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ANS309

NIGERIAN FEED AND FEEDING STUFFS

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Course code: ANS 309

Course title: Nigerian Feed and Feeding Stuffs

Course credit load: 2 units

Series 1: Foundations of Nigerian Feed and Feeding Stuffs

Part 1: Classification of Foods and Feeding Stuffs

- 1.1.1 General classification of feeds
- 1.1.2 Nigerian context of feed classification
- 1.1.3 Importance of classification in animal nutrition

Part 2: Roles of Feed Ingredients in Animal Nutrition

- 1.2.1 Nutritional contributions of cereals, legumes, and oil seeds
- 1.2.2 Substitution of feed ingredients for balanced diets
- 1.2.3 Case examples in Nigerian feeding systems

Part 3: Supplements and Their Importance

- 1.3.1 Definition and types of supplements
- 1.3.2 Role of supplements in correcting deficiencies
- 1.3.3 Practical examples of supplements in Nigerian livestock production

Introduction

Feeding animals effectively begins with a clear understanding of the materials that make up their diets. In Nigeria, livestock production depends largely on locally available feed resources, which vary in type, quality, and nutritional contribution. Without a proper foundation in how these feeds are classified and used, it becomes difficult to design balanced diets or to appreciate the role of supplements in correcting deficiencies. This Series therefore sets the stage for the rest of the course by introducing you to the essential building blocks of Nigerian feed and feeding stuffs.

The aim of this Series is to provide you with a solid grounding in the classification of feeds, the nutritional roles of different ingredients, and the importance of supplements in animal diets. By the end of this Series, you should be able to define, explain, and analyse these concepts in relation to Nigerian livestock production.

We shall commence this Series by examining the classification of foods and feeding stuffs, highlighting both general categories and the Nigerian context. Next, we will explore the roles of feed ingredients in animal nutrition, focusing on their contributions and how substitution can help achieve balanced diets. Finally, we will wrap up by considering supplements, their types, and their importance in correcting deficiencies and improving productivity in Nigerian feeding systems.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** define the major categories of foods and feeding stuffs used in Nigerian livestock production,
- **SLO 1.2** explain the significance of classifying feeding stuffs within the Nigerian context,
- **SLO 1.3** analyse the nutritional contributions of key feed ingredients such as cereals, legumes, and oil seeds,
- **SLO 1.4** demonstrate how to substitute feed ingredients to achieve balanced diets in practical situations, and
- **SLO 1.5** evaluate the importance of supplements in correcting deficiencies and improving productivity in Nigerian feeding systems.

1.1 Classification of Foods and Feeding Stuffs

1.1.1 General classification of feeds

Animal diets are composed of different categories of feeds, each serving a unique nutritional role. **Foods** are materials consumed by animals to provide nutrients essential for growth, reproduction, and maintenance. **Feeding stuffs** are specific ingredients or mixtures used in animal diets, either singly or in combination, to meet nutritional requirements. These can be broadly classified into three groups: **succulent feeds**, which are fresh and high in moisture such as grasses and forage crops; **concentrates**, which are energy-rich feeds like cereals and oil seeds; and **supplements**, which are nutrient boosters added to correct deficiencies.

Feeding stuffs with high moisture content are called _____.

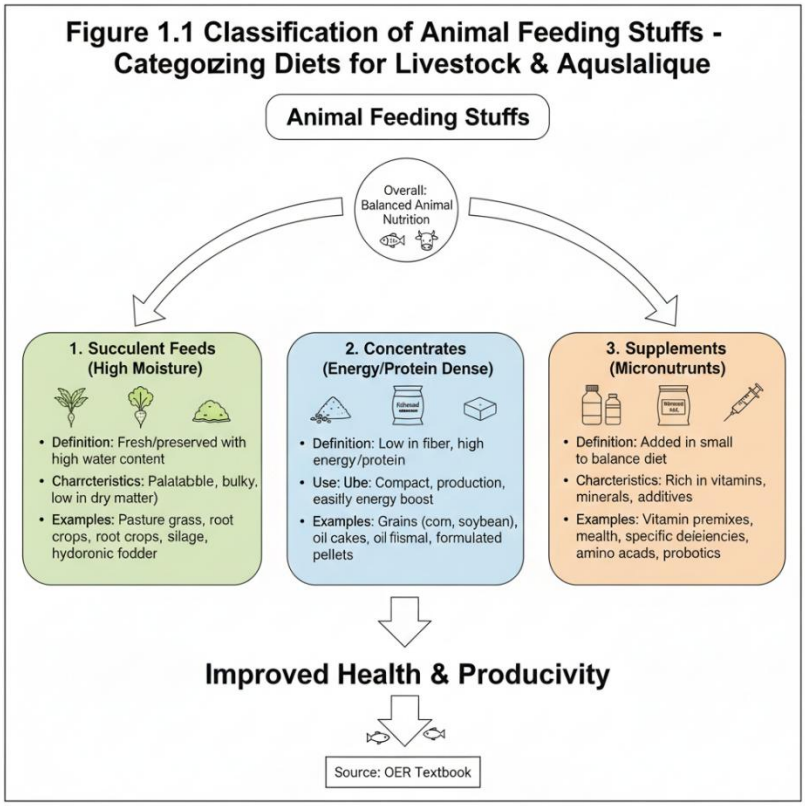


Figure 1.1 Classification of feeding stuffs

1.1.2 Nigerian context of feed classification

In Nigeria, feed classification is often influenced by availability, cost, and local production systems. Farmers rely heavily on **crop residues**, which are leftover plant materials after harvesting, such as maize stover and rice straw. These are widely used as basal diets for ruminants. Locally available **legumes** like cowpea haulms and groundnut tops are valued for their protein content, while **cereals** such as maize and sorghum provide energy. Supplements, including mineral licks and protein concentrates, are used strategically to enhance productivity.

In Nigerian livestock systems, crop residues are commonly used as _____.

Plate 1.1 Nigerian cattle feeding on maize stover

Plate 1.1 Nigerian cattle feeding on maize stover Sample

1.1.3 Importance of classification in animal nutrition

Classification of feeds is not merely academic; it has practical implications for animal nutrition. By grouping feeds into categories, nutritionists and farmers can easily identify nutrient sources and design balanced diets. For example, knowing that legumes are protein-rich helps in combining them with cereals, which are energy-rich, to achieve a balanced ration. Classification also aids in storage, quality control, and substitution when certain ingredients are scarce.

Proper classification ensures that diets are balanced and deficiencies are avoided. Balanced diets are those that provide adequate amounts of energy, protein, vitamins, and minerals.

Balanced diets are those that provide adequate amounts of _____.

Importance of Feed Classification in Nigerian Livestock Production

Classification of feeding stuffs is crucial in Nigerian livestock production for several practical and economic reasons:

1. **Optimized Ration Formulation:** It allows nutritionists and farmers to group feeds with similar nutritional profiles (e.g., concentrates vs. roughages). This systematic grouping is essential for accurately and efficiently formulating **balanced, least-cost rations** tailored to the specific needs of different animals (e.g., dairy cows, growing pigs, broilers) to maximize production (milk, meat, eggs).
2. **Efficient Resource Allocation:** Understanding the classification helps in the strategic sourcing and use of locally available feed resources. For instance, knowing which crop residues fall under **roughages** allows farmers to efficiently utilize seasonal by-products to meet the bulk and fiber requirements of ruminants like cattle and goats.
3. **Quality Control and Trading:** A standard classification system provides a common language for feed quality assessment, purchasing, and trading. It helps farmers and dealers ensure they are buying and selling feeds that meet certain minimum nutritional standards, thereby reducing the risk of poor animal performance due to substandard feed.

Pilot questions 1.1

1. Which category of feeding stuffs contains fresh, high-moisture feeds?
2. What are concentrates primarily used for in animal diets?
3. Define feeding stuffs in one sentence.
4. Name two examples of Nigerian feeding stuffs.
5. Why is classification important in animal nutrition?

1.2 Roles of Feed Ingredients in Animal Nutrition

1.2.1 Nutritional contributions of cereals, legumes, and oil seeds

Animal diets are designed to provide specific nutrients, and each feed ingredient plays a distinct role. **Cereals** are grains such as maize, sorghum, and millet. They are rich in carbohydrates, which are compounds that supply energy for growth, movement, and production. **Legumes** include plants like cowpea, groundnut, and soybean. They are valued for their high protein content, which supports tissue development, milk production, and reproduction. **Oil seeds** such as groundnut and cottonseed provide fats and essential fatty acids, which are important for energy storage, hormone production, and maintaining healthy cell membranes.

Legumes are primarily valued for their _____ content.

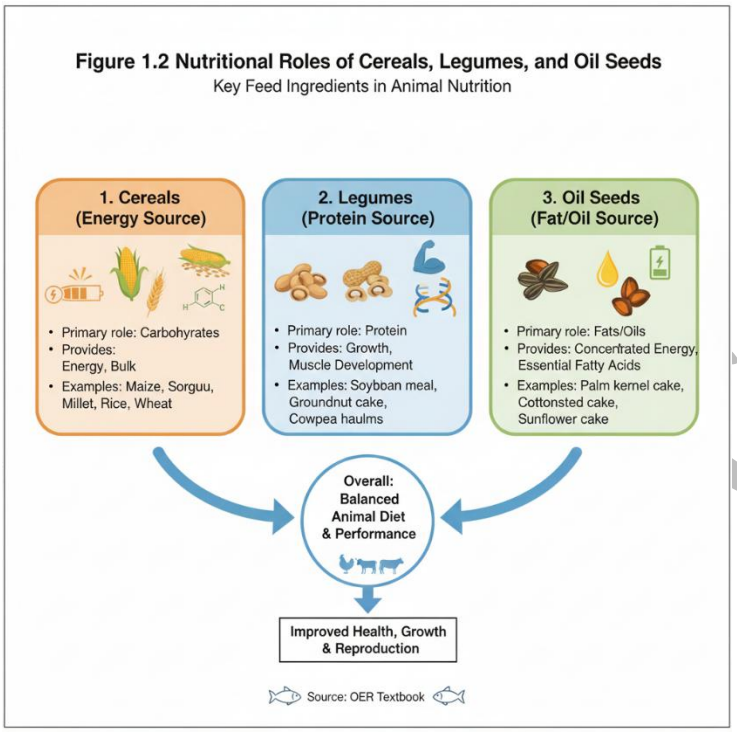


Figure 1.2 Nutritional roles of cereals, legumes, and oil seeds Sample

1.2.2 Substitution of feed ingredients for balanced diets

In practice, farmers often face shortages of certain feed ingredients. To maintain balanced diets, one ingredient can be substituted for another with similar nutritional value. For example, groundnut cake can replace soybean meal as a protein source, while sorghum can substitute for maize as an energy source. **Substitution** refers to the replacement of one feed ingredient with another of comparable nutrient contribution, ensuring that animals still receive adequate nutrition.

Substitution is important because it allows flexibility in diet formulation, reduces costs, and makes use of locally available resources. Balanced diets are achieved when energy, protein, vitamins, and minerals are supplied in the right proportions.

Balanced diets are achieved when _____ are supplied in the right proportions.

Table 1.1 Examples of feed ingredient substitutions in Nigerian livestock diets short description: Table showing common substitutions such as maize with sorghum, soybean meal with groundnut cake, and fish meal with blood meal. Sample.

Feed Ingredient to be Substituted (Original)	Substitute Ingredient (Alternative)	Primary Nutritional Role	Notes on Substitution
Maize (Yellow Corn)	**Sorghum (Guinea Corn)**	Energy (Carbohydrate)	Sorghum is a common and often cheaper substitute. Care must be taken to ensure the energy density and palatability remain adequate.
Soybean Meal (SBM)	**Groundnut Cake (GNC) / Peanut Cake**	Protein	GNC is a popular local protein source. Must be checked for Aflatoxin contamination, which is a significant concern.
Soybean Meal (SBM)	**Cotton Seed Cake (CSC)**	Protein	Lower protein quality than SBM; often high in fiber and contains gossypol, which limits inclusion levels, especially for monogastrics.
Fish Meal	**Blood Meal / Feather Meal**	Protein (Animal Source)	Used to provide essential amino acids. Blood meal is rich in lysine. Care must be taken with processing (sanitation) and palatability.

Feed Ingredient to be Substituted (Original)	Substitute Ingredient (Alternative)	Primary Nutritional Role	Notes on Substitution
Oyster Shell	**Limestone**	Calcium Source	Both provide calcium for eggshell strength and bone formation, but bioavailability may vary slightly.
Wheat Bran/Offal	**Rice Bran**	Fiber / Energy (Bulk)	Both are cereal by-products used as fillers or energy sources. Rice bran can have higher fat content, which can be beneficial but also prone to rancidity.

1.2.3 Case examples in Nigerian feeding systems

In Nigerian livestock production, practical examples highlight the roles of feed ingredients. For instance, poultry diets often rely on maize as the primary energy source, supplemented with soybean meal for protein. In ruminant systems, crop residues such as maize stover are combined with legume haulms to improve protein intake. Oil seed cakes are used to boost energy and fat levels in dairy cattle diets. These examples demonstrate how feed ingredients are combined to meet nutritional needs in real farming situations.

In Nigerian poultry diets, maize is commonly used as the primary source of _____.

Case Examples of Feed Ingredient Roles in Nigerian Livestock Production

Here are three key case examples illustrating the roles of different feed ingredients in Nigerian livestock diets:

1. **Poultry Diets (Broilers & Layers):**

- **Maize (Cereal):** Acts as the **primary energy source**, forming the largest percentage of the diet (often over 50%). It provides the necessary calories for growth (broilers) or egg production (layers).
- **Soybean Meal (Legume):** Serves as the **primary high-quality protein source**. Its balanced amino acid profile is crucial for rapid muscle development in broilers and for synthesizing egg protein in layers.

2. **Ruminant Diets (Cattle & Goats):**
    - **Crop Residues (Roughages):** Ingredients like **Maize Stover, Rice Straw, and Groundnut Haulms** form the **bulk** of the diet, especially during the dry season. Their role is to provide sufficient fiber (effective NDF) necessary for stimulating rumination and maintaining a healthy rumen environment.
    - **Forage Legumes (e.g., *Stylosanthes*):** These are introduced to **supplement protein** which is typically deficient in crop residues, thus improving the overall digestibility and intake of the roughage portion.
3. **Dairy Cattle Diets:**
    - **Oil Seed Cakes (e.g., Groundnut Cake, Palm Kernel Cake - PKC):** These are included as a **concentrate supplement** to provide high levels of both **protein and energy**. The added protein and fat from these cakes help meet the high nutrient demands for increased milk production. PKC, being fibrous, can also act as a partial roughage substitute.

Pilot questions 1.2

1. Which nutrient is mainly supplied by cereals?
2. Give one example of a protein-rich feed ingredient.
3. Why is substitution important in feed formulation?
4. What nutrient do oil seeds contribute?
5. Explain the role of legumes in animal diets.

1.3 Supplements and Their Importance

1.3.1 Definition and types of supplements

In animal nutrition, **supplements** are feed additives that provide nutrients not adequately supplied by basal diets. They are used to correct deficiencies and enhance productivity. Supplements can be grouped into three main types: **vitamin**

supplements, which provide essential vitamins for growth and immunity; **mineral supplements**, which supply elements such as calcium, phosphorus, and salt; and **protein concentrates**, which boost protein levels in diets that are otherwise deficient.

Supplements are used to correct _____ in animal diets.

