

PROXIMATE AND MINERAL COMPOSITION OF SELECTED GRASSES, TREE LEAVES AND CROP RESIDUE CONSUMED BY CATTLE, SHEEP AND GOATS IN KASHERE, GOMBE STATE, NIGERIA

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Abstract

The study was conducted to determine the proximate and mineral composition of grasses, tree leaves and crop residue consumed by ruminants during dry season in the grazing areas of Teaching and Research farm of Federal University of Kashere in Akko L.G.A, Gombe State, Nigeria. Forage samples were collected during grazing periods and identified from the designated areas (A, B, C and D) over a period of two weeks to ensure a representative diversity of forage species. Results showed that Gamba grass (*Andropogon gayanus*), Mango leaf (*Magnifera indica*), Cowpea husk (*Vigna unguiculata*), Potato leaf (*Solanum tuberosum*), and Maize husk (*Zea mays*) are the most consumed leaves among the ruminants. Most Common Forage Species include *Brachiaria brizantha*, *Digitaria smutsii*, *Cyperus esculentus* and *Setaria barbata*. Proximate analysis revealed variations in moisture, crude protein, ash, lipid, carbohydrate, fiber, organic content among the samples. Mineral composition analysis showed that the forages contained essential minerals such as calcium, potassium, magnesium, sodium, and phosphorus in varying concentrations, contributing to the nutritional needs of ruminants. The findings indicate that these forages can serve as valuable feed resources when strategically combined to balance energy, protein, and mineral requirements in livestock diets. The study emphasizes the need for supplementation of energy-rich forages with protein and mineral sources to enhance animal performance, particularly during the dry season when feed availability is limited.

Keywords: Proximate, Mineral, Forages, Tree leaves, Ruminants, Crop Residue

1.0 INTRODUCTION

Livestock production forms a vital component of Nigeria's agricultural sector, contributing significantly to food security, income generation, employment, and national development (Akinmoladun *et al.*, 2019). Among the various livestock species, cattle, sheep and goats are especially valued for their meat, milk, wool, and hides. Their adaptability to different ecological zones and minimal input requirements make them suitable for smallholder and rural farmers (FAO, 2020). In the savanna and semi-arid regions of Nigeria, including Gombe State, ruminants animals are widely kept due to the availability of natural pastures and crop residues. However, seasonal variations in the availability and quality of these feed resources affect livestock productivity (Lamidi *et al.*, 2017). During the dry season, most ruminants suffer nutritional stress due to poor-quality forage, leading to weight loss, low reproductive performance, and increased susceptibility to

diseases (Abegunde *et al.*, 2020). Feeding remains a major constraint to efficient livestock production in sub-Saharan Africa. For ruminants, forages form the principal component of their diet. The nutritional quality of these forages, particularly their proximate composition (moisture, crude protein, crude fiber, ash, ether extract, and nitrogen-free extract) and mineral content (calcium, phosphorus, potassium, magnesium, and sodium), determines animal performance (Ajayi *et al.*, 2016; Onwuka *et al.*, 2017). Despite the abundance of natural forages in Kashere, Akko L.G.A, Gombe State, information regarding their nutritional composition is scarce. This knowledge gap limits the ability of farmers and livestock nutritionists to optimize feed formulations, particularly during feed-scarce periods. Therefore, evaluating the proximate and mineral composition of common forages in the region is essential for effective ruminant animal management and enhanced productivity. In addition, the over-reliance on

conventional feedstuffs has increased competition between humans and livestock for food, raising the need to explore underutilized forage resources. The identification and analysis of locally available forages not only provide alternative feed options but also support sustainable livestock production by reducing feeding costs (Bamikole and Babayemi, 2008). Moreover, integrating scientific knowledge into traditional feeding practices can improve the nutritional balance of ruminant diets and consequently boost production outputs. Furthermore, knowledge of forage composition can support strategic feed conservation methods such as hay and silage making. These practices are vital in ensuring the year-round availability of quality feed, particularly in areas experiencing prolonged dry seasons like Kashere. Such insights are important for improving livestock productivity in rural settings where commercial feeds are often unaffordable or inaccessible (Olafadehan, 2014). This study therefore, seeks to fill the information gap on forage quality by scientifically evaluating the proximate and mineral composition of selected forages commonly consumed by ruminants in Kashere, Akko L.G.A, Gombe State the region.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was conducted at the Teaching and Research Farm, Department of Animal Science, Faculty of Agriculture, Federal University of Kashere in Gombe State, Nigeria. The state is situated within latitude 9°54'N and longitude and 10° 57' E and altitude of 349m above sea level. The annual rainfall of Kashere ranges between 800mm-900mm per annum and is characterized by distinct dry season (October-May) and rainy season (June-September) seasons. The annual mean temperature ranges from 30-32°C and it experiences a relative humidity of 17-90%.

