Harvesting the forage at the appropriate stage of maturity is crucial. Timing affects nutrient content, dry matter yield, and digestibility. Harvesting too early or too late can result in suboptimal nutrient composition and reduced silage quality.

Forage Type

Different forage types have varying characteristics that can impact silage quality. Factors such as fiber content, sugar content, and buffering capacity can influence fermentation and nutrient preservation. Proper management practices should be tailored to the specific forage being ensiled. By considering and managing these factors effectively, farmers can improve the quality and nutritional value of their silage, ensuring optimal feed for livestock.

4.3. Selecting a system of livestock feeding options

Livestock feeding systems refer to different approaches or strategies for providing nutrition to animals. Here are some common livestock feeding options:

- **Grazing Systems**

Continuous Grazing: Animals have continuous access to pasture or forage throughout the grazing season. It requires careful monitoring to prevent overgrazing and optimize forage utilization.

Rotational Grazing: The pasture is divided into smaller paddocks or grazing areas, and animals are rotated between them periodically. This allows for better forage management, promotes regrowth, and prevents overgrazing.

- **Confinement Feeding Systems**
  - ✓ Total Mixed Ration (TMR): A balanced diet is formulated by combining various feed ingredients, including forages, concentrates, grains, protein sources, and minerals, into a complete ration. The TMR is then fed to animals in a confined setting, such as a barn or feedlot.
  - ✓ Silage Feeding: Forages, such as corn or grass, are harvested and preserved as silage through a fermentation process. Silage is then used as a feed source, either as a component of a TMR or fed separately.

- **Drylot Feeding**: Animals are kept in a confined drylot area and fed a combination of hay, concentrates, and other feedstuffs. This system is commonly used for beef cattle or sheep during certain periods, such as winter or when pasture availability is limited.
- **Partial Confinement Systems**
  - ✓ Pasture-Based Systems: Animals have access to pasture for grazing, but may also receive supplementary feed, such as concentrates or hay, to meet their nutritional requirements. This approach combines the benefits of grazing with controlled supplementation.
  - ✓ Creep Feeding: In this system, young animals, such as calves or lambs, are allowed access to a specific feeding area with concentrated feed while still having access to pasture or forage. This helps supplement their nutritional needs and supports growth.
- **Intensive Systems**
  - ✓ Feedlot Systems: Livestock, typically beef cattle, are confined to a feedlot and fed a high-energy diet consisting of concentrates, grains, and roughage. This system is commonly used for finishing animals for meat production.
  - ✓ Dairy Feeding Systems: Dairy cows are typically housed in barns and fed a combination of forages, concentrates, and minerals to meet their specific nutritional requirements for milk production.
- **Dual-Purpose Systems**
  - ✓ Dual-purpose systems involve using livestock for both milk and meat production. These systems often incorporate a combination of grazing and confinement feeding, depending on the specific needs of the animal and the production goals.

The selection of a feeding system depends on factors such as the type of livestock, available resources (pasture, forage, concentrates), production goals, and management capabilities. It's important to consider the nutritional requirements of the animals, the cost-effectiveness of the chosen system, and the environmental sustainability of the approach.

4.4. Preparing feed budget according to the selected system of feeding

Feed budgeting is an important tool to help determine potential pasture deficits or surpluses and assist in matching feed supply and demand.

Feed budgeting allows for better and more timely decisions, such as determining the number of stock you can carry, and for how long, and the likely animal performance for different classes of stock.

They can be prepared a day, a week or several months ahead and separate budgets can be prepared for different mobs or areas of the farm and can help support grazing decisions to alleviate the potential for environmental damage, such as the risk of erosion or plugging.

How to do a budget?

Step 1: Measure the feed on the farm

Walk the entire farm and estimate the DM on each ha. Use a pasture meter or learn to estimate it by eye from other farmers or at discussion groups. Any dairy farmer will show you. You will need an accurate farm map with the area of each paddock on it. Make copies and take this map around the farm with you to write on. Laminate a copy so you can write on it and wipe it clean again.

Calculate how much DM is stored as hay. You can easily weigh small hay bales or you can accept the description of big bales of hay e.g. 12 bale equivalents. It's better to get them weighed somewhere if you can. For silage stacks calculate the volume (volume = length x width x height) and use the density figures in the Table below to get a weight. Note they are very general values so use scales to weigh a bale where possible. With crops it's more difficult and you'll have to weigh a few random square metre sample areas of crop, then get the DM from a sub sample and then calculate DM per hectare.

Now comes a tricky bit. You'll have to estimate how much feed will grow over the coming period of the budget and include this. You can use average figures for the district or your own values collected over time. Table 19 below shows pasture growth for the Ruakura Research Centre in the North Island of New Zealand where it has been measured for over 40 years. It grows about 15 tonnes of DM/year.

Step 2: Estimate the stock's feeding needs

Calculate the DM feed needs for every animal on the farm. Typical figures that you'll need are shown in tables 5 and 6. You'll need to add to this what is called "feed carried forward". This is

feed you need at the end of the budget period as it's no good getting to the end of the period and have eaten all the feed on the farm. It's "carry-over" feed and plan to have at least 1950 kg DM/ha for this.