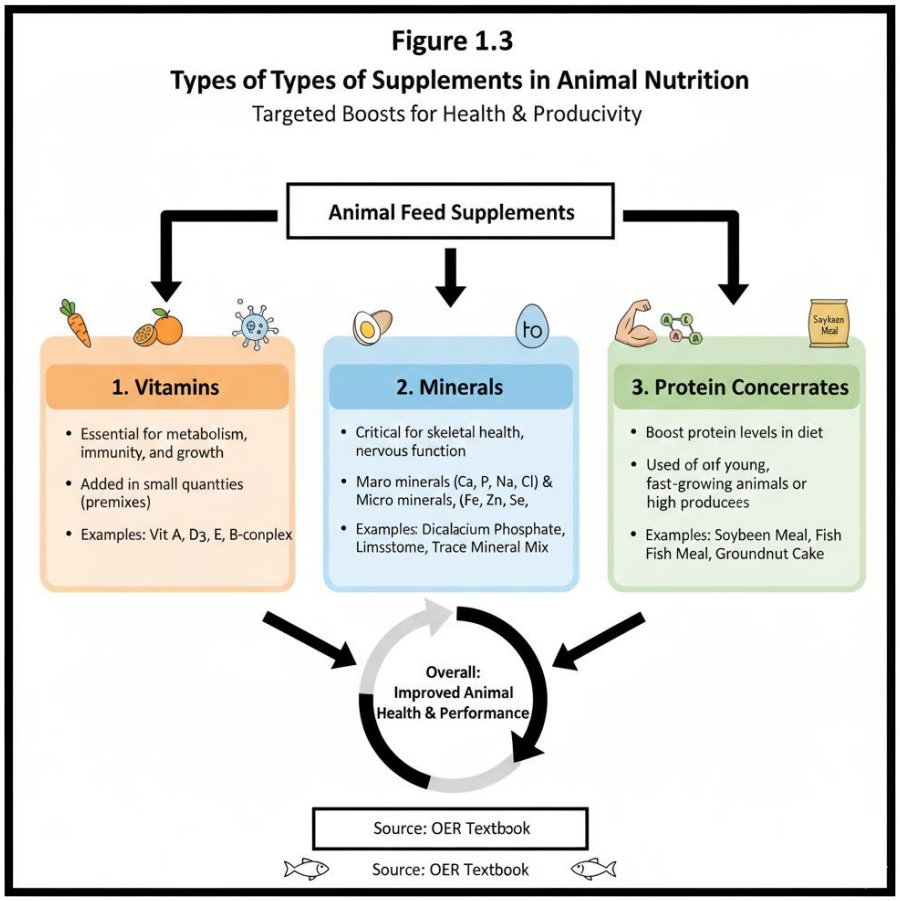


Figure 1.3 Types of supplements in animal nutrition Sample

1.3.2 Role of supplements in correcting deficiencies

Supplements play a vital role in ensuring that animals receive all the nutrients required for optimal performance. For example, mineral licks are used in grazing systems to provide calcium and phosphorus, which are often lacking in natural pastures. Vitamin supplements are added to poultry diets to prevent deficiencies that may cause poor growth or reduced egg production. Protein concentrates are used in ruminant diets to improve milk yield and weight gain.

By adding supplements, farmers can prevent diseases, improve fertility, and increase productivity. This makes supplementation an essential practice in Nigerian livestock systems, where basal diets are often limited in nutrient diversity.

Mineral licks are commonly used to provide _____ in grazing systems.

Plate 1.2 Cattle consuming mineral licks in a Nigerian grazing system Sample

1.3.3 Practical examples of supplements in Nigerian livestock production

In Nigerian livestock systems, supplements are widely applied to improve productivity. For instance, poultry farmers often add vitamin premixes to feed to enhance egg production. Dairy farmers use protein concentrates such as groundnut cake to increase milk yield. Grazing cattle are provided with mineral blocks to prevent deficiencies in calcium and phosphorus. These practical examples show how supplements are integrated into feeding systems to support animal health and performance.

In Nigerian poultry production, vitamin premixes are commonly added to feed to enhance _____.

Practical Examples of Supplement Use in Nigerian Livestock Production

Supplements play a vital role in bridging nutritional gaps in typical Nigerian livestock production systems, especially given the seasonal variations in feed quality.

1. **Mineral Blocks/Licks for Ruminants:**
    - **Context:** Nigerian cattle, sheep, and goats often graze on natural pastures or consume crop residues which are generally deficient in essential macro and micro-minerals (like phosphorus, sodium, and selenium).
    - **Supplement Use: Mineral blocks/licks** containing a mixture of salts, minerals, and sometimes molasses (for palatability) are provided *ad libitum*. This ensures constant access to essential minerals crucial for bone health, reproduction, and immune function.
2. **Vitamin and Mineral Premixes for Poultry:**
    - **Context:** Commercial poultry (broilers and layers) have high production demands and are fed formulated diets. While cereals and legumes provide energy and protein, they do not provide sufficient vitamins and trace minerals required for optimal health and production.
    - **Supplement Use: Commercial premixes** (a concentrated blend of vitamins and trace minerals) are incorporated into the feed during the mixing process. This is essential for preventing deficiency diseases, maximizing growth rate (broilers), and ensuring good eggshell quality and high hatchability (layers/breeders).
3. **Protein/Urea-Molasses Blocks (UMB) for Dry Season Feeding:**
    - **Context:** During the dry season, the quality of forages and crop residues drops significantly, leading to low protein intake and poor rumen microbe activity in ruminants.
    - **Supplement Use: Urea-Molasses Blocks** are used to provide non-protein nitrogen (from urea) and readily available energy (from molasses). This stimulates the growth of rumen microbes, which in turn enhances the digestion and utilization of the low-quality roughages, improving weight gain and survival.

Pilot questions 1.3

1. Define supplements in animal nutrition.
2. Name two types of supplements.
3. Why are supplements important in Nigerian feeding systems?

4. Give one example of a mineral supplement.
5. How do supplements improve productivity?

Series summary

This Series has provided the foundation for understanding Nigerian feed and feeding stuffs, emphasising their relevance in animal nutrition and livestock production. We began by classifying foods and feeding stuffs, considering both general categories and the Nigerian context, before highlighting why classification is important for balanced diets. We then explored the roles of feed ingredients, focusing on the nutritional contributions of cereals, legumes, and oil seeds, and examined how substitution ensures flexibility and balance in diet formulation. Finally, we discussed supplements, defining their types, explaining their role in correcting deficiencies, and presenting practical examples from Nigerian livestock systems.

By completing this Series, you should now be able to define the major categories of feeding stuffs, explain their significance in Nigerian contexts, analyse the nutritional contributions of key ingredients, demonstrate how substitution can achieve balanced diets, and evaluate the importance of supplements in improving productivity. These skills directly align with the Series Learning Outcomes and provide you with a strong foundation for progressing into the subsequent Series of this course.

Concept check questions [Series 1]

Objective questions

1. Which category of feeding stuffs contains fresh, high-moisture feeds? (Linked to SLO 1.1)
2. Cereals are primarily valued for their supply of _____. (Linked to SLO 1.3)
3. Which type of supplement is commonly used to provide calcium and phosphorus in grazing systems? (Linked to SLO 1.5)
4. Substitution of feed ingredients is important because it ensures _____. (Linked to SLO 1.4)
5. Legumes such as cowpea haulms are valued for their _____ content. (Linked to SLO 1.3)

Short-answer questions

6. Define feeding stuffs in one sentence. (Linked to SLO 1.1)

7. Explain why classification of feeding stuffs is important in Nigerian livestock production. (Linked to SLO 1.2)

8. Give one example of a protein-rich feed ingredient used in Nigerian diets. (Linked to SLO 1.3)

9. Describe how supplements improve productivity in Nigerian livestock systems. (Linked to SLO 1.5)

10. Identify one example of substitution in Nigerian feeding systems and explain its purpose. (Linked to SLO 1.4)

Long-answer questions

11. Analyse the nutritional contributions of cereals, legumes, and oil seeds, and explain how they complement each other in balanced diets. (Linked to SLO 1.3)

12. Evaluate the importance of supplements in correcting deficiencies and improving productivity in Nigerian livestock production, using practical examples. (Linked to SLO 1.5)

Answers to Concept Check Questions [Series 1]

Objective questions

1. Succulent feeds.
2. Carbohydrates.
3. Mineral licks.
4. Balanced diets.
5. Protein.

Short-answer questions

6. Feeding stuffs are ingredients or mixtures used in animal diets to provide nutrients.

7. Classification helps identify nutrient sources, design balanced diets, and manage storage and substitution.

8. Groundnut cake.

9. Supplements correct deficiencies, prevent diseases, and enhance fertility, growth, and productivity.

10. Sorghum can substitute for maize to provide energy when maize is scarce.

Long-answer questions

11. **Basic response:** Cereals supply carbohydrates for energy, legumes provide protein for tissue development, and oil seeds contribute fats and essential fatty acids. Together, they complement each other to form balanced diets that meet energy, protein, and fat requirements. **Value-added response:** Beyond their basic nutrient roles, cereals also provide fibre, legumes improve soil fertility through nitrogen fixation, and oil seeds contribute micronutrients such as vitamin E. Combining these ingredients not only balances animal diets but also supports sustainable farming practices in Nigeria.

12. **Basic response:** Supplements such as vitamins, minerals, and protein concentrates correct deficiencies in basal diets, improve health, and increase productivity. Examples include mineral licks for grazing cattle and vitamin premixes for poultry. **Value-added response:** In addition to correcting deficiencies, supplements enhance immune function, reduce disease incidence, and improve reproductive performance. Their strategic use in Nigerian systems addresses seasonal feed shortages and supports commercial livestock enterprises, making them vital for both smallholder and large-scale production.

Answers to Pilot Questions [Series 1]

Part 1: Classification of Foods and Feeding Stuffs

- Succulent feeds
- Energy
- Ingredients used in animal diets
- Grasses and crop residues
- To ensure balanced nutrition

Part 2: Roles of Feed Ingredients in Animal Nutrition

- Carbohydrates
- Groundnut cake
- To maintain balance when ingredients are scarce

- Fats and essential fatty acids
- Protein supply

Part 3: Supplements and Their Importance

- Nutrient additives
- Vitamins and minerals
- To correct deficiencies
- Mineral licks
- By enhancing health and growth

Series 2: Chemistry and Nutritive Values of Succulent Feeding Stuffs

Part 1: Chemistry of succulent feeding stuffs

- 2.1.1 Composition of water and fibre in succulent feeds
- 2.1.2 Carbohydrates, proteins, and minerals in fresh forages
- 2.1.3 Factors affecting chemical composition

Part 2: Nutritive values of succulent feeding stuffs

- 2.2.1 Energy contribution of grasses and forages
- 2.2.2 Protein and mineral values of legumes
- 2.2.3 Seasonal variations in nutritive values

Part 3: Practical importance of succulent feeding stuffs in Nigerian livestock systems

- 2.3.1 Role in ruminant diets
- 2.3.2 Limitations and challenges of using succulent feeds
- 2.3.3 Strategies for effective utilisation

Introduction

Succulent feeding stuffs such as grasses, legumes, and fresh forages form the backbone of livestock diets in Nigeria. They are rich in moisture and provide essential nutrients that sustain ruminant animals, especially under grazing systems. Understanding their chemistry and nutritive values is crucial for designing balanced diets and improving productivity. This Series therefore builds on the foundations established earlier by focusing on the scientific and practical aspects of succulent feeds.

The aim of this Series is to equip you with the knowledge to analyse the chemical composition of succulent feeding stuffs and to evaluate their nutritive contributions to animal diets.

We shall commence this Series by examining the chemistry of succulent feeding stuffs, focusing on their composition and the factors that influence it. Next, we will explore their nutritive values, highlighting the energy, protein, and mineral contributions of grasses and legumes, as well as seasonal variations. Finally, we will wrap up by considering the practical importance of succulent feeds in Nigerian livestock systems, discussing their role, limitations, and strategies for effective utilisation.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 2.1** define the chemical components of succulent feeding stuffs, including water, fibre, carbohydrates, proteins, and minerals.
- **SLO 2.2** explain the factors that influence the chemical composition of succulent feeds.
- **SLO 2.3** analyse the energy, protein, and mineral contributions of grasses and legumes.
- **SLO 2.4** evaluate the impact of seasonal variations on the nutritive values of succulent feeding stuffs.
- **SLO 2.5** assess the practical importance, limitations, and strategies for effective utilisation of succulent feeds in Nigerian livestock systems.

2.1 Chemistry of Succulent Feeding Stuffs

2.1.1 Composition of water and fibre in succulent feeds

Succulent feeding stuffs such as grasses and legumes are characterised by their high moisture content. **Water** is the most abundant component, often making up 60–90 percent of the fresh weight. It plays a vital role in maintaining hydration,

regulating body temperature, and supporting metabolic processes in animals. Alongside water, **fibre** is another key component. Fibre refers to indigestible plant material such as cellulose and lignin, which aids digestion and supports rumen function in ruminants.

Succulent feeds are distinguished by their high _____ content.

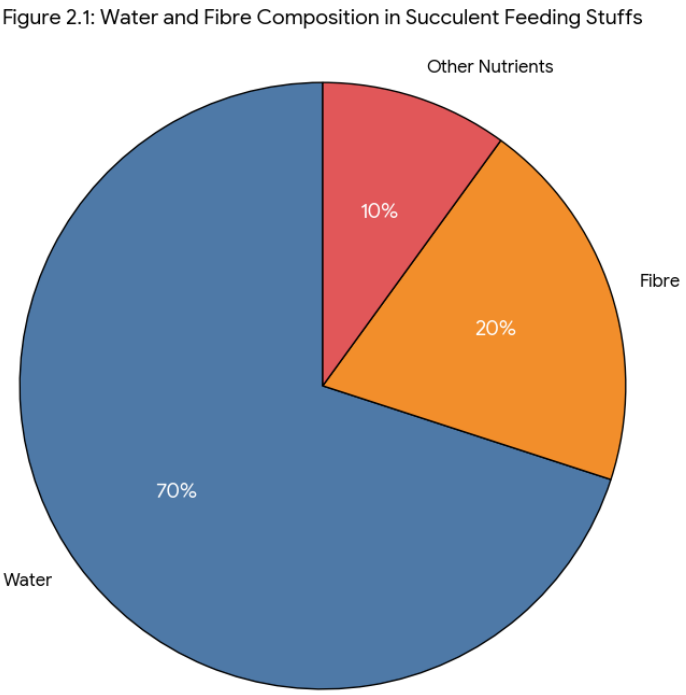


Figure 2.1 Water and fibre composition in succulent feeding stuffs Sample

2.1.2 Carbohydrates, proteins, and minerals in fresh forages

Beyond water and fibre, succulent feeds also contain important nutrients. **Carbohydrates** are compounds that provide energy, mainly in the form of simple sugars and structural polysaccharides. **Proteins** are nitrogen-containing compounds essential for tissue growth, milk production, and reproduction. Legumes generally have higher protein content than grasses. **Minerals** such as calcium, phosphorus, and potassium are present in varying amounts and are critical for bone development, nerve function, and metabolic regulation.

Legumes are particularly valued for their high _____ content compared to grasses.

Table 2.1 Nutrient composition of grasses and legumes short description: Table comparing carbohydrate, protein, and mineral levels in grasses and legumes.

Nutrient Component	Grasses (e.g., Napier Grass, Guinea Grass)	Legumes (e.g., Centrosema, Stylosanthes)	Key Implication for Livestock Feeding
Crude Protein (CP) Level	Low to Moderate (typically \$5\%\$ to \$10\%\$ DM)	High (typically \$15\%\$ to \$25\%\$ DM)	Legumes are crucial for supplementing protein deficiency in grass-based diets, essential for growth and production.
Carbohydrates (Energy)	High (Major source of Non-Structural and Structural Carbohydrates)	Moderate (Higher proportion of protein reduces space for carbohydrates)	Grasses are the primary source of bulk energy for grazing animals.
Digestible Fibre	High (Primary component for rumen function)	Moderate (Lower fibre concentration than grasses)	Grasses are necessary for stimulating rumination and maintaining rumen health.
Calcium (Ca)	Low	High (Especially for legumes like *Lucerne*)	Legumes help balance the Calcium to Phosphorus ratio, which is often poor in grasses.