2.2 Research Design

The grazing area of the University farm was demarcated into four (4) grazing units. A, B, C and D. Grazing Animals were selected and tagged from the Federal University of Kashere Teaching and Research Farm, such animals were allowed to graze on various forages in the natural

grazing field from morning(10-12 pm) and to evening (4-6 pm). The forages consumed were closely monitored, identified, sampled (while grazing) and harvested from the field.

2.3 Sample Collection

The forage samples were collected from the designated grazing areas (A, B, C and D) within the University grazing areas. Sampling was conducted over a period of two weeks during the peak growing season to ensure a representative diversity of forage species. Observational surveys were first carried out to identify the specific plant species most frequently consumed by the animals.

The "hand-plucking" method was used to simulate the natural grazing habits of the animals. This technique involves collecting the parts of the plants (leaves and stems) that the animals were seen consuming. The samples were taken using a stratified random sampling method to avoid bias and cover various microhabitats within the university environment. Each sample was collected in triplicates for statistical accuracy and was immediately placed in clean, labeled polyethylene bags to prevent contamination and maintain traceability. The samples areas were mapped and latter collection points were marked using micro sign boards to ensure traceability of samples materials. After collection, all samples were transported to the Department of Animal Science Laboratory at FUK for laboratory analysis.

2.4 Sample Preparation

Samples were sorted to remove any extraneous materials such as soil particles, insects, and damaged or decayed plant parts. Washing was done using clean distilled water to eliminate adhering dust, soil, and other contaminants that could interfere with laboratory analyses, especially mineral content and anti-nutritional assays. After washing, the samples were placed on absorbent paper and allowed to air dry under shade at ambient temperature (25-30°C) for 7 to 10 days. This shade-drying method is critical in preserving volatile nutrients like vitamins and preventing the photo degradation of sensitive compounds. During the

drying period, samples were turned daily to ensure uniform drying and to prevent fungal growth. After complete drying, the samples were ground using a mechanical Wiley mill into a fine powder, which was then sieved through a 1 mm mesh to ensure uniform particle size. The ground samples were stored in airtight, moisture-proof containers (polyethylene back) and kept in a cool, dry place until used for chemical analysis.

2.5 Proximate Composition Analysis

The determination of dry matter, crude protein, crude fiber, ether extract, nitrogen free extract and ash of the samples were carried out according to the methods of AOAC (2016). Fiber fraction: acid detergent fiber, nitrogen detergent fiber Acid detergent lignins were determined according to the procedure put forward by (Van Soest *et al.*, 1991).

2.6 Mineral Analysis

The mineral composition of some forages consumed by ruminants was determined as follows; Calcium (Ca) and Magnesium (Mg) were determined using Atomic Absorption Spectrophotometer (AAS) after digesting the samples with a nitric-perchloric acid mixture while Iron (Fe), Zinc (Zn), and Copper (Cu) were determined using AAS, with samples digested in concentrated hydrochloric acid (HCl), nitric acid (HNO₃), and hydrogen peroxide (H₂O₂). Sodium (Na) and Potassium (K) were determined using a flame photometer procedure. Phosphorus (P) was determined using the vanadomolybdate colorimetric method, where absorbance is read at 420 nm (Fiske and Subbarow, 1925).

2.7 Data Presentation and Analysis

The data obtained were presented in Tables in percentages for the proximate composition and mg/kg for the mineral values

3.0 RESULTS AND DISCUSSION

3.1 Proximate Compositions

3.1.1 Proximate Compositions of selected Grasses, Tree leaves and crop residues consumed by goat

The results from this analysis shows that Gamba grass recorded a moisture content of 3.68%,

indicating that it is relatively dry and suitable for long-term storage. Its ash content of 4.69% suggests a moderate mineral contribution, while the crude protein level at 7.24% is relatively low, which is typical of tropical grasses, especially at maturity. The lipid content of 2.73% is minimal but sufficient to supply some energy, whereas the carbohydrate fraction, reported as 31.68%, highlights its role as an energy source, even though this value seems low compared to conventional estimates this agrees with the findings of (Abegunde *et al.*, 2020) for dry season crop residues. The fiber level of 18.2% shows moderate structural material, supporting digestibility. Overall, Gamba grass serves primarily as an energy-based forage and should be combined with protein-rich supplements for balanced rations.