Does it balance?

Now you'll be able to see from the difference between Step 1 and 2 if things balance or you may find you have a feed deficit or a feed surplus. Here are some suggestions on how to manage each:

a). Managing a feed deficit

With a deficit, there are three things you can do –

Remember you have to consider the farm, your management and work load, and your bank manager: Bank managers don't like surprises! Consider these:

Reduce feed demand

- Sell all culls and surplus stock.
- Draft stock on the basis of their condition score and give the low CS animals the best feed.
- Dry off some or all lactating cows, and wean calves from suckling cows.

Increase feed supply

Apply some nitrogen fertilizer if the 10cm ground temperature is above 6°C and the soil is moist. This should boost feed, provided all other soil nutrients are at adequate levels.

- Buy in some supplements such as hay, silage, surplus crops or concentrate meal.
- Graze animals off the farm. Check the Tb status of the farm they are going to before you move them.
- Slow down the rotation to give the pastures time to grow. But you will have to feed supplements during this time to make up the difference.

Reduce production targets

- Delay the date of making silage.
- If you have paddocks closed for silage or hay, open the gates and feed your stock.

b). Managing a feed surplus

If you have a feed surplus, first check that you have you done the sums correctly? Is the surplus real or a misplaced decimal point? Don't tell anyone till you have double-checked the figures.

- If it's a true surplus, then rejoice and enjoy the peace of mind.

- But then start to worry about it going to waste.
- Feed your stock more and let them convert it into body condition, and enjoy looking at them!
- Sell some surplus as silage or hay.
- Take on grazing stock from farmers who are overstocked.
- Delay weaning calves off cows.
- Buy in some stock as grazers.

4.5. Feed plan data documentation

To ensure continual assessment and effective management planning in a feed plan, it is crucial to document relevant data. Here are some key data points that should be documented:

a) Livestock Information:
- Livestock species, breed, and production stage (e.g., growing, lactating, maintenance)
- Number of animals and their individual identification, if applicable
- Body weight or body condition score (BCS) of the animals at the beginning and throughout the feeding program
- Health status and any specific health considerations

b) Feed Ingredients and Nutritional Composition:
- List of feed ingredients used in the supplementary feeding program
- Nutrient composition of the feed ingredients, including energy, protein, minerals, and vitamins
- Quantity of each feed ingredient used in the feed formulation

c) Feeding Protocols:
- Detailed feeding protocols outlining the timing, frequency, and quantity of supplementary feeds provided
- Feeding methods and equipment used (e.g., troughs, self-feeders)
- Feed conversion efficiency data (if available) to assess the effectiveness of the feeding program

d) Feed Quantity and Inventory:
- Quantity of supplementary feeds provided to the livestock on a daily, weekly, or monthly basis

- Feed inventory records, including the amount of feed on hand and any changes in inventory over time

e) Livestock Performance Data:
- Growth rates (if applicable) or weight gain data during the feeding program
- Milk production data (if applicable)
- Body condition score (BCS) changes or other indicators of animal condition

f) Health and Veterinary Records:
- Any health issues or observations related to the animals during the feeding program
- Veterinary visits, treatments, and medications administered

g) Cost and Economic Analysis:
- Cost of feed ingredients and any associated expenses (e.g., labor, equipment)
- Economic analysis, including cost-benefit assessments and return on investment (ROI) calculations

h) Observations and Notes:
- General observations about feed intake, animal behavior, or any other relevant factors
- Any adjustments made to the feeding program based on ongoing assessments and observations
- Notes on the performance and outcomes of the feeding program

Self-Check 4.	Written Test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer (4 points)

1. What factors should be considered when determining the proportion of different feed components in livestock production systems?
   a) Availability of feeds and their nutritional value
   b) Nutrient requirements and targeted product
   c) Price of the feed if purchased
   d) Ease of production, productivity, and quality
   e) All of the above
2. In livestock systems based entirely on grazing, what is one of the challenges faced by farmers in estimating the amount of feed consumed by the animals?
   a) Difficulty in estimating the quantity of communal grazing areas
   b) Lack of knowledge about animal nutrition requirements
   c) Limited availability of grazing lands
   d) Inability to monitor animal feeding behavior
3. Which factor is crucial for achieving a successful fermentation process in silage making?
   a) Moisture Content
   b) Chop Length
   c) Packing Density
   d) Fermentation and pH
4. What is the purpose of feed budgeting?
   a) To determine the number of stocks you can carry on the farm
   b) To estimate the growth of feed over a specific period
   c) To match feed supply and demand
   d) All of the above

Test 2: Indicate each step clearly

You are managing a herd of 50 beef cattle with an average weight of 1,200 pounds (544 kg) each. The animals require a daily dry matter intake of 2.5% of their body weight. The available pasture provides an average forage yield of 1,214 kilograms per hectare. The forage has an estimated dry matter content of 85%.

Calculate the number of hectares needed to meet the daily forage requirements of the herd. (5pts).

Note: Satisfactory rating - 9 points **Unsatisfactory - below 9 points**

You can ask you teacher for the copy of the correct answers.