Nutrient Component	Grasses (e.g., Napier Grass, Guinea Grass)	Legumes (e.g., Centrosema, Stylosanthes)	Key Implication for Livestock Feeding
Phosphorus (P)	Low to Moderate	Low to Moderate	Both often require supplementation, but the mineral profile of legumes is generally superior.
Overall Digestibility	Variable (Decreases rapidly with maturity)	Generally Higher (Due to lower lignin content compared to mature grass stems)	Feeding a mixture (Grass-Legume intercropping) improves overall diet digestibility and intake.

2.1.3 Factors affecting chemical composition

The chemical composition of succulent feeding stuffs is not fixed; it varies depending on several factors. **Stage of growth** is critical, as younger plants tend to have higher protein and lower fibre, while mature plants have more fibre and less protein. **Soil fertility** influences mineral content, with nutrient-rich soils producing forages higher in calcium and phosphorus. **Seasonal variations** also play a role, as dry-season forages often have reduced moisture and protein compared to rainy-season growth.

The chemical composition of succulent feeds changes with the _____ of growth.

Factors Influencing Chemical Composition of Succulent Feeding Stuffs

The nutritional value (chemical composition) of succulent feeds like grasses and legumes is highly dynamic and depends on several environmental and biological factors:

1. **Stage of Growth (Maturity):**

- **Effect:** This is the most critical factor. As plants mature, the percentage of **Crude Protein (CP) decreases** significantly, while the proportion of **lignified fibre (lignin)** and **Crude Fibre (CF) increases**.
- **Implication:** This leads to a sharp **drop in digestibility and palatability**. Younger plants are always more nutritious than older ones.

2. **Soil Fertility and Fertilizer Application:**
    - **Effect:** Deficiencies in essential elements, particularly Nitrogen (N), can severely limit the protein content of grasses. Applying **Nitrogen fertilizer** directly increases the CP content and yield of grasses.
    - **Implication:** Forages grown on poor soils will provide inadequate nutrition, necessitating supplementation.
3. **Seasonal Variations (Climate):**
    - **Effect:** The chemical composition is significantly different between the wet and dry seasons. During the **wet season**, growth is rapid, CP and moisture are high, and fibre is low. During the **dry season**, plants often dry up, resulting in **high fibre, low protein, and low moisture content**.
    - **Implication:** Feed quality management is a major challenge during the dry season, leading to the "dry season feed gap" in Nigeria.

Pilot questions 2.1

1. What is the most abundant component of succulent feeding stuffs?
2. Why is fibre important in ruminant diets?
3. Which nutrient is generally higher in legumes compared to grasses?
4. Name two minerals commonly found in succulent feeds.
5. List three factors that influence the chemical composition of succulent feeding stuffs.

2.2 Nutritive Values of Succulent Feeding Stuffs

2.2.1 Energy contribution of grasses and forages

Succulent feeding stuffs such as grasses and fresh forages provide animals with **energy**, which is the fuel required for growth, movement, reproduction, and

production. The energy in grasses comes mainly from **carbohydrates**, including simple sugars and structural polysaccharides. Although their energy density is lower than that of concentrates, grasses are vital for ruminants because they form the bulk of their diets. The digestibility of energy from grasses depends on their stage of growth, with younger plants offering more readily available carbohydrates.

Energy in grasses is derived mainly from _____.

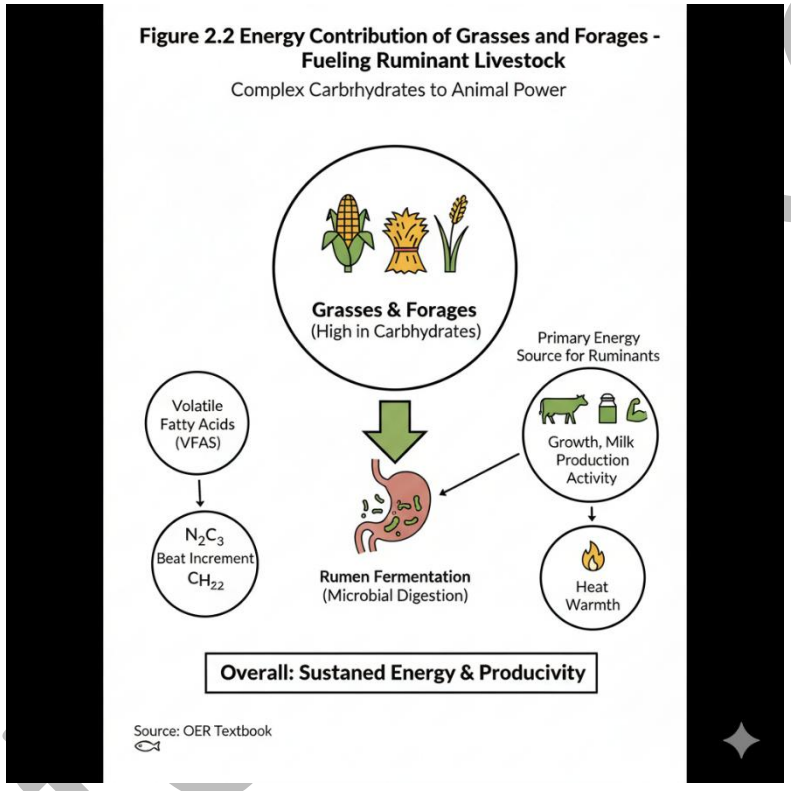


Figure 2.2 Energy contribution of grasses and forages Sample

2.2.2 Protein and mineral values of legumes

Legumes such as cowpea, groundnut, and soybean haulms are highly valued for their **protein** content. Protein is essential for tissue development, milk production, and reproduction. Legumes also provide important **minerals** such as calcium and phosphorus, which are critical for bone formation and metabolic regulation. Compared to grasses, legumes generally have higher protein and mineral concentrations, making them excellent supplements in ruminant diets.

Legumes are particularly valued for their high _____ and mineral content.

Table 2.2 Protein and mineral values of legumes compared to grasses Short description: Table comparing protein and mineral levels in legumes and grasses.

Characteristic	Legumes (e.g., Centrosema, Cowpea Haulms)	Grasses (e.g., Pennisetum, Panicum)	Implication for Livestock Diets
Crude Protein (CP) Level	High ($15\% - 30\%$ Dry Matter)	Low to Moderate ($5\% - 10\%$ Dry Matter)	Legumes are vital for supplementing protein, especially for non-ruminants and high-producing animals.
Protein Digestibility	Generally High	Moderate (Decreases rapidly with maturity)	Higher quality protein ensures better utilization and efficiency for growth and milk/meat production.
Calcium (Ca) Content	High	Low to Moderate	Legumes help correct the Ca:P imbalance common in grass-only diets.
Phosphorus (P) Content	Moderate	Low	Both often require P supplementation, but legumes are a better source than grasses.
Carotene (Pro-Vitamin A)	Generally High (especially in leaves)	Moderate	Legumes contribute significantly to Vitamin A status of grazing animals.
Nitrogen Fixing Ability	Present (Symbiotic with *Rhizobia*)	Absent	Legumes enrich the soil with Nitrogen, benefiting the

Characteristic	Legumes (e.g., Centrosema, Cowpea Haulms)	Grasses (e.g., Pennisetum, Panicum)	Implication for Livestock Diets
			companion grass when intercropped.

2.2.3 Seasonal variations in nutritive values

The nutritive values of succulent feeding stuffs vary with the seasons. During the rainy season, grasses and legumes are lush, with high moisture, protein, and mineral content. In contrast, dry-season forages often have reduced protein and energy, with increased fibre that lowers digestibility. Seasonal variation therefore affects the quality of diets available to livestock, and farmers must plan supplementation strategies accordingly.

Nutritive values of succulent feeds decline during the _____ season.

Box 2.2 Seasonal variations in nutritive values of succulent feeding stuffs short description: Box highlighting differences between rainy-season and dry-season nutritive values.

Characteristic	Wet (Rainy) Season	Dry Season	Implication for Livestock Management
Moisture Content	**High** (Up to \$80\%\$)	**Low** (Rapidly declines as plants senesce)	High moisture limits dry matter intake; low moisture makes dry, fibrous feeds hard to digest.
Crude Protein (CP)	**High** (\$10\% - 20\%\$ DM)	**Very Low** (\$3\% - 6\%\$ DM)	Protein deficiency during the dry season leads to weight loss, poor fertility, and low production (the "dry season feed gap").

Characteristic	Wet (Rainy) Season	Dry Season	Implication for Livestock Management
Fibre Content (Lignin/CF)	**Low** (Plants are young and leafy)	**High** (Stems mature, high in indigestible lignin)	High fibre content significantly reduces feed digestibility and nutrient release.
Palatability & Intake	**High**	**Low**	Reduced feed intake in the dry season compounds the problem of low nutrient quality.
Mineral Content	Generally Good	Often **Low** (Minerals leach out)	Requires strategic mineral supplementation during the dry period.

Pilot questions 2.2

1. What is the main source of energy in grasses?
2. Why are legumes considered superior to grasses in terms of nutrition?
3. Name two minerals commonly found in legumes.
4. How does the nutritive value of grasses change during the dry season?
5. Why is seasonal variation important in planning livestock diets?

2.3 Practical Importance of Succulent Feeding Stuffs in Nigerian Livestock Systems

2.3.1 Role in ruminant diets

Succulent feeding stuffs such as grasses and legumes are the primary diet for ruminants in Nigeria. They provide bulk, stimulate rumination, and support microbial activity in the rumen. The high moisture content helps maintain hydration, while the fibre aids digestion and prevents digestive disorders. Ruminants such as cattle, sheep, and goats depend heavily on these feeds, especially under traditional grazing systems.

Ruminants depend heavily on succulent feeds because of their high _____ content.

Plate 2.1 Nigerian cattle grazing on succulent pasture Sample

2.3.2 Limitations and challenges of using succulent feeds

Despite their importance, succulent feeds have limitations. Their nutrient composition varies with season, and during the dry season they often become fibrous and less digestible. Storage is also a challenge, as high moisture content makes them prone to spoilage. Additionally, overgrazing can reduce availability and lead to land degradation. Farmers must therefore recognise these challenges and plan accordingly.

Succulent feeds are prone to spoilage because of their high _____ content.

Limitations of Succulent Feeding Stuffs

While succulent feeds (pastures, green chop, etc.) are the backbone of ruminant nutrition, particularly in Nigerian grazing systems, they come with several significant limitations that livestock managers must address:

1. **Pronounced Seasonal Variation:**
    - The nutritional quality of succulent feeds drops dramatically from the wet to the dry season. During the dry season, the **protein content falls** while the **indigestible fibre (lignin)** content rises, leading to the severe "dry season feed gap" which causes significant weight loss and poor reproduction in grazing animals.
2. **Storage and Preservation Problems:**
    - Due to their inherently **high moisture content** (often 70% to 85% water), succulent feeds are heavy and bulky, making them difficult and costly to harvest, transport, and store. They are also highly susceptible to **rapid spoilage** (fermentation or mould growth) if not properly conserved (e.g., through silage or haymaking).
3. **Vulnerability to Overgrazing and Degradation:**
    - In many traditional systems, pastures are often subjected to **overgrazing**, especially around water points or settlements. This continuous, uncontrolled pressure depletes desirable species, promotes weed growth, and degrades the soil structure, ultimately reducing the future quantity and quality of the feed available.

2.3.3 Strategies for effective utilisation

To overcome these challenges, farmers adopt strategies such as **conservation** and **supplementation**. Conservation methods include silage making and hay production, which preserve nutrients for use during the dry season. Supplementation with concentrates or mineral blocks ensures animals receive balanced nutrition when succulent feeds are inadequate. Rotational grazing is another strategy that prevents overgrazing and maintains pasture quality.

Conservation methods such as silage making and hay production help preserve _____ for dry-season feeding.

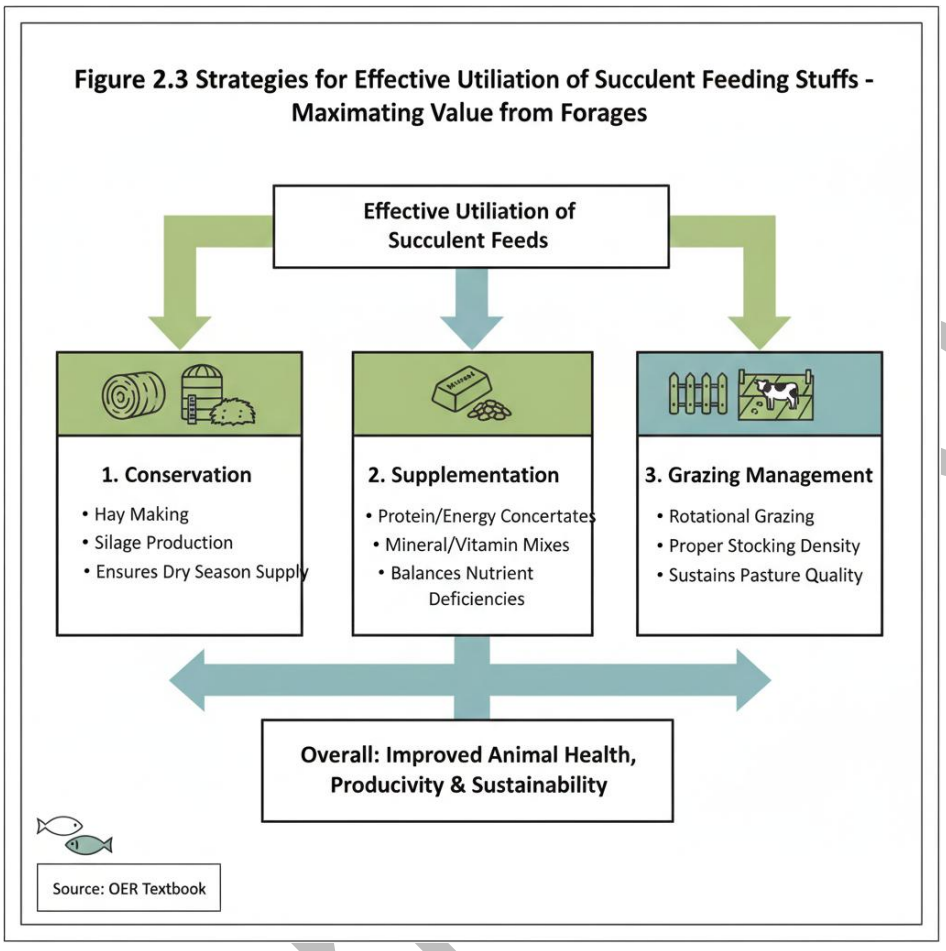


Figure 2.3 Strategies for effective utilisation of succulent feeding stuffs Sample

Pilot questions 2.3

1. Why are succulent feeds important in ruminant diets?
2. What makes succulent feeds prone to spoilage?
3. List two limitations of succulent feeding stuffs.
4. Name two conservation methods used to preserve succulent feeds.
5. How does rotational grazing improve pasture quality?

Series summary

This Series has explored the chemistry and nutritive values of succulent feeding stuffs, emphasising their importance in Nigerian livestock systems. We began by examining their chemical composition, focusing on water, fibre, carbohydrates,

proteins, and minerals, as well as the factors that influence these components. We then analysed their nutritive values, highlighting the energy contributions of grasses, the protein and mineral richness of legumes, and the seasonal variations that affect feed quality. Finally, we considered their practical importance, discussing their role in ruminant diets, the limitations of using succulent feeds, and strategies for effective utilisation such as conservation and supplementation.