Mango leaves showed a moisture content of 2.8%, making them a very dry material that can be stored under proper conditions. The ash content of 7.15% was higher than that of Gamba grass, indicating a better mineral profile, while the crude protein content of 6.20% was slightly lower than that of Gamba grass, suggesting limited protein contribution. Mango leaves had a lipid level of 3.22%, which improves energy density and palatability compared to Gamba grass as suggested by (Mc Dowell *et al.*, 2022). These attributes make mango leaves a valuable mineral and energy supplement, though they cannot serve as the main protein source. Cowpea husk emerged as the most nutrient-rich feed among the samples analyzed. With a moisture content of 4.24%, it retains slightly more water than mango leaves but still stores well. The ash level of 8.42% was the highest, emphasizing its mineral richness, while its crude protein content of 13.43% far exceeded that of all other samples, making cowpea husk an excellent protein source. Lipid content was moderate at 3.26%, contributing to energy supply and palatability. Its carbohydrate content of 34.00% was lower than that of Gamba grass but complemented by its high protein value. The fiber level of 19.19% suggests good digestibility. These qualities make cowpea husk the best supplement for

improving the protein and mineral profile of livestock diets, especially when combined with energy-rich feeds. Potato leaves contained the highest moisture content (5.65%) among all samples, which may reduce shelf life unless properly dried. They had an ash content of 7.75%, showing substantial mineral contribution. The protein level was 9.17%, higher than Gamba grass and mango leaves but lower than cowpea husk. Lipid content was 2.72%, similar to Gamba grass, providing limited energy from fats. Carbohydrate content was 37.71%, which indicates good energy provision. However, fiber content was 10.07%, the highest among all samples, which could reduce digestibility, particularly for non-ruminants.

Finally, maize husk had the lowest moisture content (2.48%), making it ideal for long-term storage and use during dry seasons. Its ash level was 5.92%, lower than most other samples, suggesting limited mineral contribution. Protein

content was 10.28%, higher than Gamba grass and mango leaves but still below cowpea husk. Lipid level stood at 2.92%, while carbohydrates were 28.41%, reflecting its role as an energy-rich feedstuff. Fiber content was moderate at 16.23%,.. These properties make maize husk a valuable energy source, particularly during periods of forage scarcity, though it should be combined with protein-rich materials to balance the diet.

In summary, cowpea husk is the most important protein and mineral source among the tested samples, while Gamba grass and maize husk are primarily energy providers. Mango leaves serve as a good mineral supplement, whereas potato leaves supply moderate protein but with high fiber content. Together, these feed resources can be strategically combined to formulate balanced rations for ruminant livestock, particularly during the dry season when green forage is scarce.

Table 1: Proximate Composition of Selected Grasses Tree Leaves and Crop Residues Consumed by Goats (%)

FORAGES	MOISTURE	ASH	CP	LIPID	CHO	CF
Gamba Grass	3.68	4.69	7.24	2.73	30.65	18.2
Mango Leaf	2.8	7.15	6.2	3.22	30.1	3.25
Cowpea Husk	4.24	8.42	13.43	3.26	120.34	3.19
Potato Leaf	5.65	7.75	9.17	2.72	124.71	10.07
Maize Husk	2.48	5.92	10.28	2.92	128.41	6.23

3.1.2 Proximate Composition of Some Selected Forages Consumed by Cattle

Results of the proximate composition of some Common forage species showed that Dry matter (DM) composition of *Digitaria species* (Table 2) showed higher yield as compared to other forage Species. The high Dry matter yield of *Digitaria species* could have been attributable to exploitation of the environmental resources by the forage, Ability of the forage to compete better for soil nutrients high proportion of leaves to

intercept solar radiation and inherent genetic characteristics of the forage as compared to other species (Hopkin 2000: Agishi and Ariba 2019). Crude Protein of *Brachiaria* and *Digitaria species* is High compared to other common forages. Ether Extract, Ash content and Nitrogen Free Extract is significantly high in *Digitaria species*, *Cyperus esculentus* in the month of June respectively. Also in a similar vain, Ether Extract, Ash content and Nitrogen Free Extract is also Significant in *Brachiaria*, *Setaria species* in the month of July respectively.