Operation Sheet -4

4.1. Developing feeding plan for livestock

A. Materials tools and equipment

- Nutrient requirements tables, for instance NRC publications
- Feed composition tables
- Current market prices for different feed resources
- Farm records (the information about animals including body weight)

B. Procedure

a) Assess the nutritional requirements of your livestock
b) Determine the expected feed intake of your livestock
c) Identify the feed resources available
d) Assess the quality and nutrient composition of each feed resource.
e) Calculate the quantity of feed required for each nutrient category
f) Determine the total amount of feed required per day, week, or month
g) Evaluate the existing feed inventory on your farm
h) Determine the quantity and nutrient content of the feed inventory through physical inventory or laboratory analysis.
i) Calculate the potential feed supply available from the inventory and compare it with the estimated feed requirements.

j) If the existing feed inventory is insufficient to meet the animals' nutritional needs, estimate the quantity of feed that needs to be purchased.
k) Keep accurate records of feed purchases, feed usage, and associated costs to facilitate future budgeting and analysis.

LAP TEST-4	

Name…… ID…… Date……

Time started: _____ Time finished: _____

Feel free to consult reliable sources, nutrient composition tables, and local market prices to gather the necessary information for your feed plan. You are required to perform the tasks within 24 hours. Each student is expected to complete the project.

Task: Develop feeding plan for 5 fattening oxen for 4 months.

LG #5	LO #5- Apply ration formulation techniques

Instruction sheet

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

- Calibrating scales and containers used for measurements
- Identifying ingredients from instructions and obtaining from storage locations
- Measuring ingredients in the specified ratios and quantities.
- Blending ingredients adequately and hygienically
- Conducting Milling of ingredients (for feeds that need milling)
- Identifying methods of ration balancing

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 –

- Calibrate scales and containers used for measurements
- Identify ingredients from instructions and obtaining from storage locations
- Measure ingredients in the specified ratios and quantities.
- Blend ingredients adequately and hygienically
- Conduct milling of ingredients (for feeds that need milling)
- Identify methods of ration balancing

Learning Instructions:

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

Information Sheet. 5

5.1. Calibrating scales and containers used for measurements

Calibrating scales and containers used for feed ingredient measurements is crucial to ensure accurate and consistent ration formulation. Here are some steps you can follow to calibrate your scales and containers

Check Accuracy

Start by verifying the accuracy of your scale. Use calibrated weights or known standard weights to compare the readings on the scale. Ensure that it is properly calibrated and provides accurate measurements. If the scale is not accurate, consult the manufacturer's instructions for recalibration or contact a professional technician.

Tare Weight

Before measuring ingredients, make sure to tare the scale or container. Taring means setting the scale or container to zero to account for the weight of the container itself. This ensures that you are measuring only the weight of the feed ingredient, not the container.

Use Standardized Containers

Use standardized containers for measuring feed ingredients. These containers should have known and consistent volumes to ensure accurate measurements. Avoid using containers with irregular shapes or sizes that can affect the volume measurements.

Measure by Weight or Volume

Depending on the ingredient and the formulation requirements, you may need to measure by weight or volume. Some ingredients, such as grains or pellets, are typically measured by weight, while others, like chopped forages or liquids, may be measured by volume. Ensure that you are using the appropriate unit of measurement and that it is consistent throughout the formulation process.

Conduct Regular Checks

Regularly check the accuracy of your scales and containers to ensure they remain calibrated. Perform periodic calibration checks to confirm that the measurements are still accurate. Additionally, monitor the condition of the containers to ensure they are clean and free from residue that could affect the measurements.

Document and Record

Keep a record of the calibration process and any adjustments made. Document the date of calibration, the person responsible, and any notes or observations relevant to the calibration process. This documentation will serve as a reference for future use and can help identify any issues or discrepancies that may arise.

By following these steps and maintaining regular calibration checks, you can ensure accurate and consistent measurements for feed ingredient quantities during ration formulation. This accuracy is essential for formulating balanced rations and optimizing the nutritional content of the feed for your livestock.

5.2. Identifying ingredients from instructions and obtaining from storage locations

When formulating rations for livestock, it's important to accurately identify feed ingredients from the instructions and obtain them from storage locations. Here's a step-by-step guide to help you with this process:

Review Ration Formulation Instructions

Carefully read the ration formulation instructions or recipe provided. Take note of the specific feed ingredients required, their quantities, and any special instructions or considerations.

Create a Checklist

Create a checklist or a list of the feed ingredients needed for the ration formulation. This will help you stay organized and ensure that you gather all the necessary ingredients.

Identify Storage Locations:

Identify the storage locations where the feed ingredients are kept. This could include feed rooms, silos, bins, or other designated areas.

Gather Necessary Equipment:

Before starting the process, ensure you have the required equipment such as containers, scoops, or buckets to collect and transport the feed ingredients.

Follow Safety Protocols

Adhere to proper safety protocols when handling feed ingredients. Use appropriate personal protective equipment (PPE) such as gloves, masks, and goggles if necessary.

Locate and Collect Feed Ingredients:

Visit the identified storage locations and locate the feed ingredients according to the checklist. Pay attention to labels, tags, or markings on containers to ensure you are collecting the correct ingredients.