By completing this Series, you should now be able to define the chemical components of succulent feeds, explain the factors influencing their composition, analyse their energy, protein, and mineral contributions, evaluate the impact of seasonal variations, and assess their practical importance in Nigerian livestock systems. These achievements directly align with the Series Learning Outcomes and provide you with the skills to apply scientific knowledge to real-world feeding practices.

Concept check questions [Series 2]

Objective questions

1. What is the most abundant component of succulent feeding stuffs? (Linked to SLO 2.1)
2. Which nutrient is generally higher in legumes compared to grasses? (Linked to SLO 2.3)
3. During which season do succulent feeds have reduced protein and energy values? (Linked to SLO 2.4)
4. Which conservation method involves fermenting fresh forage to preserve nutrients? (Linked to SLO 2.5)
5. Fibre in succulent feeds is important because it supports _____. (Linked to SLO 2.1)

Short-answer questions

6. Explain why soil fertility influences the chemical composition of succulent feeds. (Linked to SLO 2.2)

7. Describe the energy contribution of grasses to ruminant diets. (Linked to SLO 2.3)

8. Identify two limitations of using succulent feeds in Nigerian livestock systems. (Linked to SLO 2.5)

9. Give one example of a mineral found in legumes and explain its importance. (Linked to SLO 2.3)

10. How does rotational grazing improve the utilisation of succulent feeds? (Linked to SLO 2.5)

Long-answer questions

11. Analyse the differences in nutritive values between grasses and legumes, and explain how they complement each other in balanced diets. (Linked to SLO 2.3)

12. Evaluate the strategies used to overcome the limitations of succulent feeding stuffs in Nigerian livestock systems, with practical examples. (Linked to SLO 2.5)

Answers to Concept Check Questions [Series 2]

Objective questions

1. Water.
2. Protein.
3. Dry season.
4. Silage making.
5. Digestion in ruminants.

Short-answer questions

6. Soil fertility affects mineral uptake, so nutrient-rich soils produce forages with higher mineral content.

7. Grasses provide carbohydrates that supply energy for growth, movement, and production in ruminants.

8. Seasonal variation and spoilage due to high moisture content.

9. Calcium, which is important for bone development and metabolic regulation.

10. Rotational grazing prevents overgrazing, maintains pasture quality, and ensures sustainable feed supply.

Long-answer questions

11. **Basic response:** Grasses supply carbohydrates for energy, while legumes provide protein and minerals. Together, they complement each other to form balanced diets. **Value-added response:** Beyond their basic roles, grasses also provide fibre for rumen function, while legumes improve soil fertility through nitrogen fixation. Combining them enhances both animal nutrition and sustainable farming practices.

12. **Basic response:** Strategies include conservation methods such as silage and hay making, supplementation with concentrates, and rotational grazing. These approaches help overcome seasonal shortages and spoilage. **Value-added response:** In addition to these strategies, integrating forage legumes into pastures improves protein supply, while community-based grazing management prevents land degradation. These practices strengthen resilience in Nigerian livestock systems and support long-term productivity.

Answers to Pilot Questions [Series 2]

Part 2.1 Chemistry of succulent feeding stuffs

- Water
- It aids digestion and supports rumen function
- Protein
- Calcium and phosphorus
- Stage of growth, soil fertility, seasonal variations

Part 2.2 Nutritive values of succulent feeding stuffs

- Carbohydrates
- They are richer in protein and minerals
- Calcium and phosphorus
- Reduced protein and energy, increased fibre
- It guides supplementation and feeding strategies

Part 2.3 Practical importance of succulent feeding stuffs in Nigerian livestock systems

- High moisture and fibre content

- Moisture
- Seasonal variation and storage problems
- Silage making and hay production
- It prevents overgrazing and maintains pasture quality

Series 3: Concentrate Feeds: Cereals, Legumes, and Oil Seeds

Part 1: Chemistry and composition of concentrate feeds

- 3.1.1 Carbohydrate content of cereals
- 3.1.2 Protein content of legumes
- 3.1.3 Oil and fatty acid content of oil seeds

Part 2: Nutritive values and contributions of concentrates

- 3.2.1 Energy contributions of cereals
- 3.2.2 Protein and amino acid contributions of legumes
- 3.2.3 Fat and mineral contributions of oil seeds

Part 3: Practical applications of concentrate feeds in Nigerian livestock systems

- 3.3.1 Role of concentrates in poultry diets
- 3.3.2 Role of concentrates in ruminant diets
- 3.3.3 Challenges and strategies in using concentrates

Introduction

Concentrate feeds are essential in Nigerian livestock production because they provide dense sources of energy, protein, and fats that are often lacking in basal diets. Unlike succulent feeds, concentrates such as cereals, legumes, and oil seeds are more nutrient-rich and play a critical role in enhancing productivity. Farmers rely on these feeds to support growth, reproduction, and commercial output, making them indispensable in both smallholder and large-scale systems.

The aim of this Series is to equip you with the knowledge to analyse the chemistry, nutritive values, and practical applications of concentrate feeds, focusing on cereals, legumes, and oil seeds.

We shall commence this Series by examining the chemistry and composition of concentrate feeds, looking at carbohydrates in cereals, proteins in legumes, and oils in oil seeds. Next, we will explore their nutritive values, highlighting the energy, protein, fat, and mineral contributions. Finally, we will wrap up by considering their practical applications in Nigerian livestock systems, discussing their role in poultry and ruminant diets, as well as the challenges and strategies associated with their use.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 3.1** define the chemical composition of cereals, legumes, and oil seeds as concentrate feeds.
- **SLO 3.2** explain the carbohydrate contributions of cereals to livestock diets.
- **SLO 3.3** analyse the protein and amino acid contributions of legumes.
- **SLO 3.4** evaluate the fat and mineral contributions of oil seeds.
- **SLO 3.5** assess the practical applications of concentrate feeds in Nigerian poultry and ruminant diets.
- **SLO 3.6** identify challenges in using concentrate feeds and propose strategies for effective utilisation.

3.1 Chemistry and Composition of Concentrate Feeds

3.1.1 Carbohydrate content of cereals

Cereals such as maize, sorghum, millet, and wheat are the most common **concentrate feeds** used in Nigerian livestock systems. Concentrates are feedstuffs that are rich in nutrients, particularly energy and protein, and low in fibre compared to forages. Cereals are primarily valued for their **carbohydrate** content, which provides energy for growth, reproduction, and production. Carbohydrates in cereals occur mainly as starch, a polysaccharide that is easily digested by monogastric animals such as poultry and pigs. In ruminants, starch is fermented in the rumen to produce volatile fatty acids, which serve as the main energy source.

Cereals are primarily valued for their high _____ content.

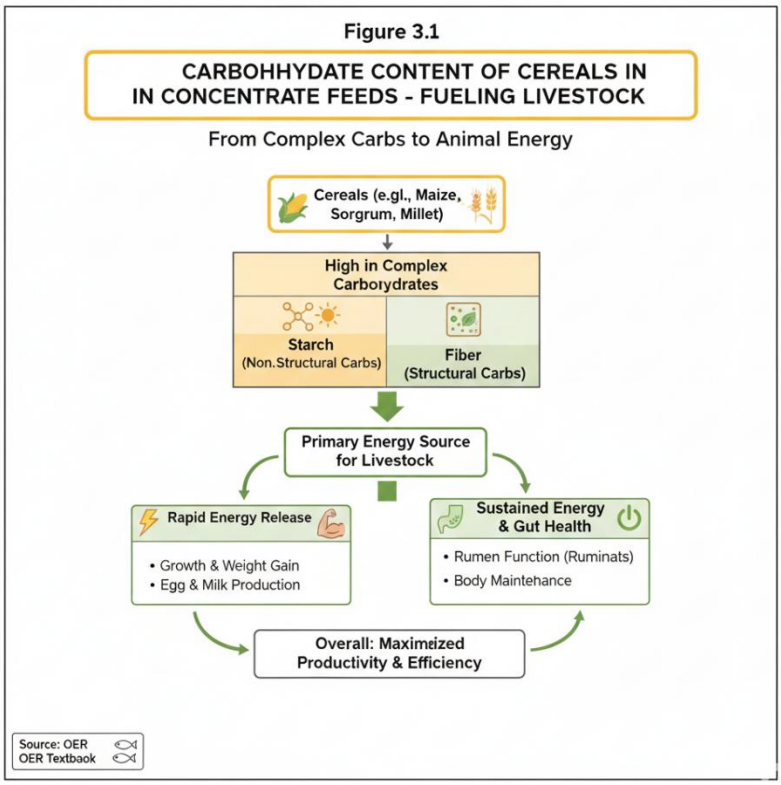


Figure 3.1 Carbohydrate content of cereals in concentrate feeds

3.1.2 Protein content of legumes

Legumes such as soybean, cowpea, and groundnut are important concentrate feeds because of their high **protein** content. Protein is defined as nitrogen-containing compounds made up of amino acids, which are essential for tissue development, milk production, and reproduction. Legumes are particularly rich in lysine, an amino acid often deficient in cereal-based diets. This makes legumes excellent complements to cereals in balanced rations. In Nigerian livestock systems, groundnut cake and soybean meal are widely used as protein concentrates.

Legumes are valued for their high _____ content and amino acid profile.

Table 3.1 Protein content of selected legumes compared to cereals Short description: Table comparing protein percentages and amino acid profiles of legumes and cereals.

Feed Type	Example Feedstuff	Crude Protein (CP) Range (% Dry Matter)	Limiting Amino Acid(s)	Role in Livestock Nutrition
Legumes	Soybean Meal	$44\% - 50\%$	Methionine, Cysteine (Sulfur-containing AAs)	Primary protein supplement; essential for growth and production.
	Groundnut Cake (Peanut Meal)	$40\% - 48\%$	Methionine, Lysine	High-protein supplement; often used as a cheaper alternative to SBM.
	Cowpea/Lentils	$23\% - 31\%$	Methionine	Protein and energy source; used for forage or processed into concentrate.
Cereals	Maize (Corn)	$8\% - 12\%$	Lysine, Tryptophan	Primary Energy source due to high starch content; protein quality is low.
	Sorghum/Millet	$7\% - 15\%$	Lysine, Threonine	Energy source; more drought-tolerant than maize.

Feed Type	Example Feedstuff	Crude Protein (CP) Range (% Dry Matter)	Limiting Amino Acid(s)	Role in Livestock Nutrition
	Wheat (Bran/Offals)	$12\% - 17\%$	Lysine	Energy source; bran is valued for fibre content in ruminant diets.

3.1.3 Oil and fatty acid content of oil seeds

Oil seeds such as groundnut, cottonseed, and sunflower are valued for their **oil** and **fatty acid** content. Oils are concentrated sources of energy, providing more than twice the energy of carbohydrates or proteins. Fatty acids are important for hormone production, cell membrane integrity, and energy storage. Oil seeds also contribute essential fatty acids such as linoleic acid, which animals cannot synthesise on their own. In Nigerian livestock diets, oil seed cakes are commonly used after oil extraction, providing both protein and residual fat.

Oil seeds are valued for their high _____ and essential fatty acid content.

Importance of Oil Seeds in Concentrate Feeds

Oil seeds (e.g., soybeans, groundnuts, palm kernel) and their processed meals are indispensable components of balanced concentrate diets for livestock, serving three key functions:

1. **Concentrated Energy Supply:**
    - **Role:** The high **fat/oil content** in intact oilseeds (or residual fat in oilseed meals) makes them incredibly energy-dense. Fats provide approximately 2.25 times more Gross Energy (GE) per unit of weight than carbohydrates (cereals).
    - **Implication:** Including fats helps meet the high energy demands of fast-growing poultry, high-producing dairy cows, and heavily pregnant animals without increasing the physical bulk of the diet.

2. **Source of Essential Fatty Acids (EFAs):**
    - **Role:** Oilseeds are rich in polyunsaturated fatty acids like **Linoleic Acid (Omega-6)** and **Linolenic Acid (Omega-3)**. These are necessary for structural integrity (cell membranes), hormone synthesis, and maintaining coat/skin health.
    - **Implication:** Ensuring adequate EFA supply is crucial for optimizing reproductive performance and immune function in all livestock.
3. **High-Quality Protein Contribution:**
    - **Role:** After the oil is extracted (creating oilseed meals like Soybean Meal or Groundnut Cake), the remaining material is a highly concentrated source of **Crude Protein (CP)**, often $40\%-50\%$ in quality meals.
    - **Implication:** Oilseed meals are the foundation of protein supplementation in monogastric diets (poultry, swine) and are used to balance the low protein content of cereal-based feeds.

Pilot questions 3.1

1. What nutrient is the primary contribution of cereals in concentrate feeds?
2. Why are legumes considered superior to cereals in terms of protein quality?
3. Name one amino acid that legumes supply in abundance.
4. What makes oil seeds an excellent source of energy?
5. List two roles of fatty acids in animal nutrition.

3.2 Nutritive Values and Contributions of Concentrates

3.2.1 Energy contributions of cereals

Cereals such as maize, sorghum, and millet are the primary energy sources in concentrate feeds. Their high **starch** content provides readily available energy for monogastric animals like poultry and pigs, while in ruminants, starch is fermented in the rumen to produce volatile fatty acids that fuel growth and production. The energy density of cereals makes them indispensable in formulating balanced diets, especially for fast-growing and high-yielding livestock.

Cereals are indispensable in livestock diets because of their high _____ content.

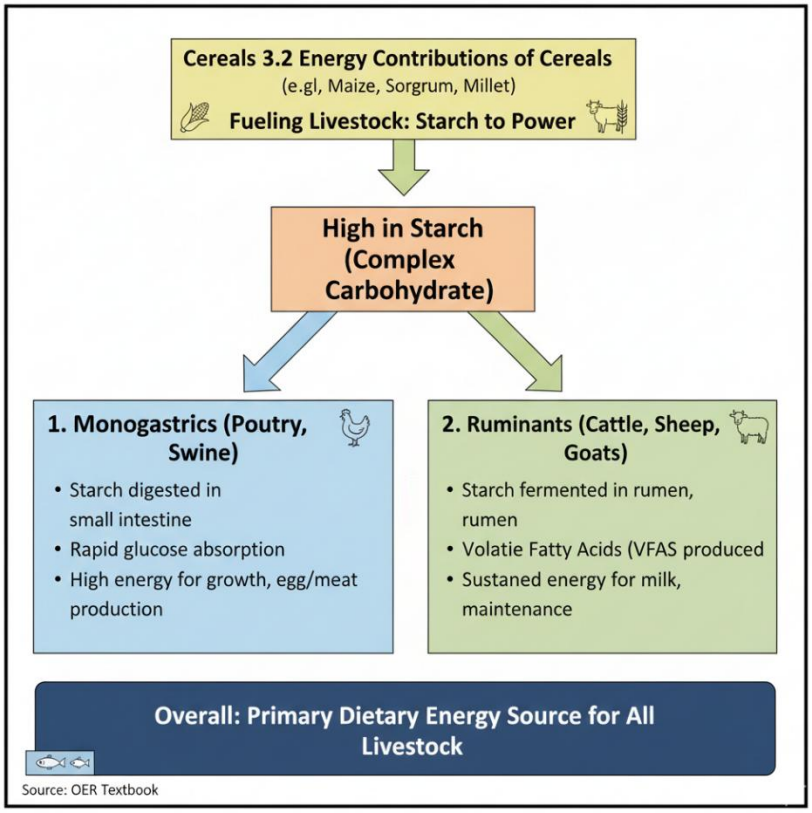


Figure 3.2 Energy contributions of cereals Sample

3.2.2 Protein and amino acid contributions of legumes

Legumes such as soybean, cowpea, and groundnut are valued for their **protein** and **amino acid** content. Proteins are essential for tissue development, reproduction, and milk production, while amino acids such as lysine and methionine are critical for growth. Legumes complement cereals by supplying amino acids that cereals lack, thereby improving the overall protein quality of diets. In Nigerian livestock systems, groundnut cake and soybean meal are widely used to boost protein intake in poultry and ruminant diets.