Table 2: Proximate Composition of Forages and Crop Residues Consumed by Cattles (%)

Forage Composition	Brachiaria. brizantha	Digitaria decumbense	Setaria specie	Cyperus esculentus
Dry matter	65.59	83.66	59.49	62.00
Crude protein	8.37	8.40	7.33	7.90
Crude fibre	24.81	24.73	23.41	22.99
Ether Extract.	2.94	3.20	2.34	2.30
Ash content	4.55	5.00	4.33	5.66
Nitrogen Free Extract	40.31	66.31	41.33	40.44

3.1.3 Proximate Composition of Selected Grasses, Tree Leaves and Crop residues Consumed by Sheep

The moisture content of the studied samples were generally low, ranging from 2.13% in maize stalk to 4.17% in potato leaf. This indicates that all the forages were relatively dry, which is beneficial for storage and reduces the risk of spoilage. Ash content, which represents the total mineral matter, varied from 3.15% in Gamba grass to 8.11% in potato leaf and all the findings tally with the values reported by (NRC, 2021). Highest ash value was recorded in potato leaf which suggests a higher concentration of minerals compared to the other forages, while the low value in Gamba grass indicates a lower mineral contribution. High ash content can support metabolic functions and improve feed buffering capacity. However, very high ash may also dilute the energy density of a ration. Gamba grass with ash values below 4%, may need to be supplemented with mineral-rich ingredients to meet total dietary mineral needs (McDowell, 2022). Crude protein is crucial for muscle development, rumen microbial synthesis, and reproductive performance. Cowpea husk (12.37%) exhibited significantly high CP content, exceeding the minimum protein requirement for maintenance in adult ruminants (around 7–10%) and even supporting production in lactating and growing animals (NRC, 2021).

Table 3: Proximate Composition of Forages and crop residues Consumed by Sheep (%)

Forages	Moisture	Ash	Crude Protein	Ether Extracts	Carbohydrates	Crude Fiber	Dry Matter
Cowpea husk	3.15	6.17	12.37	2.17	76.36	19.65	96.85
Gamba grass	2.85	3.15	6.13	2.27	85.6	16.63	97.15
Mango leaf	2.73	4.12	6.81	1.75	84.41	23.41	97.32
Maize stalk	2.13	4.92	6.62	7.02	80.31	28.12	97.88
Potato leaf	4.17	8.11	4.16	1.91	81.65	18.15	95.83

Values are means of triplicate determinations.

This forage could reduce the need for costly protein sources such as soybean meal. On the other hand, Gamba grass (6.13%), mango leaf (6.81%), and maize stalk (6.62%) close to minimum protein requirement for maintenance in adult ruminants (around 7–10%), little supplementation is recommended (NRC, 2021). Potato leaf (4.16%) had the lowest CP value and should be combined with protein-rich sources to

ensure balanced diets. Ether extract (lipid) content showed marked variation. Maize stalk had the highest value (7.02%), suggesting it can contribute more dietary energy from fats, while mango leaf had the lowest (1.75%), meaning it is less energy-dense in terms of fat content. However, excessive fat (>6–7% of total diet) may negatively affect fiber digestion and rumen microbial activity (McDonald *et al.*, 2023).

This supports efficient microbial activity in the rumen, leading to better digestion and energy supply for the animal (Sampaio *et al.*, 2015). Crude fiber supports proper rumen motility, saliva secretion, and microbial fermentation. Potato leaf (6.15%) had the highest fiber level, making it useful as a roughage source. However, excessive fiber can decrease voluntary feed intake and nutrient digestibility. Gamba grass had the lowest CF (16.63%), contributing to better digestibility and faster passage rates. A balanced CF level is important to ensure both rumen function and optimal nutrient utilization (Mertens, 2022). Dry matter indicates the total amount of nutrients available in the feed after moisture has been removed. High DM content enhances feed storage, reduces spoilage risk, and improves transportability. All forages had high DM values (>95%), which falls within acceptable levels for preserved feed materials (Adeyeye, 1996). Dry matter (DM) values were high, with maize stalk having the highest DM (97.88%) and potato leaf the lowest (95.83%), making it the most suitable for long-term storage and transportation. A higher DM also means nutrients are more concentrated, allowing for more

effective ration formulation (McDonald *et al.*, 2023).

