

NUTRIENT DIGESTIBILITY AND NITROGEN RETENTION IN GROWING YANKASA RAMS FED SILAGE-BASED DIETS CONTAINING FINGER AND PEARL MILLET STRAWS SUPPLEMENTED WITH POULTRY LITTER

¹Tada, Y. A., ²Hamza Y. A., ²Nura Suleiman., ²Muslim H. J. and ¹Sulaiman, U. B.

¹Department of Animal Health and Production Technology, federal polytechnic Daura, Katsina state

²Department of Agricultural Technology, Federal polytechnic Daura, Katsina State

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ABSTRACT

This study evaluated the effects of varying proportions of finger millet (*Eleusinecoracana*) and pearl millet (*Pennisetumglaucum*) straw silage, supplemented with poultry litter, on the chemical composition, nutrient intake, digestibility, and nitrogen utilization of growing Yankasa rams. Five experimental diets were formulated by substituting finger millet straw with increasing levels of pearl millet straw at 0, 18.75, 35.5, 56.25, and 75%, while maintaining poultry litter as a constant basal supplement. Chemical analysis revealed that dry matter and fiber fractions (crude fiber, acid detergent fiber, and neutral detergent fiber) increased progressively with higher pearl millet straw inclusion, while crude protein and ether extract contents declined. Nitrogen-free extract (NFE) peaked at moderate inclusion levels (T2 and T3) before decreasing. Nutrient intake and digestibility were significantly ($P < 0.05$) influenced by dietary treatments; rams fed moderate inclusion levels exhibited superior feed intake and nutrient digestibility. Nitrogen balance data indicated improved retention and utilization efficiency in rams fed the T2 and T3 diets, whereas higher inclusion levels (T4 and T5) increased nitrogen loss and reduced retention. In conclusion, incorporating pearl millet straw silage at 18.75–35.5% in combination with poultry litter enhances nutrient utilization and performance in growing Yankasa rams. Conversely, excessive inclusion levels reduce diet quality due to elevated fiber content and diminished protein availability. For optimal performance, a pearl millet straw inclusion level of 18.75–35.5% is recommended.

Keywords: Nutrient Digestibility, Nitrogen Retention, Straw Silage, Poultry Litters, Yankasa Rams.

1. INTRODUCTION

Small ruminant production is critical to food security and rural livelihoods in the semi-arid regions of sub-Saharan Africa, where seasonal feed scarcity significantly constrains productivity. In Nigeria, the indigenous Yankasa sheep is favored for its adaptability to harsh environments; however, its growth potential is often limited by poor dietary quality, specifically low protein intake and reduced nutrient digestibility. Millet crop residues are among the most abundant feed resources available in these regions. Straws from finger millet (*Eleusinecoracana*) and pearl millet (*Pennisetumglaucum*) are commonly fed to sheep during the dry season. Despite their availability, these residues are characterized by low crude protein (CP) content (typically <7%),

high lignocellulosic fibre fractions, and low fermentable energy, which collectively impair rumen function and overall digestibility (Van Soest, 1994; McDonald et al., 2011).

Nitrogen deficiency in such residues limits microbial proliferation in the rumen, thereby reducing the degradation of structural carbohydrates. Improving the nutritive value of these fibrous residues requires strategic supplementation. While ensiling is a practical preservation method that enhances palatability, cereal straws often lack sufficient nitrogen to support optimal fermentation and microbial activity. Supplementation with nitrogenous sources enhances rumen degradability by stimulating microbial protein synthesis and increasing fibre digestion (Preston & Leng, 1987). Consequently, poultry litter has been recognized as a cost-effective nitrogen supplement for ruminants. It contains appreciable CP and minerals that support microbial growth and improve the digestibility of low-quality roughages (Fontenot et al., 1971; Akinfala & Komolafe, 2011).

Incorporating poultry litter into millet straw silage may enhance dry matter, CP, and fibre digestibility by improving nitrogen availability within the rumen ecosystem. However, there is limited information on how varying proportions of finger and pearl millet straw silage, combined with poultry litter, influence nutrient utilization in growing Yankasa rams. Understanding the digestibility response to different inclusion levels is essential for optimizing feed efficiency in straw-based diets under semi-arid production systems. Therefore, this study aimed to evaluate the effects of varying proportions of finger millet and pearl millet straw silage supplemented with poultry litter on the nutrient digestibility and nitrogen retention of growing Yankasa rams.