Legumes complement cereals by supplying essential _____ that cereals lack.

Table 3.2 Protein and amino acid contributions of legumes short description: Table comparing amino acid profiles of legumes and cereals.

Feature	Legume Meal (e.g., Soybean Meal)	Cereal Grain (e.g., Maize)	Significance for Feed Formulation
Crude Protein (CP) % (DM basis)	High ($40\% - 50\%$)	Low ($8\% - 12\%$)	Legumes are the primary source of protein supplementation.
Limiting Amino Acid	Methionine and Cysteine (S-AAs)	Lysine and Tryptophan	Amino acids that must be supplied through supplementation or complementary feeds.
Lysine Contribution	High	Low	Lysine is critical for muscle growth, and legumes are the primary source.
Methionine Contribution	Moderate/Low	Moderate	Methionine is important for feather/hair growth and is the usual limiting factor in legume-based diets.
Digestibility	Highly digestible protein (especially SBM)	Highly digestible starch (energy), but protein is less digestible.	Indicates the bioavailability of nutrients to the animal.
Role in Monogastric Diets	Protein Balancer (Supplies Lysine)	Energy Base (Supplies Starch)	Their complementary AA profiles allow nutritionists to create a

Feature	Legume Meal (e.g., Soybean Meal)	Cereal Grain (e.g., Maize)	Significance for Feed Formulation
			balanced diet by mixing them.

3.2.3 Fat and mineral contributions of oil seeds

Oil seeds such as groundnut, cottonseed, and sunflower contribute both **fats** and **minerals** to livestock diets. Fats are concentrated sources of energy, providing more than twice the energy of carbohydrates or proteins. They also supply essential fatty acids that support hormone production and cell membrane integrity. Minerals such as phosphorus and magnesium are present in oil seeds and play vital roles in metabolic regulation and bone development. Oil seed cakes, produced after oil extraction, remain valuable protein and fat sources in Nigerian feeding systems.

Oil seeds are important in livestock diets because they supply both _____ and minerals.

Contributions of Oil Seeds in Concentrate Feeds

Oil seeds, such as soybeans, groundnuts, and cottonseed, are vital components of concentrate feeds, offering a dense package of essential nutrients crucial for the health and productivity of livestock.

1. **Concentrated Energy Supply:**
    - **Contribution:** Oilseeds and their residual meals are rich in **fats and oils**, which provide approximately 2.25 times more metabolic energy per unit of weight than carbohydrates (cereals).
    - **Impact:** This high energy density is essential for formulating diets for high-producing animals, such as lactating dairy cows and broiler chickens, without excessive feed bulk.
2. **Source of Essential Fatty Acids (EFAs):**
    - **Contribution:** They are excellent sources of Polyunsaturated Fatty Acids (PUFAs), including **Linoleic Acid (Omega-6)** and **Alpha-Linolenic Acid (Omega-3)**, which the animals cannot synthesize themselves.

- **Impact:** EFAs are critical for maintaining cell membrane structure, optimizing reproductive function, and improving the quality of animal products (e.g., increasing Omega-3 content in eggs and meat).

3. **Protein and Amino Acid Contribution (in Meals):**
    - **Contribution:** After oil extraction, the remaining **oilseed meal** is a highly concentrated source of quality protein (often \$40\%-50\%\$ CP), rich in crucial amino acids like Lysine.
    - **Impact:** Oilseed meals are the most common and effective plant-based protein supplements used to balance cereal-heavy diets for monogastric animals (poultry, swine).
4. **Mineral Contribution:**
    - **Contribution:** Oilseeds often provide significant amounts of essential minerals, including **Phosphorus**, **Magnesium**, **Potassium**, and trace minerals.
    - **Impact:** They contribute to the overall mineral balance of the diet, reducing the need for high levels of synthetic mineral supplementation.

Pilot questions 3.2

1. What nutrient is the primary contribution of cereals in concentrate feeds?
2. Which amino acids do legumes supply that cereals often lack?
3. Why are legumes considered superior to cereals in terms of protein quality?
4. What makes fats from oil seeds more energy-dense than carbohydrates?
5. Name two minerals commonly found in oil seeds.

3.3 Practical Applications of Concentrate Feeds in Nigerian Livestock Systems

3.3.1 Role of concentrates in poultry diets

Concentrates are indispensable in poultry diets because they provide the dense nutrients required for rapid growth, egg production, and meat yield. **Cereals** such as maize supply energy, while **legumes** like soybean meal provide protein for tissue development. Oil seed cakes contribute fats and essential fatty acids that improve egg quality and overall productivity. Balanced concentrate diets ensure that poultry achieve high feed conversion efficiency, making them cost-effective for farmers.

Poultry diets rely heavily on concentrates because they provide _____ for growth and production.

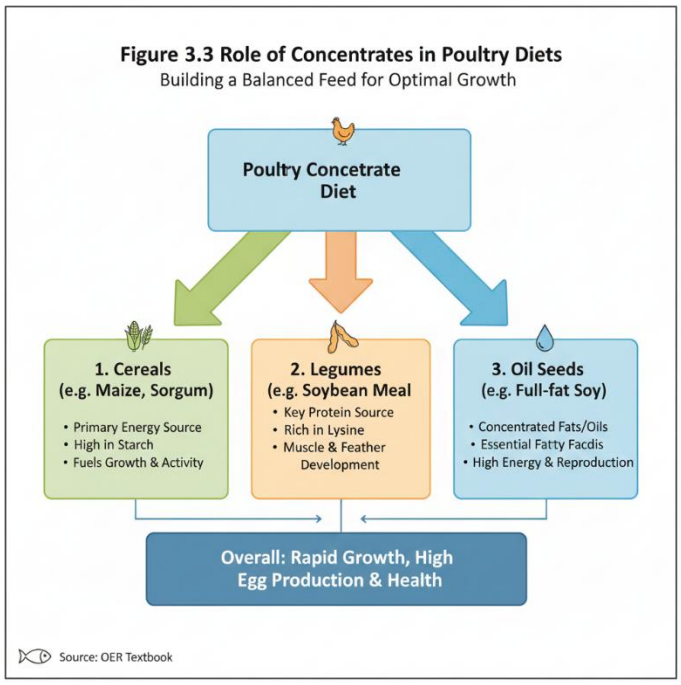


Figure 3.3 Role of concentrates in poultry diets Sample

3.3.2 Role of concentrates in ruminant diets

Although ruminants primarily consume forages, concentrates are used to supplement their diets, especially in intensive production systems. Cereals provide additional energy to support milk yield and weight gain, while legumes and oil seed cakes supply protein and fats to balance forage-based diets. Concentrates are particularly important for dairy cattle, fattening beef cattle, and high-producing goats, where nutrient demands exceed what forages alone can provide.

Concentrates are used in ruminant diets to supplement _____ provided by forages.

Plate 3.1 Dairy cattle consuming concentrate feeds Sample

3.3.3 Challenges and strategies in using concentrates

Despite their importance, concentrates present challenges in Nigerian livestock systems. High costs, seasonal availability, and competition with human food use often limit their accessibility. In addition, poor storage can lead to spoilage and nutrient loss. Strategies to overcome these challenges include sourcing locally available alternatives, adopting proper storage practices, and formulating rations that combine concentrates with forages to reduce costs. Farmers also explore agro-industrial by-products such as brewers' grains and cassava peels as affordable concentrate substitutes.

Concentrates are often expensive because they compete with _____ for human consumption.

Challenges and Strategies in Using Concentrate Feeds in Nigerian Livestock Systems

Concentrate feeds are essential for high productivity in modern Nigerian livestock systems, but their use is constrained by several economic and logistical challenges. Effective strategies must be employed to maximize their benefits.

Key Challenges

1. **High Cost and Price Volatility:**
    - **Issue:** Major ingredients like maize and soybean meal are often subjected to fierce competition with human consumption and industrial use, leading to high prices and frequent, unpredictable price increases.
    - **Impact:** This significantly raises the final cost of production, reducing profit margins for farmers.
2. **Seasonal Availability:**
    - **Issue:** The supply of major feedstuffs is often seasonal, peaking during harvest and becoming scarce and expensive during the off-season.
    - **Impact:** Farmers face inconsistency in feed supply and quality, complicating production planning.
3. **Quality and Adulteration Concerns:**
    - **Issue:** Due to poor regulation or lack of ethical practices, some commercially produced concentrates are adulterated (e.g., fillers added) or fail to meet the labeled nutrient specifications.
    - **Impact:** Animals receive unbalanced nutrition, leading to poor growth, low productivity, and health issues.

Effective Strategies

1. **Prioritize Local Sourcing of Non-Conventional Ingredients:**
    - **Strategy:** Shift partial reliance from standard concentrates to locally available, underutilized ingredients (e.g., cassava peels, palm kernel cake, spent grain, groundnut haulms).
    - **Benefit:** Reduces cost and dependence on volatile markets, improving local circular economy.
2. **Optimize Feed Ration Formulation:**
    - **Strategy:** Employ the services of qualified animal nutritionists to formulate diets using sophisticated methods (e.g., Linear Programming) that select the **least-cost combination** of ingredients while meeting all nutrient requirements.

- **Benefit:** Ensures that nutrients are supplied precisely, minimizing waste and over-supplementation.

3. **Invest in Proper Storage and Handling:**
    - **Strategy:** Store concentrates in cool, dry, and rodent-proof facilities to prevent spoilage, mould growth, and loss of nutritional value. Practice **First-In, First-Out (FIFO)** inventory.
    - **Benefit:** Extends the shelf life and maintains the quality of expensive feedstuffs, protecting the farmer's investment.

Pilot questions 3.3

1. Why are concentrates important in poultry diets?
2. How do concentrates complement forage-based diets in ruminants?
3. Name one challenge associated with the use of concentrates in Nigeria.
4. Give one strategy farmers use to overcome the high cost of concentrates.
5. Why are agro-industrial by-products considered useful in livestock feeding?

Series summary

This Series has examined the chemistry, nutritive values, and practical applications of concentrate feeds, focusing on cereals, legumes, and oil seeds. We began by exploring their chemical composition, highlighting carbohydrates in cereals, proteins in legumes, and oils and fatty acids in oil seeds. We then analysed their nutritive values, considering the energy contributions of cereals, the protein and amino acid contributions of legumes, and the fat and mineral contributions of oil seeds. Finally, we discussed their practical applications in Nigerian livestock systems, emphasising their role in poultry and ruminant diets, as well as the challenges and strategies associated with their use.

By completing this Series, you should now be able to define the chemical composition of concentrate feeds, explain the carbohydrate contributions of cereals, analyse the protein and amino acid contributions of legumes, evaluate the fat and mineral contributions of oil seeds, assess their practical applications in poultry and ruminant diets, and identify challenges and strategies for effective utilisation. These achievements directly align with the Series Learning Outcomes and provide you with the skills to apply concentrate feeds effectively in Nigerian livestock production.

Concept check questions [Series 3]

Objective questions

1. What nutrient is the primary contribution of cereals in concentrate feeds? (Linked to SLO 3.2)
2. Which amino acid is particularly abundant in legumes compared to cereals? (Linked to SLO 3.3)
3. Oil seeds are valued for their high _____ content. (Linked to SLO 3.4)
4. Which type of livestock relies most heavily on concentrates for rapid growth and production? (Linked to SLO 3.5)
5. Concentrates are often expensive because they compete with _____ for human consumption. (Linked to SLO 3.6)

Short-answer questions

6. Define concentrate feeds in one sentence. (Linked to SLO 3.1)

7. Explain why legumes complement cereals in livestock diets. (Linked to SLO 3.3)

8. Give one example of a mineral found in oil seeds and its importance. (Linked to SLO 3.4)

9. Describe the role of concentrates in poultry diets. (Linked to SLO 3.5)

10. Identify one strategy farmers use to overcome the high cost of concentrates. (Linked to SLO 3.6)

Long-answer questions

11. Analyse the nutritive contributions of cereals, legumes, and oil seeds, and explain how they complement each other in balanced livestock diets. (Linked to SLO 3.2, SLO 3.3, SLO 3.4)

12. Evaluate the challenges and strategies associated with concentrate use in Nigerian livestock systems, providing practical examples. (Linked to SLO 3.6)

Answers to Concept Check Questions [Series 3]

Objective questions

1. Carbohydrates.
2. Lysine.

3. Oil and fatty acids.
4. Poultry.
5. Human food.

Short-answer questions

6. Concentrate feeds are nutrient-rich feedstuffs, low in fibre, used to provide energy, protein, and fats.

7. Legumes supply essential amino acids such as lysine, which cereals lack, improving protein quality.

8. Phosphorus, important for bone development and metabolic regulation.

9. Concentrates provide energy, protein, and fats that support rapid growth, egg production, and meat yield.

10. Farmers use agro-industrial by-products such as brewers' grains or cassava peels as affordable substitutes.

Long-answer questions

11. **Basic response:** Cereals supply carbohydrates for energy, legumes provide protein and amino acids, and oil seeds contribute fats and minerals. Together, they complement each other to form balanced diets. **Value-added response:** Beyond their basic roles, cereals also provide fibre for rumen function, legumes improve soil fertility through nitrogen fixation, and oil seeds supply essential fatty acids that enhance reproductive performance. Combining them ensures both nutritional adequacy and sustainable farming practices.

12. **Basic response:** Challenges include high costs, seasonal availability, and competition with human food. Strategies include local sourcing, proper storage, supplementation, and use of agro-industrial by-products. **Value-added response:** In addition to these strategies, farmers adopt ration formulation techniques to balance costs, integrate forage legumes into pastures, and explore community-based feed cooperatives. These practices strengthen resilience and improve productivity in Nigerian livestock systems.

Answers to Pilot Questions [Series 3]

Part 3.1 Chemistry and composition of concentrate feeds

- Carbohydrates

- They provide higher protein quality
- Lysine
- Oils and fats provide more energy per unit weight
- Hormone production and cell membrane integrity

Part 3.2 Nutritive values and contributions of concentrates

- Starch
- Lysine and methionine
- They improve protein quality in diets
- Fats provide more than twice the energy of carbohydrates
- Phosphorus and magnesium

Part 3.3 Practical applications of concentrate feeds in Nigerian livestock systems

- Dense nutrients for growth and production
- Energy and protein supplementation
- High costs and seasonal availability
- Use of agro-industrial by-products
- They reduce feeding costs and provide affordable alternatives

Series 4: Nigerian Grasses and Legume Species: Composition and Value

Part 1: Composition of Nigerian grasses

- 4.1.1 Nutrient profile of common grasses
- 4.1.2 Seasonal variations in grass composition
- 4.1.3 Factors influencing grass quality

Part 2: Composition of Nigerian legumes

- 4.2.1 Nutrient profile of common legumes
- 4.2.2 Amino acid and mineral contributions
- 4.2.3 Factors influencing legume quality

Part 3: Value of grasses and legumes in livestock production

- 4.3.1 Role in ruminant diets
- 4.3.2 Role in non-ruminant diets
- 4.3.3 Practical importance and limitations

Introduction

Grasses and legumes form the backbone of livestock feeding systems in Nigeria. They are widely available, affordable, and provide essential nutrients that sustain both ruminant and non-ruminant animals. Understanding their composition and value is crucial for designing balanced diets and improving productivity, especially in systems where farmers rely heavily on natural pastures and crop residues.

The aim of this Series is to equip you with the knowledge to analyse the composition of Nigerian grasses and legumes and to evaluate their value in livestock production.