Proximate Composition of Selected Tree Leaf Samples (% Dry Matter Basis)

The dry matter values were high (88.00 to 90.8%), the crude protein values ranged from 17.02% (Gmelina) to 25.04% (moringa) these values were quite higher than the critical protein values of 7 to 10 % for maintenance (McDonald *et al.* 2023). The ether extracts values of 5.03 to 7.05 are high and can contribute to the energy pool of the animals they fell within the maximum recommended values of 6 to 7% (McDonald *et al.* 2023) and 5 to 6% (Maithison *et al.*, 1997). The ash values of 7.09 to 9.01 are high and suggests high mineral content, though higher ash contents may also compromise the energy values, The crude fibre values of 11.0% (Moringa) to 17.02% (Gmelina), these values are moderate by ruminant standards and also considering that the analyses were carried out during the dry season

Table 4: Proximate Composition of Selected Tree Leaf Samples (% Dry Matter Basis)

Leaf Type	Moisture	Dry Matter	Crude Protein	Crude Fibre	Ether Extract	Ash	NFE
Moringa	9.20	90.80	25.04	11.08	7.05	9.01	37.00
Neem	10.40	89.06	19.06	14.02	6.04	8.05	40.09
Gmelina	12.00	88.00	17.02	17.03	5.03	7.08	42.04
Shea Butter	11.33	88.07	14.06	16.05	4.08	8.01	44.07
Tamarind	10.08	89.02	18.05	15.20	5.06	7.09	42.00
Locust Bean	11.05	88.05	21.08	13.01	6.01	8.03	39.02

Values are means of triplicate determinations.

3.2 Mineral composition

3.2.1 Mineral composition of selected Grasses, Tree Leaves and Crop Residue consumed by Red Sokoto goats

Results from table 5 shows the mineral composition (g/kg) of some forages focusing on Magnesium (Mg), Phosphorus (P), Cobalt (Co), Copper (Cu), and Calcium (Ca).

The values for Magnesium ranged from 0.337 g/kg in Maize husk to 0.564 g/kg (Mango leaf). Mango leaf had the highest magnesium content

(0.564 g/kg), which is beneficial for metabolic functions such as enzyme activation and nerve transmission in ruminants. Gamba grass contained 0.341 g/kg, which is moderate, while cowpea husk and potato leaf had similar values (0.388 g/kg and 0.353 g/kg respectively). The maize husk, with the lowest magnesium content (0.337 g/kg), may not supply sufficient magnesium for optimal performance, especially in lactating goats that have higher magnesium requirements as suggested by (NRC, 2021).

Phosphorus levels ranged from 0.322 g/kg (Maize husk) to 0.641 g/kg (Mango leaf). Mango leaf which the highest phosphorus value, which is important for bone development, energy metabolism (ATP), and reproductive performance. Gamba grass had a moderate level (0.414 g/kg), while cowpea husk and potato leaf were slightly lower (0.364 g/kg and 0.333 g/kg respectively). Maize husk had the lowest value (0.322 g/kg), suggesting that animals fed predominantly on maize husk could face phosphorus deficiency, which may lead to reduced fertility and poor bone strength.

Cobalt is a critical trace mineral needed for Vitamin B12 synthesis. The values ranged from 0.003 g/kg (Gamba grass) to 0.004 g/kg (Mango leaf and Maize husk). All values are extremely low and below the recommended levels for

ruminants (usually around 0.1 mg/kg of diet). This deficiency could impair rumen microbial activity, leading to poor fiber digestion and reduced productivity. Thus, supplementation with cobalt is necessary when feeding these forages.

Copper levels were generally low across all samples, ranging from 0.038 g/kg (Cowpea husk) to 0.200 g/kg (Gamba grass). Gamba grass had the highest copper content (0.200 g/kg), but this is still marginal for ruminant requirements (10 mg/kg DM). Potato leaf (0.113 g/kg) and maize husk (0.119 g/kg) had slightly higher levels than cowpea husk (0.038 g/kg), which had the lowest copper content. Copper deficiency can cause anemia, poor growth, and reproductive failure in goats, so mineral supplementation is essential as reported by (NRC, 2021)..