2. MATERIALS AND METHODS

Study Area

The research was conducted at the livestock Teaching and research farm, Department of Animal Health and production Technology, Federal Polytechnic Daura, Katsina State, the site was located on Latitude 13.5°N and Longitude 8.3°E

Sample collection

Silage preparation involved the use of pearl millet and finger millet straws which was obtained from local farmers in Daura Local Government Area after grain harvest. The straws were chopped into approximately 2 cm lengths to facilitate proper compaction and fermentation.

Poultry litter was collected from the poultry unit of the Department of Animal Health and Production technology. Foreign materials that were not part of the litter were carefully removed, and the litter was sun-dried for three days to reduce moisture and minimize microbial contamination. The chopped straws were mixed in varying proportions of pearl millet and finger millet straw together with poultry litter to form the experimental mixtures.

Sample preparation

A total of five different mixtures were prepared, representing the experimental treatments as presented in Table 3. For each mixture, 100 kg of the straw combination was thoroughly mixed with poultry litter and 100 liters of water to ensure adequate moisture for fermentation. The prepared mixtures were tightly packed into 100 kg capacity polythene bags, properly labelled, sealed, and compressed using heavy sandbags to create anaerobic conditions necessary for effective silage fermentation. The silage was allowed to ferment for 21 days before opening. The prepared silage was used as the basal diet for growing Yankasa rams.

Diet formulation and production

A concentrate diet containing 14% crude protein was formulated using wheat offal, cottonseed cake, bone meal, salt, and potash. The concentrate was offered to the animals at 2% of their body weight, while the silage (basal diet) and clean drinking water were provided *ad libitum*. The table for silage preparation and concentrate is presented in table 1 and 2.

Table 1: varying proportion of finger and pearl millet straw silage with poultry litters as a basal diet fed to growing Yankasa rams (%)

Treatments	T1(0)	T2(18.75)	T3(35.5)	T4(56.25)	T5(75)
Finger millet straw	75	56.25	37.5	18.75	0
Pearl millet straw	0	18.75	35.5	56.25	75
Poultry litter	25	25	25	25	25
Total	100	100	100	100	100

Table 2: composition of concentrate diet fed as supplement

Feed ingredient	Quantity %
Wheat offal	60
Cotton seed cake	38
Bone meal	1.0
Salt	0.5
Potash	0.5
Total	100

Experimental Design and Management

A total of Fifteen (15) growing Yankasa rams with an average weight of 28 kg were used for the experiment. The rams were obtained from Mai Aduwa local Livestock Market. They were weighed and identified using plastic ear tags and assigned to five (5) dietary treatments using Completely Randomized Design (CRD) with three rams (3) per treatment with each ram as replicate. The rams were treated against internal and external parasite using Albendazole (2.5%) oral suspension and Ivermectin injection which was injected subcutaneous, and also injected with broad spectrum antibiotics (ox-tetracycline) at 1 ml/10 kg body weight before the commencement of the experiments. And also, multivitamin injection was given at 1 ml/10 kg body weight for 3 days to reduce stress. The rams were fed with formulated diet at 2 % of their body weight and Sorghum Stover as basal diet was given *ad-libitum*. The rams were allowed 14 days adjustment period to the feed and cage while 7 days was used as collection period for urine and faeces.

$$\text{Apparent nutrient digestibility} = \frac{\text{Nutrient intake} - \text{Nutrient in faeces}}{\text{Nutrient intake}} \times 100$$

Proximate composition of diet and faecal samples

The experimental diet and faecal samples were collected and taken to laboratory to determine their proximate composition such as Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), Crude Fiber (CF), and Nitrogen Free Extract (NFE) were calculated differently. While neutral detergent fibre (NDF) and Acid detergent fibre (ADF) of concentrate diet and faecal output were analyzed using (Van soest, 1994).

Statistical analysis:

Data collected were subjected to analysis of variance using General Linear Model Procedure of Van soest(1994), while significant means were separated using Duncan multiple range test.

Below is the Experimental model used:

Statistical Model

$$Y_{ij} = \mu + T_i + E_{ij \text{ IKM}}$$

Where: Y_{ij} = Dependent variables

μ = overall mean

T_i = Effect of i^{th} treatment diets ($i= 1, 2, 3, \text{ and } 4$);

E_{ij} = Random error assumed to be normally and independently distributed with Zero means and standard variation.