Verify Ingredient Quality:

Inspect the feed ingredients for any signs of spoilage, mold, infestation, or other quality issues. Exclude any ingredients that appear compromised or unfit for use.

Measure and Record Quantities:

Use calibrated scales or measuring devices to accurately measure the required quantities of each feed ingredient. Tare the scales or containers before measuring to account for the weight of the container itself.

Transfer Ingredients to Designated Area:

Once measured, transfer the feed ingredients to a designated area, such as a mixing bin or container, where the ration formulation will take place. Keep different ingredients separate until all the required ingredients have been gathered.

Double-Check and Reconcile:

Double-check the gathered ingredients against your checklist to ensure that all the required feed ingredients have been obtained. Verify that the quantities match the formulation instructions.

Store Unused Ingredients:

Properly seal and store any unused feed ingredients according to their specific storage requirements. This helps maintain their quality and prevents contamination.

Clean and Organize:

Clean up the work area, removing any spills or debris. Return equipment to their designated storage areas and organize the remaining feed ingredients for future use.

By following these steps, you can accurately identify feed ingredients from the instructions and obtain them from storage locations for ration formulation. This ensures that you have the necessary ingredients to formulate a balanced and nutritious ration for your livestock.

5.3. Measuring ingredients in the specified ratios and quantities.

Measuring feed ingredients accurately is crucial for precise ration formulation. Here are the general steps to follow when measuring feed ingredients:

Gather the necessary equipment: Collect the appropriate measuring tools such as scales, measuring cups, scoops, or volumetric containers. Ensure that these tools are clean and calibrated for accurate measurements.

Determine the unit of measurement: Identify whether the ingredients need to be measured by weight (e.g., kilograms, pounds) or volume (e.g., liters, gallons) based on the formulation requirements or the specific ingredient being measured.

Tare the scale or container: If using a scale or container, set it to zero to account for the weight of the container itself. This ensures that you are measuring only the weight of the feed ingredient, not the container.

Use standardized containers: Utilize containers with known and consistent volumes for measuring feed ingredients. Avoid using containers with irregular shapes or sizes that can affect the volume measurements.

Measure the ingredients: Carefully measure the required quantity of each feed ingredient according to the formulation instructions or recipe. Pour or scoop the ingredient into the measuring device, ensuring that it is level and not compacted or overflowing.

Record the measurements: Keep track of the measurements for each ingredient, either manually or using digital tools. This record will be useful for documentation, future reference, and potential adjustments to the ration formulation.

Double-check measurements: Verify the accuracy of your measurements by cross-checking against the formulation instructions or recipe. Ensure that you have measured the correct quantities for each ingredient. Transfer the measured ingredients: Once measured, transfer the feed ingredients to the designated mixing or storage area. Keep different ingredients separate until all the required ingredients have been measured.

Clean and maintain equipment: After measuring the ingredients, clean the measuring tools and containers to prevent cross-contamination. Store them appropriately for future use.

Conduct regular checks: Periodically check the accuracy of your measuring equipment to ensure they remain calibrated. Perform calibration checks and maintenance as recommended by the manufacturer.

By following these steps, you can ensure accurate measurements of feed ingredients for ration formulation, allowing for precise formulation of balanced and nutritious rations for livestock.

5.4. Blending ingredients adequately and hygienically

Blending ingredients adequately and hygienically during ration formulation is essential to ensure uniform distribution of nutrients and maintain feed quality. Here are some steps to follow when blending ingredients:

Prepare the blending equipment: Ensure that the blending equipment, such as a mixer or blender, is clean and free from any residue or contaminants. Follow the manufacturer's instructions for preparing the equipment before use.

Calculate the batch size: Determine the desired batch size based on the number of animals or the amount of feed required. This will help you determine the appropriate capacity of the blending equipment.

Add ingredients in the correct order: Start by adding the base or bulk ingredients to the blender. These are usually ingredients present in larger quantities. Gradually add the remaining ingredients while ensuring uniform distribution.

Blend ingredients thoroughly: Mix the ingredients in the blender for an adequate duration to ensure thorough blending. The duration may vary depending on the type and quantity of ingredients. Follow the recommended blending time provided by the manufacturer or consult a nutritionist for guidance.

Ensure even distribution: During blending, monitor the mixture to ensure that all ingredients are evenly distributed. Pay attention to any clumps or areas where ingredients may not be thoroughly mixed. Use appropriate blending techniques, such as adjusting the speed or direction of the blender, if necessary.

Maintain hygiene: Maintain a clean and hygienic environment throughout the blending process. Avoid cross-contamination by cleaning the equipment between batches or when switching between different types of feed. Follow good hygiene practices, such as wearing gloves and using clean utensils.