Table 5: Mineral Compositions of Selected Grasses, Tree Leaves and Crop Residues Consumed by Goat (g/kg)

Minerals	MAGNESIUM (mg)	PHOSPHURUS (P)	COBALT (Co)	COPPER (cu)	CALCIUM (Ca)
Gamba grass	0.34	0.41	0.003	0.2	0.63
Mango leaf	0.64	0.64	0.004	0.038	0.34
Cowpea husk	0.38	0.39	---	0.11	0.62
Potato leaf	0.36	6.38	---	0.13	0.34
Maize husk	0.37	3.23	0.004	0.19	0.35

Calcium values ranged from 0.324 g/kg (Cowpea husk) to 0.634 g/kg (Gamba grass). Gamba grass provided the highest calcium content, making it a good forage for bone and teeth development. Mango leaf (0.334 g/kg), potato leaf (0.340 g/kg), and maize husk (0.335 g/kg) had moderate calcium levels, which may still require supplementation depending on the production stage (e.g., lactation, growth).

3.2.2 : Mineral Composition of Selected Grasses, Tree Leaves and Crop Residues Consumed by Sheep

Results from Table 6 indicate that Magnesium (Mg) levels were generally low, with cowpea husk having the highest value (0.07g/kg) to 0.03g/kg. This suggests cowpea husk provides slightly more magnesium than the other forages, indicating these forages can prevent grass tetany

and related disorders when included appropriately (NRC, 2021). Phosphorus (P) content was highest in cowpea husk (3.12%) and potato leaf (3.12%), while mango leaf had the lowest (1.64g/kg. All the findings agree with that of (Mc Donall *et al.*, 2022) where high phosphorus in cowpea husk and potato leaf support bone development and metabolic functions in sheep. Cobalt (Co) levels were uniformly low across all forages, ranging from 0.001–0.00g/kg Mango leaf had the highest cobalt (0.004g/kg), which may slightly enhance vitamin B₁₂ synthesis in the rumen. This trace element supports immune responses, enzyme systems, and reproductive performance. Copper (Cu) content was highest in maize stalk (0.31g/kg) and lowest in Gamba grass

(0.02g/kg). The high copper content in maize stalk suggests it can make a notable contribution to the animals' copper requirements but excessive Cu can be toxic to sheep and must be monitored. Calcium is essential for skeletal

development, blood clotting, and muscle contraction. Calcium (Ca) content ranged from 0.14g/kg in mango leaf to 0.44 g/kg in potato leaf. This indicates that potato leaf is the richest source of calcium among the forages studied.

Table 6: Mineral Composition of Selected Grasses, Tree Leaves and Crop Residues Consumed by Sheep (g/kg)

Forage	Magnesium	Phosphorus	Cobalt	Copper	Calcium
Cowpea husk	0.07	3.12	0.001	0.12	0.18
Gamba grass	0.03	2.03	0.002	0.02	0.23
Mango leaf	0.05	1.64	0.004	0.03	0.14
Maize stalk	0.03	2.03	0.002	0.31	0.19
Potato leaf	0.03	3.12	0.002	0.03	0.44

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The study demonstrated that the forages consumed by sheep in Kashere vary significantly in their nutritional composition. Cowpea husk emerged as a good protein and phosphorus source, while maize stalk provided higher energy from fat. Potato leaf contributed more calcium and fiber, whereas gamba grass, though low in protein, was highly preferred by sheep, indicating its palatability. These findings suggest that no single forage provides a balanced diet. However, combining forages in a mixed feeding strategy can help meet the nutrient requirements of sheep more effectively. This highlights the importance of using locally available feed resources to enhance sheep production and reduce reliance on costly conventional feeds. The evaluated forages and crop residues provide sufficient energy but inadequate protein and critical minerals and this imbalance can adversely affect the growth, reproduction, and health in goats. The data serve as a baseline for designing feeding interventions for Red Sokoto goats in semi-arid northern Nigeria.

4.2 Recommendation

Most of the forages identified can be improved in yield and good proximate composition by proper Grazing, avoiding of over stocking and fertilization. The study therefore recommends:

- I. **Forage Conservation:** Forage conservation strategies such as hay and silage could be implemented for high quality forages for feeding during the dry season.
- II. **Pasture Management:** The University is encouraged to implement rotational grazing and reseeding with high nutrient value as a means to enhance the sustainability of its pastures.
- III. **For Researchers:** There is a need to assess the mineral composition and the value of forages during the different seasons to enhance productivity.
- IV. **Farmer Education:** Local pastorals need to be educated on forages available and grazing management to improve herd nutritional value.
- V. **Inclusion in Feed Formulation:** Commercial feed and formulated diets should be reduced by adding nutrient dense forages into the cattle diets.

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