3. RESULTS AND DISCUSSION**Chemical composition and nutritive profile of experimental ruminant diets**

The chemical composition of the experimental diets as influenced by varying proportions of finger and pearl millet straw silage supplemented with poultry litter is presented in Table 3. The results indicate a progressive change in nutrient composition with increasing inclusion levels of pearl millet straw across the treatments. Dry matter (DM) content increased steadily from 86.50% in T1 to 90.50% in T5, suggesting that diets became relatively drier as the proportion of pearl millet straw increased. This trend may be attributed to the lower moisture content of pearl millet straw compared to finger millet straw. Crude protein (CP) content showed a consistent decline from 11.87% in T1 to 9.25% in T5, indicating that increasing levels of pearl millet straw resulted in reduced protein concentration of the diets. This implies that finger millet straw contributed relatively higher protein content than pearl millet straw. Crude fibre (CF) increased progressively from 26.50% in T1 to 29.87% in T5, reflecting the higher fibre content associated with pearl millet straw. Similarly, acid detergent fibre (ADF) and neutral detergent fibre (NDF) values increased across the treatments, with ADF rising from 28.00% to 30.40% and NDF from 45.00% to 62.00%. The increase in these fibre fractions suggests a higher proportion of structural carbohydrates, which may negatively influence digestibility and voluntary feed intake at higher inclusion levels. Ether extract (EE) decreased from 4.90% in T1 to 2.80% in T5, indicating a reduction in lipid content as pearl millet straw inclusion increased. Nitrogen-free extract (NFE), representing soluble carbohydrates, increased from 31.90% in T1 to a peak of 37.40% in T3, before declining to 30.95% in T5

Table 3: Chemical composition of experimental ruminant diets

Parameters	Varying proportion of finger and pearl millet Stover				
	T1(0)	T2(18.75)	T3(35.5)	T4(56.25)	T5(75)
Dry Matter (%)	86.5	88.60	89.10	90.20	90.50
Crude Protein (%)	11.87	11.25	10.56	9.9	9.25
Crude Fibre (%)	26.50	27.30	28.50	29.60	29.87
Ether Extract (%)	4.90	4.20	3.50	3.00	2.8
Nitrogen-Free Extract (%)	31.90	36.10	37.40	36.40	30.95
Acid Detergent Fibre (%)	28.00	28.40	28.80	29.60	30.40
Neutral Detergent Fibre (%)	45.00	50.00	55.00	60.00	62.00

^{abc}Means with different superscripts in the same row differed significantly ($P < 0.05$), SEM: standard Error of means.

Nutrient intake of growing Yankasa rams fed varying proportions of finger and pearl millet straw silage supplemented with poultry litter

The nutrient intake of growing Yankasa rams fed varying proportions of finger and pearl millet straw silage with poultry litter as a basal diet showed significant variations across treatments. Dry matter intake (DMI) differed significantly ($P < 0.05$), with animals on T2 recording the highest value (646.97 g/day), while T1 had the lowest (561.86 g/day). The superior intake observed at T2 suggests that moderate inclusion of pearl millet straw enhanced palatability and intake. However, the decline in intake at higher inclusion levels (T4 and T5) may be attributed to increased fibre content, which can limit voluntary feed intake due to rumen fill. This observation agrees with the findings of Osuji et al. (1993), who reported that optimal feed intake in ruminants is achieved when diets maintain a balance between fibre and digestibility. Crude protein (CP) intake showed a clear decreasing trend with increasing levels of pearl millet straw, with T1 and T2 recording significantly higher values (75.33 and 74.71 g/day, respectively), while T5 had the lowest (53.78 g/day). This decline could be due to the inherently low nitrogen content of crop residues, particularly pearl millet straw, which reduces protein availability to the animals. This finding is consistent with reports by Norton (2003), who noted that low-quality roughages are deficient in crude protein and often require supplementation to meet the nutritional needs of ruminants. Crude fibre (CF), acid detergent fibre (ADF), and ash intake did not differ significantly ($P > 0.05$) across treatments, although numerically higher values were observed at higher inclusion levels. The lack of significant differences suggests that fibre fractions were relatively similar across diets, despite increasing proportions of pearl millet straw. However, neutral detergent fibre (NDF) intake increased significantly, with the highest values recorded in