Check for consistency: Once the blending process is complete, visually inspect the mixture for consistency. Ensure that there are no visible clumps or segregation of ingredients. If inconsistencies are observed, mix the blend for longer or adjust the blending technique as needed.
Collect a representative sample: Collect a representative sample of the blended mixture for analysis or quality control purposes. This sample can be used to assess nutrient composition, particle size, or any other relevant parameters.
Store the blended feed properly: Transfer the blended feed to appropriate storage containers or bags that are clean, airtight, and labeled. Store the feed in a suitable location that is protected from moisture, pests, and other factors that may compromise its quality.
Clean and maintain the equipment: After blending, clean the blending equipment thoroughly to remove any residual feed particles. Regularly inspect and maintain the equipment as per the manufacturer's recommendations to ensure its optimal performance.
By following these steps, you can effectively blend feed ingredients to achieve a homogeneous and high-quality ration for livestock.

5.6. Conducting Milling of ingredients (for feeds that need milling)

Conducting milling of feed ingredients is necessary for certain feeds that require particle size reduction or processing. Here are some steps to follow when milling feed ingredients for ration formulation:
Identify the ingredients requiring milling: Determine which feed ingredients in your formulation require milling. Some ingredients, such as grains, seeds, or fibrous materials, may need to be processed to achieve a desired particle size or improve digestibility.
Select the appropriate milling equipment: Choose the milling equipment suitable for the specific ingredients and desired particle size. Common types of milling equipment include hammer mills, roller mills, and grinders. Consider factors such as the ingredient characteristics, production capacity, and available resources when selecting the equipment.

Clean the milling equipment: Before starting the milling process, ensure that the milling equipment is clean and free from any residue or contaminants. Clean and inspect the equipment according to the manufacturer's guidelines to maintain hygiene and prevent cross-contamination.

Adjust the milling settings: Set the milling equipment to the appropriate settings based on the desired particle size. The specific settings may vary depending on the equipment used and the target particle size. Consult the equipment manufacturer's guidelines or seek advice from a milling expert for proper adjustment.

Load the ingredients into the mill: Carefully load the feed ingredients into the milling equipment. Follow the recommended capacity and avoid overloading the mill, as it may affect the milling efficiency and result in uneven particle size.

Mill the ingredients: Start the milling equipment and allow it to process the ingredients. Monitor the milling process to ensure consistent and uniform particle size reduction. Adjust the milling settings if necessary to achieve the desired particle size distribution.

Collect representative samples: As the ingredients are being milled, periodically collect samples from the output to assess the particle size distribution. These samples can be used for quality control purposes or to make adjustments to the milling process if needed.

Clean the milling equipment: Once the milling process is complete, clean the milling equipment thoroughly to remove any leftover feed particles. Pay attention to areas that may be difficult to clean, such as crevices or screens, to prevent contamination in subsequent milling operations.

Store the milled ingredients properly: Transfer the milled feed ingredients to appropriate storage containers or bags that are clean, airtight, and labeled. Store them in suitable conditions to maintain their quality until they are used in the ration formulation.

Maintain the milling equipment: Regularly inspect and maintain the milling equipment according to the manufacturer's recommendations. This includes lubrication, replacing worn parts, and addressing any mechanical issues to ensure optimal performance.

Types of millers

Hammer milling and roller milling are two common methods used in the processing of feed ingredients in the animal feed industry. Both methods have their advantages and disadvantages, and the choice between them depends on various factors such as the type of feed ingredient, desired particle size, and specific requirements of the feed formulation.

a) Hammer milling:

Hammer milling involves the use of a series of hammers rotating at high speed inside a grinding chamber. The feed ingredient is fed into the mill and repeatedly struck by the hammers, which break it down into smaller particles. The size of the final particles is determined by the size of the perforations in the screen covering the mill's discharge opening.

Table 15: Recommended screen size for milling for different types of livestock

Livestock type	Screen size (mm)
Cattle	6.5–12.5
sheep	3.0–12.5
Finishing pigs	2.5–4.0
Young pigs	1.5–3.0
Poultry	2.0–4.0

- **Advantages of hammer milling:**

Versatility: Hammer mills can handle a wide range of feed ingredients, including grains, oilseeds, and fibrous materials.

Efficiency: They are generally more energy-efficient than roller mills.

Flexibility: The particle size can be easily adjusted by changing the screen size or hammer configuration.