We shall commence this Series by examining the composition of Nigerian grasses, focusing on their nutrient profile, seasonal variations, and factors influencing quality. Next, we will explore the composition of Nigerian legumes, highlighting their amino acid and mineral contributions as well as the factors that affect their quality. Finally, we will wrap up by considering the value of grasses and legumes in livestock production, discussing their role in ruminant and non-ruminant diets, along with their practical importance and limitations.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 4.1** describe the nutrient profile of common Nigerian grasses.
- **SLO 4.2** explain the seasonal variations that affect the composition of grasses.
- **SLO 4.3** analyse the factors influencing the quality of Nigerian grasses.
- **SLO 4.4** describe the nutrient profile of common Nigerian legumes.
- **SLO 4.5** explain the amino acid and mineral contributions of legumes.
- **SLO 4.6** analyse the factors influencing the quality of Nigerian legumes.

- **SLO 4.7** evaluate the role of grasses and legumes in ruminant diets.
- **SLO 4.8** assess the role of grasses and legumes in non-ruminant diets.
- **SLO 4.9** identify the practical importance and limitations of grasses and legumes in Nigerian livestock production.

4.1 Composition of Nigerian Grasses

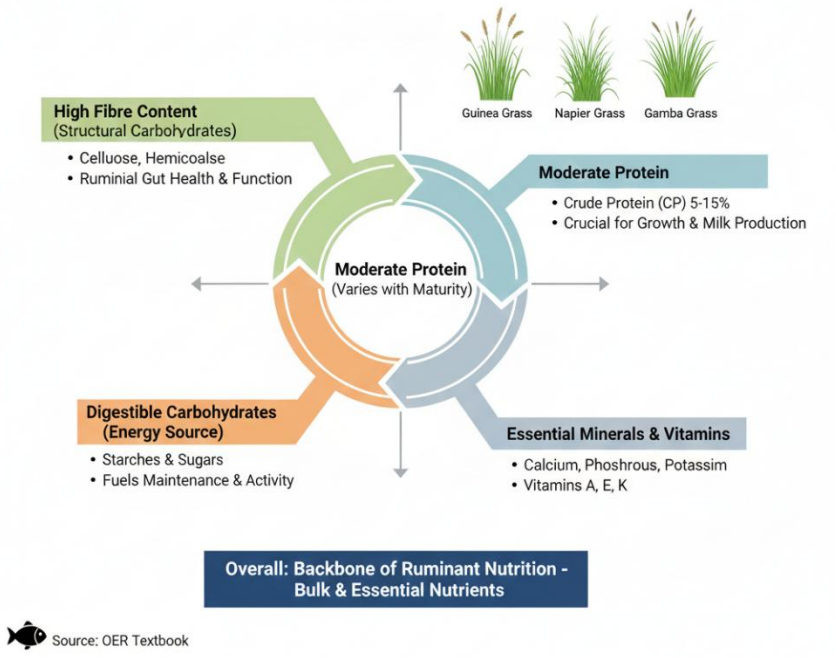
4.1.1 Nutrient profile of common grasses

Nigerian grasses such as guinea grass (Panicum maximum), elephant grass (Pennisetum purpureum), and gamba grass (Andropogon gayanus) are widely used in livestock feeding systems. Their composition is characterised by high **fibre**, which refers to indigestible plant material such as cellulose and lignin that supports rumen function in ruminants. They also contain moderate levels of **protein**, defined as nitrogen-containing compounds made up of amino acids, though this varies with species and stage of growth. Carbohydrates, mainly in the form of structural polysaccharides, provide energy, while minerals such as calcium and phosphorus are present in small amounts.

Grasses are generally characterised by high _____ content, which supports rumen function in ruminants.

Figure 4.1 Nutrient Profile of Nigerian Grasses

The Building Blocks of Ruminant Diets in Nigeria



Source: OER Textbook

Figure 4.1 Nutrient profile of Nigerian grasses Sample

4.1.2 Seasonal variations in grass composition

The nutrient composition of grasses changes with the seasons. During the rainy season, grasses are lush, with higher moisture and protein content, making them more digestible. In contrast, dry-season grasses become fibrous, with reduced protein and energy values. Seasonal variation therefore affects the quality of diets available to livestock, and farmers must plan supplementation strategies to maintain productivity.

Grasses are more nutritious during the _____ season compared to the dry season.

Table 4.1 Seasonal variations in nutrient composition of Nigerian grasses short description: Table comparing rainy-season and dry-season nutrient values (protein, fibre, energy

Nutrient Component	Rainy Season (High Growth/Immature)	Dry Season (Mature/Dormant)	Implications for Livestock
Crude Protein (CP)	High ($8\% - 15\%$)	Very Low ($2\% - 6\%$)	Low CP in the dry season is the primary cause of weight loss and reduced productivity, as it often falls below the 7% threshold needed for rumen microbial function.
Crude Fibre (CF) / Lignin	Low to Moderate	Very High	High fibre (lignin) reduces overall digestibility and intake, leading to a

Nutrient Component	Rainy Season (High Growth/Immature)	Dry Season (Mature/Dormant)	Implications for Livestock
			"belly full but starving" situation.
Energy (ME/GE)	Moderate (High Digestible Energy)	Low (Low Digestible Energy)	The energy value drops significantly because the high fibre content slows digestion and reduces the amount of metabolizable energy (ME) extracted.
Moisture Content	High ($>50\%$)	Low ($<10\%$)	High moisture contributes to lower dry matter intake; low moisture can make feed less palatable but helps preservation.
Palatability	High	Low	The grass is less appealing to animals due to hardness, lower succulence, and lower nutrient density.

4.1.3 Factors influencing grass quality

Several factors influence the quality of Nigerian grasses. **Stage of growth** is critical, as younger grasses contain more protein and less fibre, while mature grasses are fibrous and less digestible. **Soil fertility** also plays a role, with nutrient-rich soils producing grasses higher in minerals such as calcium and phosphorus. **Management practices** such as grazing intensity and cutting frequency affect regrowth and nutrient content. These factors must be considered when evaluating the feeding value of grasses in Nigerian livestock systems.

Grass quality declines as plants reach _____ maturity.

Pilot questions 4.1

1. What is the main nutrient component of Nigerian grasses?
2. How does the nutrient composition of grasses change between rainy and dry seasons?
3. Name two minerals commonly found in Nigerian grasses.
4. Why are younger grasses considered more nutritious than mature grasses?
5. List three factors that influence the quality of Nigerian grasses

4.2 Composition of Nigerian Legumes

4.2.1 Nutrient profile of common legumes

Legumes such as cowpea (Vigna unguiculata), groundnut (Arachis hypogaea), and soybean (Glycine max) are widely cultivated in Nigeria and serve as important feed resources. Their composition is characterised by high **protein**, which refers to nitrogen-containing compounds made up of amino acids essential for growth, reproduction, and milk production. Legumes also contain moderate levels of **carbohydrates**, mainly in the form of starch, and valuable **minerals** such as calcium, phosphorus, and potassium. Compared to grasses, legumes are richer in protein and minerals, making them excellent supplements in livestock diets.

Legumes are generally richer in _____ compared to grasses.

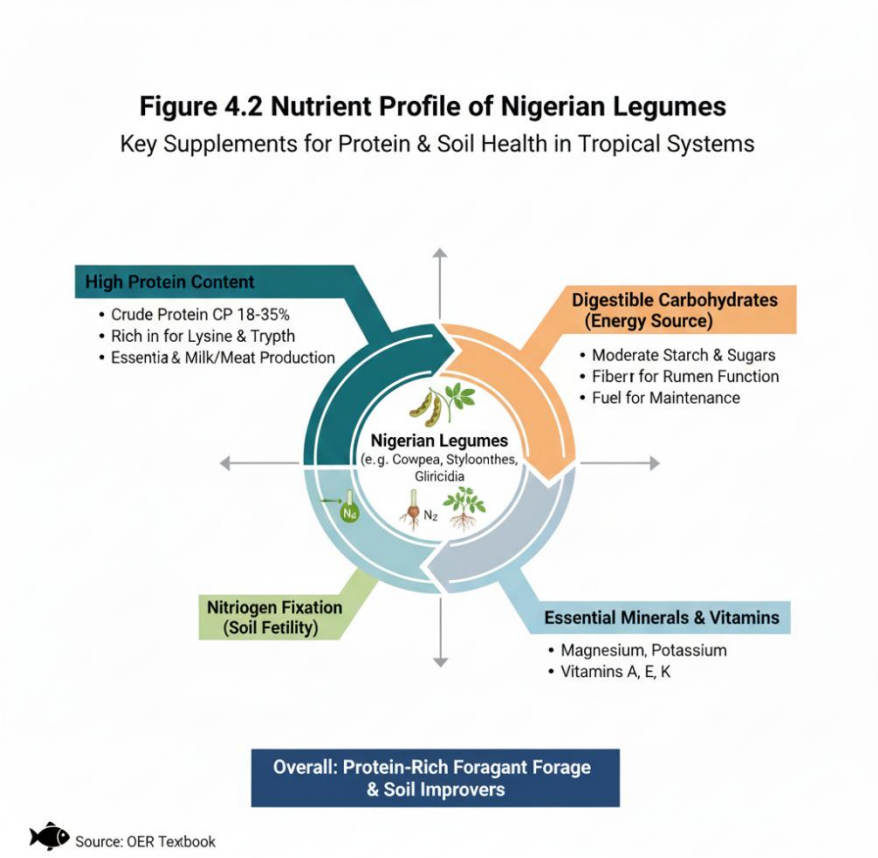


Figure 4.2 Nutrient profile of Nigerian legumes Sample

4.2.2 Amino acid and mineral contributions

Legumes are particularly valued for their amino acid profile. **Amino acids** are the building blocks of proteins, and legumes supply essential amino acids such as lysine and methionine, which are often deficient in cereal-based diets. This makes legumes an excellent complement to cereals in balanced rations. In addition, legumes contribute important minerals such as calcium and phosphorus, which are vital for bone development and metabolic regulation.

Legumes complement cereals by supplying essential _____ that cereals lack.

Table 4.2 Amino acid and mineral contributions of Nigerian legumes Short description: Table comparing amino acid and mineral contributions of legumes and cereals

Nutrient Component	Legume Meal (Protein Source)	Cereal Grain (Energy Source)	Significance in Livestock Diet
Amino Acid: Lysine	High Concentration	Low Concentration (Limiting)	Crucial for muscle growth, antibody formation, and production. Legumes are the indispensable source.
Amino Acid: Methionine	Moderate to Low (Limiting)	Moderate	Important for feather/hair growth and is the most common limiting AA when high levels of SBM are used.
Protein Quality	High (Excellent source of most EAAs)	Low (Poorly balanced AA profile)	Legumes are necessary to raise the overall protein quality and content of the final feed mix.
Total Phosphorus (P)	High	Moderate	Legumes contribute significantly to the total P requirement; however, much of the P is bound as phytate in both.
Calcium (Ca)	Moderate to High	Low	Legumes generally provide a better contribution to Ca than cereals, though both often require supplementation.

Nutrient Component	Legume Meal (Protein Source)	Cereal Grain (Energy Source)	Significance in Livestock Diet
Trace Minerals (Fe, Mn, Zn)	High	Moderate	Legumes (especially oilseeds) are richer in essential trace minerals, aiding in metabolism and immunity.

4.2.3 Factors influencing legume quality

The quality of legumes as feed resources is influenced by several factors. **Stage of harvest** is important, as immature legumes may have higher moisture but lower protein, while properly matured legumes provide optimal nutrient content. **Soil fertility** affects mineral composition, with nutrient-rich soils producing legumes higher in calcium and phosphorus. **Processing methods** such as drying, roasting, or oil extraction also influence nutrient availability, as some methods may reduce anti-nutritional factors and improve digestibility.

Legume quality is influenced by factors such as stage of harvest, _____, and processing methods.

Factors Influencing Legume Quality

The nutritional value and suitability of legumes for livestock feed (both as forage and as concentrate meals) are highly dependent on several management and processing factors.

1. **Stage of Harvest/Maturity:**
   - **Factor:** The age of the plant when harvested is the single most critical factor for forage legumes (e.g., cowpea hay).
   - **Influence:** Immature legumes (pre-flowering) have a **higher Crude Protein (CP) content** and **lower fibre/lignin content**, making them more digestible. As the plant matures, CP decreases and indigestible fibre increase significantly.
2. **Soil Fertility and Fertilizer Application:**
   - **Factor:** The availability of essential soil nutrients, especially Phosphorus and Sulfur, can directly impact the legume's nutritional composition.

- **Influence:** Good soil fertility enhances the synthesis of **protein and minerals** in the plant tissue, leading to a nutritionally superior feedstuff. Poor soils result in stunted growth and lower nutrient concentration.

3. **Post-Harvest Processing Methods (for Concentrate Meals):**
    - **Factor:** The methods used to process oil seeds into meals (e.g., heat treatment, solvent extraction).
    - **Influence:** Adequate **heat treatment** (e.g., roasting soybeans) is necessary to **deactivate Anti-Nutritional Factors (ANFs)** like trypsin inhibitors, thereby improving protein digestibility and safety. However, excessive heat can damage beneficial amino acids (e.g., Lysine), reducing overall quality.
4. **Drying and Storage Conditions:**
    - **Factor:** How the harvested legume (whether forage or seed) is dried and stored.
    - **Influence:** Inadequate drying or high-moisture storage encourages **mould growth (mycotoxins)** and leads to the degradation of proteins and energy. Proper drying and dry storage are essential to preserve nutritional integrity.

Pilot questions 4.2

1. What is the main nutrient contribution of Nigerian legumes?
2. Name two minerals commonly found in legumes.
3. Which amino acids do legumes supply that cereals often lack?
4. How does soil fertility influence the quality of legumes?
5. List three factors that influence legume quality.

4.3 Value of Grasses and Legumes in Livestock Production

4.3.1 Role in ruminant diets

Grasses and legumes are the foundation of ruminant diets in Nigeria. **Ruminants** are animals such as cattle, sheep, and goats that possess a rumen, a specialised stomach chamber where microbial fermentation occurs. Grasses provide bulk and fibre, which stimulate rumination and support microbial activity, while legumes supply protein and minerals that enhance growth, milk yield, and reproductive performance. Together, they form balanced diets that sustain ruminant productivity under grazing systems.

Ruminants depend on grasses for fibre and legumes for _____ in their diets.

Plate 4.1 Cattle grazing on mixed grasses and legumes in Nigeria Sample

4.3.2 Role in non-ruminant diets

Although non-ruminants such as poultry and pigs cannot digest fibre as efficiently as ruminants, legumes and certain grasses still contribute to their diets. Legume seeds and by-products such as soybean meal and groundnut cake provide high-quality protein for growth and egg production. Grasses may be used in limited amounts as fresh forage or processed into meals for pigs and rabbits. The inclusion of legumes in non-ruminant diets improves amino acid balance, complementing cereal-based feeds.

Non-ruminants benefit from legumes because they supply high-quality _____ for growth and production.

Table 4.3 Contributions of grasses and legumes to non-ruminant diets Short description: Table comparing the roles of grasses and legumes in poultry, pigs, and rabbits.

Feed Type	Target Non-Ruminant	Primary Contribution of Grasses (Hay/Meal)	Primary Contribution of Legumes (Meal/Forage)	Key Limitation
Grasses (High Fibre)	Poultry/Swine	Minor/Zero (Except for specialty diets)	Zero/Minor (Except for young animals or certain breeding stock)	High Fibre (CF) and Lignin: Non-ruminants cannot digest high fibre efficiently, leading to low energy intake and bulky manure.
	Rabbits	Essential Fibre Source (Hay/Fresh)	Excellent Protein and Mineral Source (Leafy Forage)	Energy Density: Even for rabbits, grasses alone are too low in energy for maximum growth and production.
Legumes (High Protein)	Poultry/Swine	N/A	Protein & Amino Acids: Legume meals (Soybean Meal) are the primary source of Lysine and protein, balancing cereal energy.	Anti-Nutritional Factors (ANFs): Raw legumes must be processed (heated) to deactivate ANFs that inhibit protein digestion.