T4 and T5. This indicates that increasing pearl millet inclusion resulted in higher structural carbohydrate content, which may negatively influence intake and digestibility. This observation is in line with Van Soest (1994), who emphasized that high NDF levels are associated with reduced feed intake due to rumen fill limitations. Ether extract (EE) intake decreased significantly as the level of pearl millet straw increased, with T1 having the highest value (26.10 g/day) and T5 the lowest (15.98 g/day). This trend reflects the low lipid content typical of fibrous crop residues compared to more digestible feed ingredients. Similar findings were reported by McDonald *et al.* (2011), who noted that high-fibre diets are generally associated with reduced ether extract content. Nitrogen free extract (NFE), which represents the readily available energy fraction, was significantly influenced by dietary treatments. T2 recorded the highest value (296.12 g/day), while T1 had the lowest (233.51 g/day). The improved NFE intake at moderate inclusion levels suggests better availability of soluble carbohydrates and overall energy utilization. This supports the findings of Aregheore (2000), who reported that moderate inclusion of treated crop residues can enhance energy intake and utilization in small ruminants.

Table 4: Nutrient intake of growing Yankasa rams fed varying proportions of finger and pearl millet straw silage supplemented with poultry litter

Parameters	Varying proportion of finger and pearl millet Stover					SEM
	T1 (0)	T2 (10)	T3 (20)	T4 (30)	T5	
Dry matter	561.86 ^b	646.97 ^a	604.04 ^{ab}	572.18 ^b	578.60 ^b	31.19
Crude protein	75.33 ^a	74.71 ^a	66.58 ^b	59.89 ^c	53.78 ^d	2.67
Crude fibre	184.71 ^a	215.65 ^a	193.30 ^a	210.19 ^a	212.92 ^a	11.66
Ether Extract	26.10 ^a	24.18 ^a	19.07 ^b	16.89 ^b	15.98 ^c	1.01
Nitrogen free extract	233.51 ^b	296.12 ^a	262.62 ^{ab}	279.28 ^{ab}	283.56 ^{ab}	15.63
Acid detergent fibre	195.75 ^a	230.32 ^a	201.50 ^a	219.96 ^a	221.81 ^a	13.09
Neutral detergent fibre	293.99 ^b	357.60 ^a	336.98 ^{ab}	366.64 ^a	368.50 ^a	18.51
Ash	50.91 ^a	51.64 ^a	41.42 ^a	52.88 ^a	53.40 ^a	2.42

^{abc}Means with different superscripts in the same row differed significantly (P<0.05), SEM: standard Error of means.

Nutrient digestibility in growing Yankasa rams fed varying proportions of finger and pearl millet straw silage supplemented with poultry litter

The digestibility coefficients of nutrients in growing Yankasa rams fed varying proportions of finger and pearl millet straw silage with poultry litter as a basal diet showed significant (P < 0.05) variations across treatments, indicating that dietary inclusion levels influenced nutrient utilization. Dry matter digestibility (DMD) was significantly affected, with T5 (64.00%) and T2 (63.22%) recording the highest values, while T1 had the lowest (47.10%). The improved