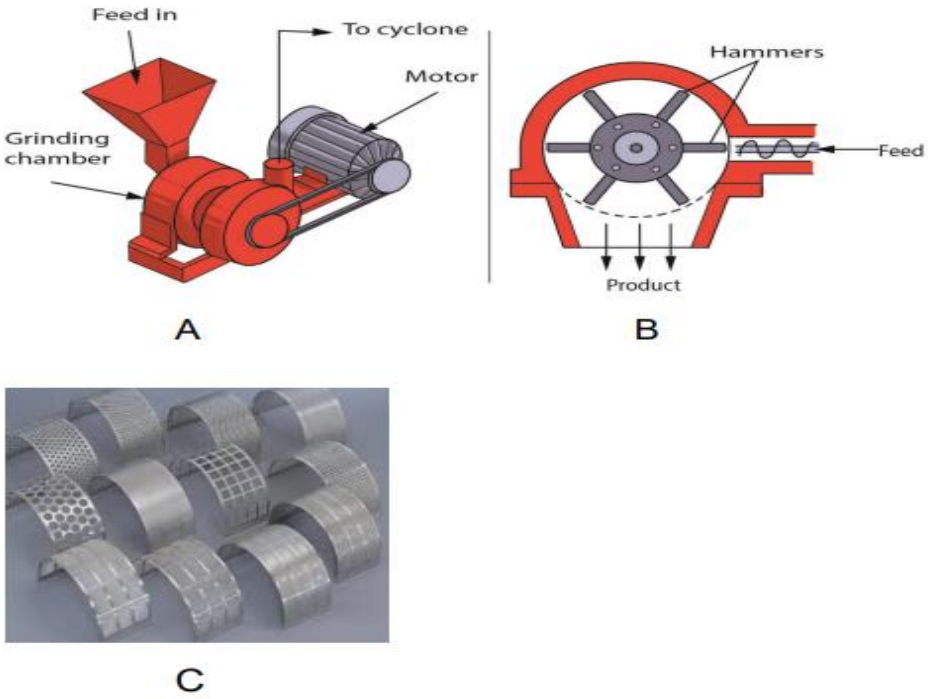
Cost-effective: Hammer mills are often less expensive to purchase and maintain compared to roller mills.

- **Disadvantages of hammer milling:**

Particle size distribution: The resulting particle size distribution may be wider compared to roller milling, with a larger proportion of fines.

Dust generation: Hammer milling can produce a significant amount of dust, which requires proper dust control measures.

Potential for heat damage: The high-speed impact of hammers on the feed ingredients can generate heat, which may affect the nutritional quality of heat-sensitive materials.



A: complete hammer mill and motor, B: section showing the hammers and grinding chamber, C: different sizes of sieves

Figure 12: Different parts of hammer mill.

b) Roller milling:

Roller milling involves the passage of feed ingredients between two or more rollers that rotate in opposite directions. The gap between the rollers determines the size of the particles produced. Roller mills typically consist of corrugated rollers that exert shearing and compressive forces on the feed material.

- **Advantages of roller milling:**

Particle size control: Roller mills generally provide better control over particle size distribution, resulting in more uniform and consistent particle sizes.

Reduced dust generation: Roller milling tends to generate less dust compared to hammer milling.

Enhanced digestibility: Roller milling can improve the digestibility of certain feed ingredients, especially grains, by breaking down the tough outer seed coat.

- **Disadvantages of roller milling:**

Limited versatility: Roller mills are best suited for grinding grains and certain fibrous materials, but they may not be as effective for processing oilseeds or other feed ingredients.

Higher initial cost: Roller mills are often more expensive to purchase and maintain compared to hammer mills.

Higher energy consumption: Roller mills generally require more energy to operate compared to hammer mills.

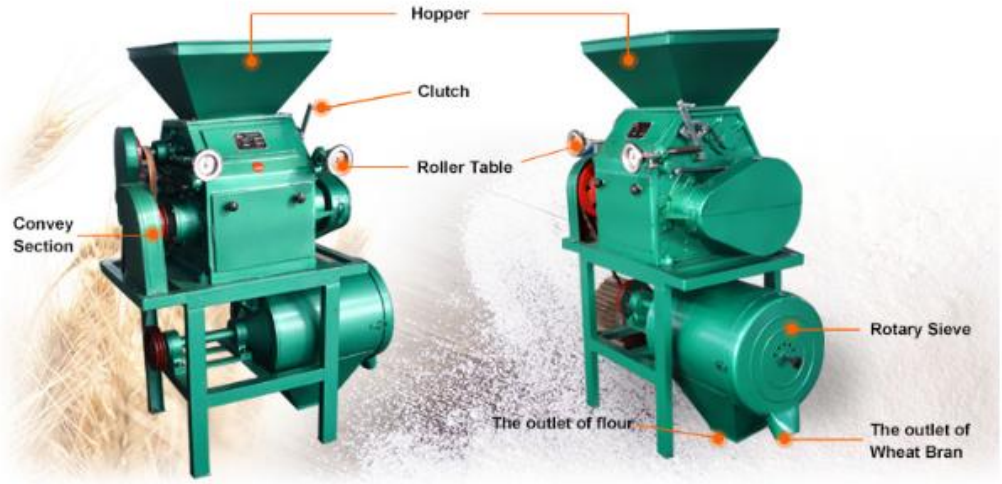


Figure 13: Roller miller :

In summary, hammer milling and roller milling are both widely used methods in feed ingredient processing. Hammer mills offer versatility and cost-effectiveness, while roller mills provide better particle size control and reduced dust generation. The choice between the two methods depends on the specific requirements of the feed formulation and the characteristics of the feed ingredients being processed.

5.7. Identifying methods of ration balancing

There are several methods commonly used for ration balancing in animal nutrition. Here are some of the most widely employed methods:

Pearson Square Method

The Pearson Square is a simple graphical method used to balance rations for two ingredients. It involves creating a square or rectangle and using ratios to determine the proportion of each

ingredient needed to meet the desired nutrient levels. This method is useful for small-scale or on-farm ration balancing.