Feed Type	Target Non-Ruminant	Primary Contribution of Grasses (Hay/Meal)	Primary Contribution of Legumes (Meal/Forage)	Key Limitation
Processed Grains (Cereals)	Poultry/Swine	N/A	N/A	Energy Base: Cereals are the primary energy source in these diets, complemented by legume protein.

4.3.3 Practical importance and limitations

Grasses and legumes are practical feed resources because they are widely available, affordable, and sustainable. They reduce dependence on expensive concentrates and support smallholder livestock systems. However, limitations exist. Seasonal variation reduces quality during the dry season, while overgrazing and poor pasture management can lead to land degradation. Farmers must adopt strategies such as rotational grazing, forage conservation, and integration of legumes into pastures to maximise their value.

Grasses and legumes are limited by seasonal variation and _____ caused by poor management.

Box 4.3 Practical importance and limitations of grasses and legumes Short description: Box highlighting availability, affordability, seasonal variation, and management challenges of grasses and legumes.

Importance Factor	Description
Availability and Affordability	Grasses and legumes (either natural pasture or cultivated) are the cheapest and most accessible feed source, particularly in rural and pastoral systems. They reduce the reliance on expensive, purchased concentrate feeds.

Importance Factor	Description
Nutrient Base	Grasses provide the bulk of energy (carbohydrates) and fill the animal's rumen. Legumes provide vital protein and essential minerals, especially for ruminants, by fixing atmospheric nitrogen into the soil.
Fibre for Rumen Health	Grasses provide the Effective Fibre (eNDF) necessary to stimulate rumination, saliva production, and maintain a healthy, stable rumen pH, which is essential for microbial activity.
Sustainability	Utilizing forage is environmentally sustainable, as legumes improve soil fertility through nitrogen fixation, and proper pasture management prevents erosion.

Pilot questions 4.3

1. Why are grasses and legumes important in ruminant diets?
2. How do legumes improve non-ruminant diets?
3. Name one example of a legume by-product used in poultry diets.
4. What are two limitations of grasses and legumes in Nigerian livestock systems?
5. Suggest one strategy farmers can use to overcome seasonal variation in grass quality.

Series summary

This Series has focused on the composition and value of Nigerian grasses and legumes, which form the backbone of livestock feeding systems. We began by examining the nutrient profile of common grasses, highlighting their fibre, protein, and carbohydrate content, as well as seasonal variations and factors influencing quality. We then explored the composition of Nigerian legumes, emphasising their protein richness, amino acid contributions, and mineral values, along with the factors that affect their quality. Finally, we considered the value of grasses and legumes in livestock production, discussing their role in ruminant and non-

ruminant diets, their practical importance, and the limitations farmers face in using them.

By completing this Series, you should now be able to describe the nutrient profiles of Nigerian grasses and legumes, explain seasonal variations and factors influencing their quality, analyse their amino acid and mineral contributions, evaluate their role in ruminant and non-ruminant diets, and identify their practical importance and limitations. These achievements directly align with the Series Learning Outcomes and provide you with the skills to apply grasses and legumes effectively in Nigerian livestock systems.

Concept check questions [Series 4]

Objective questions

1. What is the main nutrient component of Nigerian grasses? (Linked to SLO 4.1)
2. During which season are grasses more nutritious? (Linked to SLO 4.2)
3. Which amino acid is particularly abundant in legumes compared to cereals? (Linked to SLO 4.5)
4. Legumes are richer in _____ compared to grasses. (Linked to SLO 4.4)
5. Poor pasture management can lead to _____. (Linked to SLO 4.9)

Short-answer questions

6. Explain why younger grasses are considered more nutritious than mature grasses. (Linked to SLO 4.3)
7. Name two minerals commonly found in Nigerian legumes. (Linked to SLO 4.5)
8. Describe the role of legumes in non-ruminant diets. (Linked to SLO 4.8)
9. Identify one limitation of grasses and legumes in Nigerian livestock systems. (Linked to SLO 4.9)
10. Suggest one strategy farmers can use to overcome seasonal variation in grass quality. (Linked to SLO 4.9)

Long-answer questions

11. Analyse the nutrient profiles of Nigerian grasses and legumes, and explain how they complement each other in balanced diets. (Linked to SLO 4.1, SLO 4.4)

12. Evaluate the practical importance and limitations of grasses and legumes in Nigerian livestock production, providing examples of strategies to maximise their value. (Linked to SLO 4.9)

Answers to Concept Check Questions [Series 4]

Objective questions

1. Fibre.
2. Rainy season.
3. Lysine.
4. Protein.
5. Land degradation.

Short-answer questions

6. Younger grasses contain more protein and less fibre, making them more digestible and nutritious.

7. Calcium and phosphorus.

8. Legumes provide high-quality protein and amino acids that complement cereal-based feeds in poultry and pigs.

9. Seasonal variation reduces quality during the dry season.

10. Farmers can conserve forage through silage or hay making.

Long-answer questions

11. **Basic response:** Grasses provide fibre and carbohydrates, while legumes supply protein and minerals. Together, they complement each other to form balanced diets. **Value-added response:** Beyond their basic roles, grasses stimulate rumination and microbial activity, while legumes improve amino acid balance and soil fertility through nitrogen fixation. Their combination enhances both animal nutrition and sustainable farming practices.

12. **Basic response:** Grasses and legumes are important because they are widely available and affordable, but limitations include seasonal variation and poor management. Strategies such as rotational grazing and forage conservation help overcome these challenges. **Value-added response:** In addition to these strategies, integrating forage legumes into pastures improves protein supply, while community-based grazing management prevents land degradation. These practices strengthen resilience and productivity in Nigerian livestock systems.

Answers to Pilot Questions [Series 4]

Part 4.1 Composition of Nigerian grasses

- Fibre
- Rainy season grasses are more nutritious
- Calcium and phosphorus
- They contain more protein and less fibre
- Stage of growth, soil fertility, management practices

Part 4.2 Composition of Nigerian legumes

- Protein
- Calcium and potassium
- Lysine and methionine
- It affects mineral composition and nutrient content
- Stage of harvest, soil fertility, processing methods

Part 4.3 Value of grasses and legumes in livestock production

- Fibre from grasses and protein from legumes
- They improve amino acid balance and protein quality
- Groundnut cake or soybean meal
- Seasonal variation and poor pasture management
- Forage conservation through silage or hay making

Series 5: Storage and Quality Control of Feeding Stuffs and Feeds

Part 1: Principles of feed storage

- 5.1.1 Importance of proper storage
- 5.1.2 Methods of storing dry and moist feeds
- 5.1.3 Factors affecting feed stability

Part 2: Quality control measures in feeding stuffs

- 5.2.1 Physical and sensory evaluation of feeds
- 5.2.2 Chemical and microbiological testing
- 5.2.3 Standards and regulations for feed quality

Part 3: Challenges and strategies in storage and quality control

- 5.3.1 Common storage problems and spoilage
- 5.3.2 Strategies for maintaining feed quality
- 5.3.3 Role of farmers and feed industries in quality assurance

Introduction

Feeds are only as valuable as the way they are stored and managed. Even the most nutrient-rich rations can lose their effectiveness if exposed to poor storage conditions, contamination, or spoilage. In Nigerian livestock systems, where farmers often struggle with seasonal availability and limited resources, proper storage and quality control are essential for sustaining productivity and ensuring animal health.

The aim of this Series is to introduce you to the principles of feed storage and quality control, equipping you with practical knowledge to preserve feed value and maintain standards in livestock production.

We shall commence this Series by examining the principles of feed storage, focusing on why proper storage is important, the methods used for dry and moist feeds, and the factors that affect feed stability. Next, we will explore quality control measures, including physical and sensory evaluation, chemical and microbiological testing, and the role of standards and regulations. Finally, we will wrap up by discussing the challenges faced in storage and quality control, along with strategies and the roles of farmers and feed industries in ensuring quality assurance.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 5.1** define the importance of proper storage in maintaining feed quality.
- **SLO 5.2** describe methods of storing dry and moist feeds.
- **SLO 5.3** analyse the factors that affect feed stability during storage.

- **SLO 5.4** demonstrate how to carry out physical and sensory evaluation of feeds.
- **SLO 5.5** explain the role of chemical and microbiological testing in feed quality control.
- **SLO 5.6** identify standards and regulations governing feed quality.
- **SLO 5.7** evaluate common storage problems and spoilage in feeding stuffs.
- **SLO 5.8** propose strategies for maintaining feed quality under Nigerian livestock conditions.
- **SLO 5.9** assess the role of farmers and feed industries in quality assurance.

5.1 Principles of Feed Storage

5.1.1 Importance of proper storage

Proper storage of feeds is essential to maintain their **nutritional quality**, which refers to the ability of feeds to retain their nutrients such as protein, energy, vitamins, and minerals until they are consumed by animals. Without adequate storage, feeds may deteriorate due to moisture, pests, or microbial contamination, leading to nutrient loss and health risks for livestock. Effective storage also reduces wastage, ensures feed availability during scarce periods, and improves farm profitability.

Feeds must be stored properly to prevent _____ loss and contamination.

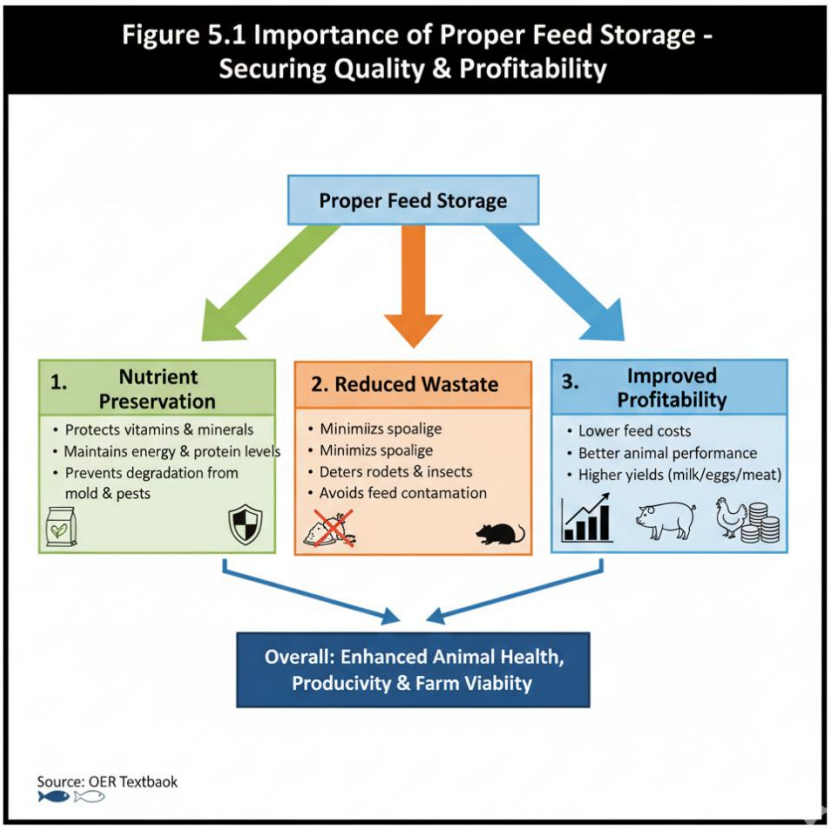


Figure 5.1 Importance of proper feed storage Sample

5.1.2 Methods of storing dry and moist feeds

Different feeds require different storage methods. **Dry feeds**, such as grains and pellets, should be stored in airtight containers, silos, or bags kept in cool, dry environments to prevent moisture absorption and insect infestation. **Moist feeds**, such as silage and fresh forage, require anaerobic conditions to prevent spoilage. Silage is stored in pits, trenches, or plastic-wrapped bales to exclude air and encourage fermentation, which preserves nutrients. Hay, although dry, must be protected from rain and excessive humidity to prevent mould growth.

Dry feeds should be stored in _____ containers to prevent moisture absorption.

Plate 5.1 Storage methods for dry and moist feeds Sample

5.1.3 Factors affecting feed stability

Feed stability refers to the ability of feeds to retain their quality over time. Several factors influence stability. **Moisture content** is critical, as high moisture encourages mould growth and nutrient loss. **Temperature** also plays a role, with high temperatures accelerating spoilage and reducing vitamin content. **Light exposure** can degrade sensitive nutrients such as vitamins A and E. In addition, **pest activity** such as rodents and insects can damage stored feeds. Farmers must therefore monitor these factors closely to ensure feeds remain safe and nutritious.

Feed stability is reduced when feeds are exposed to excessive _____, temperature, and pests.

Factors Affecting Feed Stability

Feed stability refers to the ability of feed to maintain its nutritional value, palatability, and safety over time. Several environmental and biological factors can compromise this stability:

1. **Moisture Content:**
    - **Effect:** The most critical factor. High moisture content ($>12\%-14\%$ depending on the feed type) provides an ideal environment for the growth of molds, yeasts, and bacteria.
    - **Implication:** This leads to nutrient loss, production of harmful **mycotoxins** (a major concern in Nigeria), and spoilage/caking of the feed.
2. **Temperature:**
    - **Effect:** High ambient temperatures, especially when combined with high humidity, accelerate chemical reactions (like fat oxidation) and microbial activity.
    - **Implication:** This can cause the feed to spoil faster and reduces the nutritional value of heat-sensitive components like vitamins and certain proteins.
3. **Light Exposure:**
    - **Effect:** Direct sunlight and high-intensity light can degrade light-sensitive vitamins (e.g., Vitamin A and Riboflavin) and promote the oxidation of fats.
    - **Implication:** Storage facilities should minimize direct exposure to sunlight to preserve essential micronutrients.
4. **Pest and Vermin Activity:**
    - **Effect:** Insects (e.g., weevils), rodents, and birds consume the feed, contaminate it with droppings, and spread disease-causing organisms.
    - **Implication:** This results in significant quantitative loss, reduces feed quality, and poses health risks to the animals.

Pilot questions 5.1

1. Why is proper storage important in livestock feeding systems?
2. How should dry feeds such as grains be stored?
3. What storage method is used for silage?
4. Name two factors that affect feed stability.
5. How does light exposure affect feed quality?

5.2 Quality Control Measures in Feeding Stuffs

5.2.1 Physical and sensory evaluation of feeds

One of the first steps in ensuring feed quality is **physical and sensory evaluation**, which refers to the use of sight, touch, and smell to assess feed characteristics. Farmers and feed millers often check for colour, texture, odour, and the presence of foreign materials. For example, mouldy feeds may appear discoloured and have a musty smell, while good-quality grains are bright and uniform in appearance. Sensory evaluation is simple, cost-effective, and can quickly identify obvious defects before feeds are offered to animals.

Physical and sensory evaluation of feeds involves checking for _____, texture, odour, and foreign materials.

Figure 5.1 Physical and sensory evaluation of feeds Sample

5.2.2 Chemical and microbiological testing

Beyond sensory checks, **chemical testing** is used to determine the nutrient composition of feeds. This involves laboratory analysis of protein, fibre, fat, and mineral content to ensure feeds meet nutritional standards. **Microbiological testing** refers to the identification of harmful microorganisms such as bacteria, fungi, and moulds that may contaminate feeds. These tests are critical for preventing diseases and ensuring animal health. For example, aflatoxin contamination in maize can be detected through microbiological assays, protecting livestock from poisoning.

Chemical testing helps determine nutrient composition, while microbiological testing identifies harmful _____ in feeds.