digestibility at higher inclusion levels suggests better microbial degradation of the silage-based diets, possibly due to enhanced fermentation and improved fibre breakdown. The low digestibility observed in T1 may be attributed to poor synchronization of nutrients for rumen microbes. This finding is consistent with Van Soest (1994), who reported that proper treatment and inclusion of fibrous feeds can enhance their digestibility. Crude protein digestibility (CPD) increased significantly at higher inclusion levels, with T5 (62.56%) and T4 (61.55%) being superior, while T1 and T3 recorded lower values. The improvement in CP digestibility at higher pearl millet inclusion may be due to better nitrogen utilization and possible associative effects between the silage and poultry litter. This agrees with the findings of Osuji et al. (1993), who noted that nitrogen supplementation enhances rumen microbial activity and protein utilization. Crude fibre digestibility showed significant differences, with T4 (54.53%) and T5 (53.89%) having the highest values, while T1 (29.36%) had the lowest. This indicates that increasing pearl millet straw improved fibre utilization, likely due to better adaptation of rumen microbes to fibrous diets. Similar observations were reported by McDonald et al. (2011), who stated that fibre digestibility improves when animals adapt to high-roughage diets. Ether extract digestibility did not differ significantly ($P > 0.05$) among treatments, although numerically higher values were observed in T2 (65.36%) and T1 (63.20%). The lack of significant variation suggests that fat digestion was not markedly influenced by the dietary treatments. This is in line with Norton (2003), who reported that ether extract digestibility is usually less affected by fibre level compared to other nutrients. Nitrogen free extract (NFE) digestibility was significantly higher in T2 (87.47%) and T3 (88.62%), while T1, T4, and T5 recorded lower values. This indicates that moderate inclusion levels enhanced the availability and utilization of soluble carbohydrates. The reduced digestibility at higher inclusion levels may be due to increased fibre content interfering with carbohydrate digestion. This observation agrees with Aregheore (2000), who reported improved energy digestibility at moderate inclusion of crop residues. Neutral detergent fibre (NDF) digestibility differed significantly, with T2 (54.68%) having the highest value, while T1, T3, and T5 had lower values. This suggests that moderate inclusion optimizes fibre degradation, whereas excessive fibre may reduce digestibility due to lignification. Similarly, acid detergent fibre (ADF) digestibility increased significantly, with T4 (59.54%) and T2 (52.62%) recording higher values, while T1 had the lowest (32.08%). This supports the assertion by Van Soest (1994) that fibre digestibility is highly dependent on fibre composition and treatment.

Table 4: Nutrient digestibility in growing Yankasa rams fed varying proportions of finger and pearl millet straw silage supplemented with poultry litter

Parameters	Varying proportion of finger and pearl millet Stover					SEM
	T1(0)	T2(10)	T3(20)	T4(30)	T5	
Dry matter	47.10 ^b	63.22 ^a	57.13 ^{ab}	63.17 ^a	64.00 ^a	3.83
Crude protein	52.39 ^b	54.97 ^{ab}	51.46 ^b	61.55 ^a	62.56 ^a	4.81
Crude fiber	29.36 ^b	49.27 ^a	37.61 ^{ab}	54.53 ^a	53.89 ^a	6.00

Ether extract	63.20 ^a	65.36 ^a	50.67 ^a	55.69 ^a	50.87 ^a	9.22
NFE	71.07 ^b	87.47 ^a	88.62 ^a	75.53 ^b	71.35 ^b	1.86
NDF	37.89 ^b	54.68 ^a	38.79 ^b	50.56 ^{ab}	38.79 ^b	4.76
ADF	32.08 ^c	52.62 ^{ab}	38.96 ^{bc}	59.54 ^a	38.96 ^{bc}	4.36

^{abc}Means with different superscripts in the same row differed significantly ($P < 0.05$), SEM: standard Error of means.

Note; NFE =Nitrogen Free Extract, NDF = neutral detergent fibre, ADF =Acid detergent fibre

Nitrogen balance in growing Yankasa rams fed varying proportions of finger and pearl millet straw silage supplemented with poultry litter

Nitrogen balance is a critical indicator of protein utilization and overall animal performance, and the results obtained in this study showed significant ($P < 0.05$) differences across treatments. Nitrogen intake decreased significantly with increasing levels of pearl millet straw inclusion. The highest values were observed in T1 (12.05 g/day) and T2 (11.95 g/day), while the lowest values occurred in T4 (9.58 g/day) and T5 (9.61 g/day). This trend reflects the declining crude protein intake previously observed, as pearl millet straw is relatively low in nitrogen content compared to finger millet straw. This agrees with Norton (2003), who reported that crop residues generally have low nitrogen content, leading to reduced nitrogen intake when included at higher proportions. Fecal nitrogen output did not differ significantly ($P > 0.05$) among treatments, although numerically higher values were recorded in T1 (2.87 g/day) and lower values in T5 (1.81 g/day). The lack of significant variation suggests that dietary treatments did not markedly affect nitrogen losses through feces, indicating relatively stable digestibility of protein across diets. This observation is consistent with Van Soest (1994), who noted that fecal nitrogen is often less responsive to dietary changes compared to urinary nitrogen. Urinary nitrogen output showed significant differences, with T1 (2.39 g/day) and T2 (2.47 g/day) recording higher values, while T3 (0.88 g/day) had the lowest. The reduction in urinary nitrogen at moderate inclusion levels suggests improved nitrogen utilization and reduced nitrogen wastage. This supports the findings of Osuji et al. (1993), who reported that efficient synchronization of energy and nitrogen in the rumen reduces urinary nitrogen losses. Total nitrogen outgo followed a similar trend, with significantly higher values in T1 (5.27 g/day) and T2 (5.17 g/day), and lower values in T3–T5. This indicates that animals on higher inclusion levels lost less nitrogen overall, likely due to improved utilization efficiency. Nitrogen absorbed decreased significantly from T1 (9.18 g/day) and T2 (9.25 g/day) to T4 (7.74 g/day) and T5 (7.80 g/day), reflecting the reduced nitrogen intake at higher inclusion levels. However, nitrogen retained (g/day) did not differ significantly ($P > 0.05$) across treatments, with T3 recording the highest value (7.18 g/day) and T4 the lowest (6.24 g/day). This suggests that despite lower nitrogen intake at higher inclusion levels, animals were able to maintain comparable nitrogen retention, indicating efficient utilization of available nitrogen. Notably, nitrogen retained as a percentage of intake showed significant differences, with T3 (67.39%), T5 (66.59%), and T4 (65.17%) being significantly higher than T1 (56.26%) and T2 (56.81%). This indicates improved nitrogen use efficiency at moderate to higher inclusion levels. The higher retention efficiency may be attributed to better synchronization between energy and nitrogen supply, enhancing