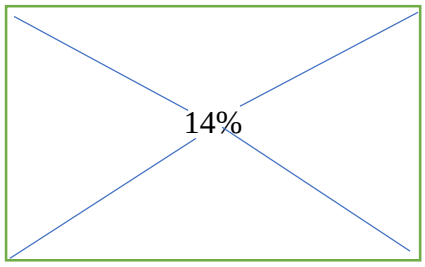
Example:

Let's say we want to formulate a ration for cow that meets a target crude protein level of 14% using two feed ingredients: soybean meal (with 50% crude protein) and corn (with 8% crude protein).

Step 1: Determine the desired protein level: Target crude protein: 14%

Step 2: Set up the Pearson's Square:

Corn (8% CP)



Soybean Meal (50% CP)

Step 3: Calculate the difference:

Subtract across the diagonal:

a. 50% - 14% = 36parts of corn
b. 14% - 8% = 6 parts of Soybean Meal

Step 4: Sum the parts:

6 parts soybean meal + 36 parts corn = 42 total parts

Step 6: Divide each part by the total to calculate the percent of each feed to include:

a. 6 parts soybean meal ÷ 42 total parts = 0.143 * 100 = 14.3% soybean meal
b. 36 parts corn ÷ 42 total parts = 0.857 * 100 = 85.7% soybean meal

So, in a 500kg batch of this corn and soybean meal mix, 71.5kg of soybean meal and 428.5kg of corn are needed to achieve 14% CP in the mix.

Math check for the example above:

71.5kg soybean meal * 50% CP = 35.75kg CP

428.5kg corn * 8% CP = 34.28kg CP

Cow’s requirement = 500kg * 14% CP = 70kg CP

Check: 35.75kg CP + 34.28kg CP = 70.03kg CP

Algebraic equations

Algebraic equations may be generated for nutrient concentration and their solutions used in finding proportions of mixing the feedstuffs into a diet. Two feedstuffs, maize (10% CP) and soya meal (50% CP), are combined to make a mix for starter pigs at 20% CP.

Two equations can be developed.

Let the amount of maize be X and the amount of soya meal be Y

In making 100 kg (or a 100% mixture), X kg of maize and Y kg of soya are to be used.

Therefore:

$X + Y = 100$

The concentrations of protein being as above, to make a diet that is 20% (or 20 kg of protein in 100 kg of mixture) a second equation can be generated, reflecting the ingredients' CP content:

$0.1X + 0.5Y = 20$

The set of simultaneous equation is therefore:

i.) $X + Y = 100$ (the total amount of mixture)

ii.) $0.1X + 0.5Y = 20$ (the total amount of CP)

iii.) $X + 5Y = 200$ which is (ii x 10)

$4Y=100$ (iii-i)

$Y=25$ and $X=75$

The unique solutions are $X=75$ and $Y= 25$.

Trial and error method

This method involves continuously adjusting the ratios of ingredients until the right mix of ingredients that meets the standards is achieved. It is best achieved using computer-based software (e.g. Excel spreadsheets) where the ratios of the ingredients are continuously adjusted based on the outcome of the previous ratio to achieve the final objective(https://www.youtube.com/watch?v=THupzYyKAsU)

Table 16: : Example of trial error calculations made using a spreadsheet for layer feed

Ingredient	Ingredient contribution			Nutrient content of ingredients/feed			
	T1*	T2*	T3*	ME (Kcal/kg)	CP (%)	Ca (%)	Available P (%)
Maize grain, ground	40	55	62	3,300	10.0	0.03	0.15
Pollard	30	20	15	1,800	16	0.13	0.45
CSC	15	13	6	2,000	35	0.18	0.33
Fish meal	8	5	8	3,000	55	2.0	1.5
Limestone	5	6	7	0	0	33	0
Dicalcium phosphate(DCP)	2	1	2	0	0	23	18
Total	100	100	100				
T1*				2,400	18.45	2.348	0.7245
T2*				2,585	16	2.375	0.4704
T3*				2,676	15.1	2.978	0.6603
Requirement				2,750	16.0	3.0	0.45

In this example, the formulator through experience comes up with the first combination of ingredients (T1) for a layer ration and calculates the nutrient contribution of the formulation and compares with the requirement.

The calculation for the nutrient contribution for each of the materials is calculated as shown for ME and CP as an example:

ME per kg of feed= maize will contribute 40/100*3300, pollard=30/100*1800, CSC =15/100*2000, fish meal =8/100*3000= 2,400Kcal/kg feed (Note Limestone and DCP do not contribute to ME).

CP%= maize will contribute 40/100*10, pollard=30/100*16, CSC =15/100*35, fish meal =8/100*55= 18.45%CP.

From the shortcomings, the formulator, from knowledge of ingredients, subtracts amount of ingredient to reduce the nutrients in excess or adds to increase deficient nutrients

T1: represents a layer feed with excess protein and phosphorus but with low energy and calcium.

T2: maize is added to improve energy and the protein sources reduced. To improve Ca, limestone is increased.

Note that any increase of one ingredient must be accompanied by a decrease on another as the total is always 100.

T2 is an improvement of T1 and involves increasing the content of energy and calcium sources (i.e. maize and limestone). However, T2 is still low in energy and has been improved in T3. T3 does not exactly balance due to limitation of ingredients used. In the trial and error method, it is difficult to get an exact balance, but one should attempt to get as close as possible to the requirement.