Table 5.1 Examples of chemical and microbiological tests in feed quality control short description: Table listing chemical tests (protein, fibre, fat, minerals) and microbiological tests (bacteria, fungi, toxins).

Test Category	Specific Test Examples	Purpose in Feed Quality Control
I. Chemical Analysis (Nutrient Content & Purity)	Crude Protein (CP) determination (Kjeldahl or combustion method)	Confirms the protein level matches the label/standard, essential for growth diets.
	Crude Fibre (CF) and Acid Detergent Fibre (ADF)/Neutral Detergent Fibre (NDF)	Assesses the digestibility and bulk of the feed, critical for ruminant diets.
	Ether Extract (EE) for Fat Content	Measures energy content; checks for excessive fat which can lead to rancidity.
	Ash Content & Specific Minerals (Ca, P, Na)	Determines the total inorganic matter and verifies essential mineral fortification levels.
	Urea/Ammonia Test	Measures non-protein nitrogen (NPN) to ensure safe inclusion levels in ruminant feeds.
II. Microbiological Analysis (Safety & Hygiene)	Total Plate Count (TPC) for Bacteria	Indicates overall hygienic quality and potential contamination.

Test Category	Specific Test Examples	Purpose in Feed Quality Control
	Yeast and Mold Count	**Identifies potential for spoilage and the risk of mycotoxin production.**
	Mycotoxin Screening (e.g., Aflatoxin, Zearalenone)	**Crucial safety test to detect dangerous toxins produced by fungi, which are common contaminants in improperly stored grains.**
	Detection of Specific Pathogens (e.g., *Salmonella*)	**Ensures the feed is safe and does not transmit diseases to the livestock or humans.**

5.2.3 Standards and regulations for feed quality

Quality control is guided by **standards and regulations**, which are official guidelines set by government agencies and international organisations to ensure feed safety and consistency. In Nigeria, agencies such as the Standards Organisation of Nigeria (SON) and the National Agency for Food and Drug Administration and Control (NAFDAC) regulate feed production and distribution. These standards cover nutrient requirements, permissible levels of contaminants, and labelling practices. Compliance with regulations not only protects animal health but also builds consumer confidence in livestock products.

Feed quality standards are enforced by agencies such as _____ and NAFDAC in Nigeria.

Standards and Regulations for Feed Quality in Nigeria

Feed quality control in Nigeria is managed by a combination of national regulatory bodies and adherence to international guidelines to ensure safety, efficacy, and fair-trade practices.

1. **Standards Organisation of Nigeria (SON):**

- **Role:** SON is responsible for setting and enforcing **mandatory standards** for livestock feed products (raw materials, concentrates, and finished feeds). These standards define minimum nutrient levels, permissible moisture limits, and acceptable levels of contaminants.
- **Implication:** Feeds must obtain the SON certification mark (MANCAP) to be legally produced and sold in Nigeria.

2. **National Agency for Food and Drug Administration and Control (NAFDAC):**
    - **Role:** While primarily focused on human food and drugs, NAFDAC plays a crucial role in regulating the **safety of feed ingredients** and ensuring that feeds do not contain harmful residues (like heavy metals or certain antibiotics) that could transfer to animal products (meat, milk, eggs) and pose a risk to human health.
    - **Implication:** NAFDAC registration is mandatory for certain specialized feed additives and medicated feeds.
3. **International Guidelines (Codex Alimentarius):**
    - **Role:** Nigerian producers and exporters often adhere to international standards, particularly those set by the **Codex Alimentarius Commission (CAC)**, which provides guidelines on animal feeding, good manufacturing practices (GMP), and maximum limits for residues (e.g., mycotoxins and pesticides).
    - **Implication:** Compliance ensures that Nigerian products meet global quality benchmarks, facilitating international trade.

Pilot questions 5.2

1. What is the purpose of physical and sensory evaluation of feeds?
2. Name two characteristics checked during sensory evaluation.
3. What is the role of chemical testing in feed quality control?
4. Give one example of a harmful microorganism detected through microbiological testing.
5. Which agencies regulate feed quality in Nigeria?

5.3 Challenges and Strategies in Storage and Quality Control

5.3.1 Common storage problems and spoilage

Feeds are highly susceptible to spoilage if not stored properly. One major issue is **mould growth**, which refers to the development of fungi in moist or poorly

ventilated storage conditions. Moulds not only reduce feed quality but may also produce toxins harmful to livestock. Another common problem is **insect infestation**, where pests such as weevils damage grains and reduce their nutritive value. Poor storage practices can also lead to **nutrient loss**, especially of vitamins and proteins, when feeds are exposed to sunlight, heat, or moisture.

Feeds are prone to spoilage when exposed to excessive _____ or poor ventilation.

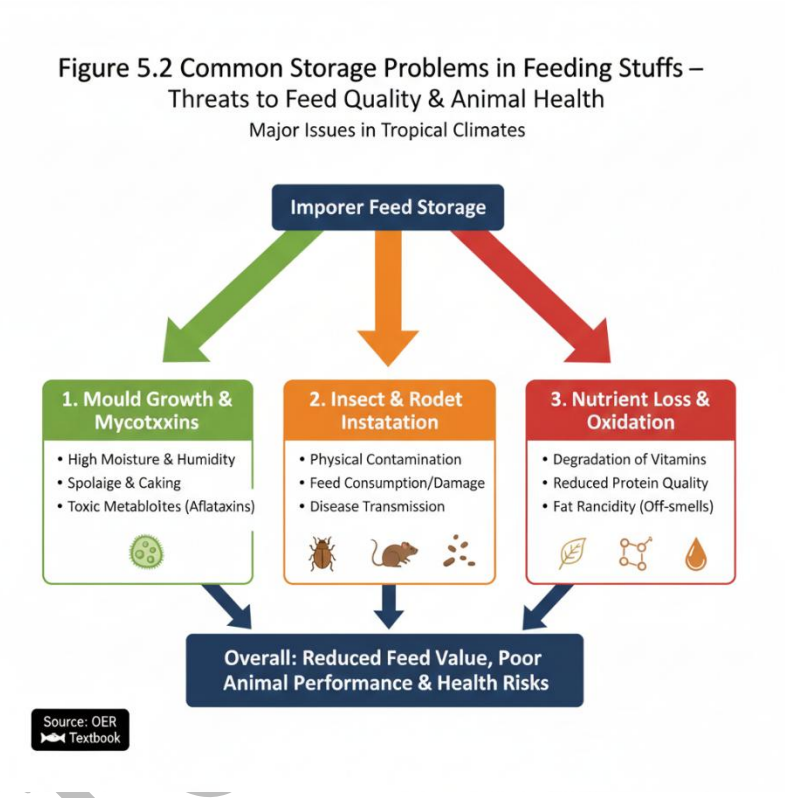


Figure 5.2 Common storage problems in feeding stuffs Sample

5.3.2 Strategies for maintaining feed quality

To overcome these challenges, farmers and feed industries adopt several strategies. **Proper storage facilities**, such as silos and airtight containers, help prevent moisture entry and pest infestation. **Regular inspection** ensures early detection of spoilage or contamination. **Use of preservatives**, such as organic acids, can inhibit mould growth and extend shelf life. In addition, **forage conservation methods** like silage and hay making preserve nutrients for dry-season feeding. These strategies collectively safeguard feed quality and ensure livestock receive safe and nutritious diets.

One effective strategy for maintaining feed quality is the use of _____ to inhibit mould growth.

Strategies for Maintaining Feed Quality

Maintaining the quality of livestock feed is essential to optimize animal performance, prevent disease, and ensure economic viability. Key strategies focus on management, preservation, and monitoring:

1. **Utilize Proper Storage Facilities:**
    - **Strategy:** Construct and use storage facilities (like silos, well-ventilated sheds, or barns) that are **cool, dry, and protected** from the elements. Floors should be raised concrete.
    - **Goal:** Minimize moisture absorption and maintain low temperatures, which are critical for preventing mould growth and nutrient degradation.
2. **Implement Regular Inspection and Inventory Management:**
    - **Strategy:** Routinely inspect stored feeds for signs of spoilage (caking, off-odour, mould) and pest activity. Practice **First-In, First-Out (FIFO)** inventory management.
    - **Goal:** Identify and isolate spoiled batches immediately to prevent widespread contamination and ensure that older, more vulnerable feed is used up quickly.
3. **Use of Preservatives and Additives:**
    - **Strategy:** Employ chemical preservatives like **Propionic Acid** to inhibit mold and fungal growth in grains, or **Antioxidants** to prevent the rancidity (oxidation) of fats in finished feeds.
    - **Goal:** Extend the shelf life and nutritional integrity of high-risk ingredients, particularly in hot, humid climates like Nigeria.
4. **Practice Forage Conservation Techniques:**
    - **Strategy:** Convert excess wet-season forage into stable forms like **hay** (low-moisture, sun-dried) or **silage** (anaerobically fermented) for use during the dry season.
    - **Goal:** Ensure a consistent supply of quality feed throughout the year, bridging the seasonal feed gap and avoiding reliance on expensive concentrates.

5.3.3 Role of farmers and feed industries in quality assurance
Quality assurance requires active participation from both farmers and feed industries. Farmers must adopt good storage practices, monitor feed regularly, and avoid feeding spoiled materials to animals. Feed industries play a role by adhering to production standards, conducting laboratory testing, and ensuring proper

packaging and labelling. Collaboration between farmers, industries, and regulatory agencies strengthens the overall feed value chain and protects animal health.

Farmers and feed industries must collaborate with _____ agencies to ensure quality assurance.

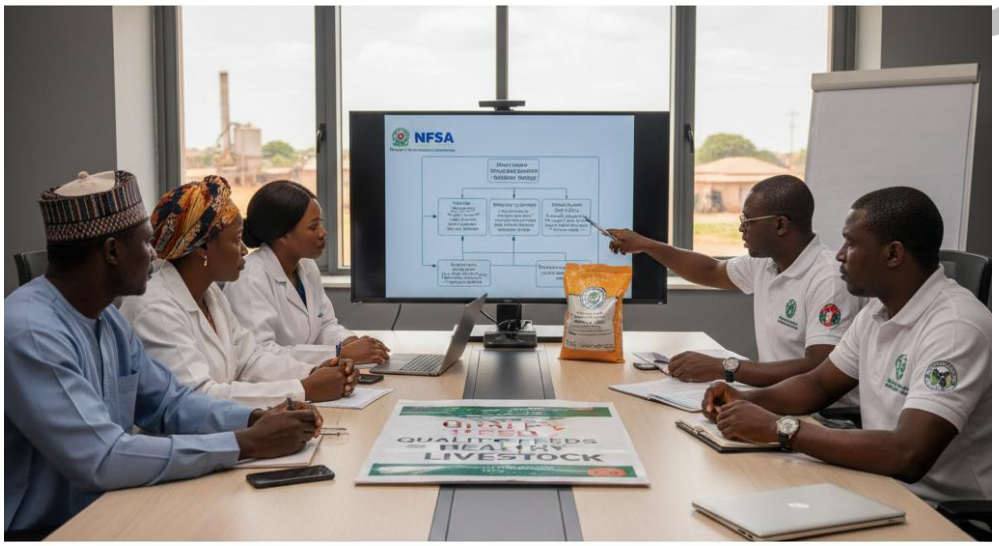


Plate 5.2 Collaboration in feed quality assurance

Plate 5.2 Collaboration in feed quality assurance Sample

Pilot questions 5.3

1. What is one common storage problem affecting feeds?
2. How do insect infestations reduce feed quality?
3. Name one preservative used to inhibit mould growth in feeds.
4. What role do farmers play in feed quality assurance?
5. Why is collaboration with regulatory agencies important in maintaining feed quality?

Series summary

This Series has examined the storage and quality control of animal feeds, which are critical for maintaining livestock health and productivity. We began by exploring the principles of feed storage, highlighting the importance of proper storage, methods for dry and moist feeds, and the factors that affect feed stability. We then considered quality control measures, including physical and sensory evaluation, chemical and microbiological testing, and the role of standards and regulations. Finally, we discussed the challenges faced in storage and quality control, along with practical strategies and the roles of farmers, feed industries, and regulatory agencies in ensuring quality assurance.

By completing this Series, you should now be able to define the importance of proper storage, describe methods of storing feeds, analyse factors affecting feed stability, demonstrate physical and sensory evaluation, explain chemical and microbiological testing, identify standards and regulations, evaluate common storage problems, propose strategies for maintaining feed quality, and assess the role of farmers and industries in quality assurance. These achievements align directly with the Series Learning Outcomes and provide you with practical skills to safeguard feed quality in Nigerian livestock systems.

Concept check questions [Series 5]

Objective questions

1. What is the main purpose of proper feed storage? (Linked to SLO 5.1)
2. Which type of feed is more prone to spoilage, dry or moist? (Linked to SLO 5.2)
3. Physical and sensory evaluation involves checking for _____, texture, odour, and foreign materials. (Linked to SLO 5.4)
4. Which harmful microorganisms are detected through microbiological testing? (Linked to SLO 5.5)
5. Feed quality standards in Nigeria are enforced by _____ and NAFDAC. (Linked to SLO 5.6)

Short-answer questions

6. Explain why moisture control is important in feed storage. (Linked to SLO 5.3)

7. Name two characteristics checked during sensory evaluation of feeds. (Linked to SLO 5.4)

8. What is the role of chemical testing in feed quality control? (Linked to SLO 5.5)

9. Identify one common storage problem affecting feeds. (Linked to SLO 5.7)

10. Suggest one strategy farmers can use to maintain feed quality. (Linked to SLO 5.8)

Long-answer questions

11. Analyse the importance of physical, chemical, and microbiological testing in ensuring feed quality. (Linked to SLO 5.4, SLO 5.5)

12. Evaluate the challenges and strategies in feed storage and quality control, providing practical examples from Nigerian livestock systems. (Linked to SLO 5.7, SLO 5.8, SLO 5.9)

Answers to Concept Check Questions [Series 5]

Objective questions

1. To maintain feed quality and prevent spoilage.
2. Moist feeds.
3. Colour.
4. Bacteria, fungi, and moulds.
5. SON.

Short-answer questions

6. Moisture encourages mould growth and nutrient loss, so controlling it preserves feed quality.

7. Colour and odour.

8. Chemical testing determines nutrient composition to ensure feeds meet nutritional standards.

9. Mould growth.

10. Use airtight containers or silos to prevent moisture entry.

Long-answer questions

11. **Basic response:** Physical testing checks appearance and smell, chemical testing analyses nutrients, and microbiological testing detects harmful organisms. Together, they ensure feed safety and quality. **Value-added response:** Beyond basic checks, these methods protect animal health, prevent economic losses, and build consumer confidence in livestock products. Integrating them into routine quality control strengthens the feed value chain.

12. **Basic response:** Challenges include mould growth, insect infestation, and nutrient loss. Strategies include proper storage, preservatives, and regular inspection. **Value-added response:** In addition to these, collaboration between farmers, industries, and regulatory agencies ensures compliance with standards. Forage conservation methods and modern storage technologies further enhance resilience in Nigerian livestock systems.

Answers to Pilot Questions [Series 5]

Part 5.1 Principles of feed storage

- To maintain feed quality and prevent spoilage
- Dry and moist feeds require different storage methods
- Moisture, heat, and poor ventilation

Part 5.2 Quality control measures in feeding stuffs

- To quickly identify defects in feeds
- Colour and odour
- To determine nutrient composition
- Aflatoxin-producing fungi
- SON and NAFDAC

Part 5.3 Challenges and strategies in storage and quality control

- Mould growth
- They damage grains and reduce nutritive value
- Organic acids
- Adopting good storage practices and avoiding spoiled feeds
- It ensures compliance with standards and protects animal health