microbial protein synthesis in the rumen. This finding agrees with Aregheore (2000), who reported that improved dietary balance enhances nitrogen retention efficiency in small ruminants.

Table 5: Nitrogen balance in growing Yankasa rams fed varying proportions of finger and pearl millet straw silage supplemented with poultry litter

Parameters	Varying proportion of finger and pearl millet Stover					
	T1 (0)	T2 (10)	T3 (20)	T4 (30)	T5	SEM
N intake	12.05 ^a	11.95 ^a	10.65 ^b	9.58 ^c	9.61 ^c	0.43
Fecal N output	2.87 ^a	2.70 ^a	2.58 ^a	1.85 ^a	1.81 ^a	0.32
Urinary N output	2.39 ^a	2.47 ^a	0.88 ^b	1.47 ^{ab}	1.40 ^{ab}	0.30
Total N outgo	5.27 ^a	5.17 ^a	3.46 ^b	3.34 ^b	3.21 ^b	0.51
Nitrogen absorbed	9.18 ^a	9.25 ^a	8.07 ^b	7.74 ^b	7.80 ^b	0.33
Nitrogen retained/balance	6.78 ^a	6.78 ^a	7.18 ^a	6.24 ^a	6.41 ^a	0.48
Nitrogen retained as %	56.26 ^b	56.81 ^b	67.39 ^a	65.17 ^a	66.59 ^a	4.24

^{abc}Means with different superscripts in the same row differed significantly ($P < 0.05$), SEM: standard error of means.

4. CONCLUSION

This study demonstrates that varying proportions of finger and pearl millet straw silage, supplemented with poultry litter, significantly influence the dietary nutrient profile, intake, digestibility, and nitrogen utilization in growing Yankasa rams. Increasing the inclusion of pearl millet straw resulted in a linear increase in fibre fractions, which was accompanied by a reduction in crude protein and energy content. Optimal performance was observed at moderate inclusion levels (T2 and T3), which provided a superior nutrient balance that improved feed intake, digestibility, and nitrogen retention. Conversely, higher inclusion levels (T4 and T5) negatively impacted nutrient availability and utilization due to elevated lignocellulosic fibre and reduced protein availability. Therefore, while the partial replacement of finger millet straw with pearl millet straw is beneficial, excessive inclusion should be avoided to prevent a decline in the overall nutritional value of the diet and subsequent animal performance.

5. RECOMMENDATION

For optimal nutrient utilization and performance in growing Yankasa rams, the inclusion of pearl millet straw silage in finger millet straw-based diets should be maintained at moderate levels (18.75–35.5%). Higher inclusion levels (exceeding 50%) should be avoided, as elevated fibre fractions and diminished crude protein content negatively impact diet quality. Furthermore, poultry litter is recommended as an effective nitrogen supplement to improve the nutritive value of low-quality crop residues. Future research should evaluate the long-term effects of these dietary combinations on growth performance, carcass characteristics, and the economic viability of the feeding system.

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