Computer Software:

There are various computer-based ration balancing software programs available that can simplify the process of formulating rations. These software programs take into account the nutrient requirements, ingredient composition, and other factors to calculate the optimal quantities of each ingredient.

There are several popular computer software programs used for feed formulation in the animal feed industry. Here are a few examples:

- Feedwin
- WinFeed
- Brill Feed Formulation System

Linear Programming

Linear programming is an advanced mathematical technique used to optimize ration formulation. It considers multiple nutrient requirements, ingredient costs, ingredient availability, and other constraints to develop an optimal ration formulation. Linear programming models are often used in large-scale commercial feed mills.

Self-Check 5.	Written Test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer (3 point)

1. When identifying feed ingredients, it is important to:
   a) Review the ration formulation instructions
   b) Wear appropriate personal protective equipment (PPE)
   c) Measure the quantities accurately
   d) All of the above
2. What should you do if a feed ingredient appears compromised or unfit for use?
   a) Use it anyway, as it may still be acceptable
   b) Exclude it from the ration formulation process
   c) Mix it with other ingredients to dilute any potential issues
   d) Store it separately and report it to the supervisor
3. When transferring measured ingredients to a designated area for ration formulation, it is important to:
   a) Keep different ingredients separate until all ingredients have been gathered
   b) Mix all the ingredients together immediately
   c) Store the ingredients in open containers to allow for easier access
   d) Skip this step and directly proceed to blending the ingredients

Test II: Project work

Instructions: You are responsible for preparing a feed plan for a small-scale dairy farm. The farm has 2 dairy cows that are lactating and producing an average of 15 liters of milk per day, with a fat content of 3%. The body weight of each dairy cow is approximately 300kg. Additionally, there are 5 fattening sheep with a body weight of 40kg each and 4 fattening oxen with a body weight of 350kg each.

Your task is to develop a feed plan for these animals for a period of 6 months. Please consider the following assumptions:

Assumptions:

- The dairy cows will continue lactating at a similar production level throughout the 6-month period.
- The desired weight gain for the fattening sheep is 200 grams per day.
- The desired weight gain for the fattening oxen is 1 kilogram per day.
- The animals have access to good-quality pasture for grazing.

Based on these assumptions, calculate and determine the following:

- The daily nutritional requirements (energy, protein, minerals, and vitamins) for each animal category.
- The quantity and type of feed resources needed to meet the nutritional requirements of the animals.
- The estimated feed costs for the 6-month period, considering the current market prices for the required feed resources.

Please present your feed plan in a clear and organized manner, specifying the daily feed quantities and any necessary supplements or concentrates. Additionally, provide a breakdown of the estimated feed costs for the 6-month period. (15pts).

Note: Satisfactory rating - 15 points **Unsatisfactory - below 15 points**

You can ask you teacher for the copy of the correct answers.

Operation Sheet -5

5.1 Ration Formulation

A. Materials and Equipment

- Formulation instructions or recipe
- Ingredient inventory and labels
- Scales and measuring devices
- Blending equipment(machine)
- Milling equipment(machine).
- Containers and storage
- Personal protective equipment (PPE)
- Cleaning supplies
- Computer software
- Documentation tools
- Quality control equipment (moisture analyzers, sieves, or particle size analyzers)

B. Procedure for formulating ration

a) Wear PPE
b) Calibrate scales and containers accurately
c) Retrieve the required ingredients from the storage areas, ensuring that they are properly labeled and free from contamination.
d) Measure the ingredients one by one, ensuring that each measurement is precise and consistent.
e) Identify the ingredients that require milling based on the formulation requirements
f) Select the appropriate milling equipment suitable for the specific ingredients and desired particle size.
g) Clean the milling equipment before use and adjust the settings according to the desired particle size.
h) Load the ingredients into the mill and process them.
i) Monitor the milling process to achieve the desired particle size distribution.
j) Clean the milling equipment thoroughly after milling to prevent contamination.
k) Prepare the blending equipment, ensuring it is clean and free from any residue.

l) Add the ingredients in the correct order, starting with base or bulk ingredients and gradually adding the rest.
m) Blend the ingredients thoroughly
n) Monitor the blending process to ensure proper mixing and consistency.
o) Maintain a hygienic environment throughout the blending process by following good sanitation practices.
p) Choose storage containers that are clean, dry, and free from any residue or contaminants. Containers made of food-grade materials, such as plastic bins or metal bins with airtight lids, are commonly used for storing blended feed.
q) Clearly label each storage container with important information, including the feed type, date of blending, batch number (if applicable), and any specific instructions or precautions.
r) Seal the storage containers tightly to prevent moisture, air, pests, and other contaminants from entering.
s) Place the storage containers in a cool, dry, and well-ventilated area.

LAP test-5	

Name…… ID…… Date……

Time started: _____ Time finished: _____

Instructions: Using the provided templates, tools, and materials, you are required to perform the following tasks within 3 hours. Each student is expected to complete the project.

1. Formulate poultry ration

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