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Assessing Protein Sources on Growth Performance, Nutrient Intake, Digestibility and Nitrogen Balance of Growing Goats in Maiduguri, Borno State Nigeria

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Abstract: A study was conducted to evaluate growth performance, digestible nutrient intake and nitrogen balance in sixteen growing bucks fed different protein sources in total mixed ration for 56 days. The different protein sources were cotton seed cake, poultry litter, rumen content, and soya bean waste for treatment 1, 2, 3 and 4 respectively. Significant (P<0.05) variation was observed in the proximate composition of the diets with treatment 1 exhibiting the highest crude protein (17.99%) and metabolizable energy (2425.3 kcal/kg) while treatment 4 had the highest crude fibre (28.0%) and moisture content (22.3%). Growth performance parameters showed that bucks fed treatment 1 diet achieved the highest daily weight gain (9.52 g/day) and better feed conversion ratio. The result indicated differences (P<0.05) in nutrient intake across the treatments in all the parameters. Animals in treatment 1 had the highest values in dry matter, organic matter, crude protein and ether extract intake while the lowest in treatment 4. The results also revealed that bucks fed cotton seed cake protein source exhibited superior nutrient digestibility with its corresponding lowest value in treatment 4. A positive nitrogen balance was observed for all the animals across the treatment with significant (P<0.05) differences between the treatments ranging from 10.87g/day for bucks fed rumen content (T3) to 13.91g/day for those on cotton seed cake (T1). It was concluded from this study that diets containing cotton seed cake fed to bucks gave better result in terms of growth performance, nutrient intake, digestibility and nitrogen balance than other diets.

Keywords: *Bucks, Protein Sources, Nutrient Intake, Digestibility and Nitrogen Balance.*

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I. INTRODUCTION

Goat production is a vital component of livestock farming, particularly in arid and semi-arid regions where goats are raised for meat, milk, fibre, and hide. Goats' adaptability to harsh environmental conditions and their relatively low feed requirements makes them ideal for smallholder farming systems in developing countries. However, despite their resilience, their growth performance heavily depends on proper nutrition, particularly the availability of high-quality protein sources in their diet (Akinfemi *et al.*, 2015).

Protein is a key nutrient that influences various physiological processes such as growth, reproduction and immune function in goats. In growing goats, adequate dietary protein intake is necessary to support muscle development and efficient nutrient utilization, which are critical for improving overall productivity (Kahn and Line, 2010). However, the availability of quality protein sources in many regions, especially in developing countries is often constrained by limited access to commercial feeds, making it essential for farmers to rely on locally available feedstuffs (Tadesse *et al*., 2018). These include crop residues and by-products such as groundnut haulm, maize bran, sorghum husk, and cottonseed cake, which are commonly incorporated into the diet but vary in their nutritional content and digestibility.

Nutrient digestibility refers to the proportion of ingested nutrients that are absorbed and utilized by the animal. In ruminants, this process is influenced by the composition of

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the diet, the quality of the feed and the efficiency of the digestive system. Goats being versatile feeders can utilize a wide range of feedstuffs; however, the digestibility of these feedstuffs can vary significantly. Studies have shown that the digestibility of nutrients such as carbohydrates, proteins, and fats can be affected by the source and composition of the energy provided in the diet (National Research Council, 2007; Van Soest, 1994).

The concept of total mixed ration (TMR) has gained significant traction in ruminant nutrition as it provides a balanced diet that ensures a uniform intake of nutrients across meals. TMR combines forages, concentrates, minerals, and vitamins into a single homogenous mixture preventing selective feeding by the animals and improving nutrient intake (Moghaddam *et al*., 2020). However, the efficacy of TMR in improving performance largely depends on the protein sources incorporated into the mix. Therefore, selecting the most appropriate protein sources to maximize nutrient digestibility and cost-efficiency is vital for achieving optimal growth performance in goats.

Maiduguri, located in the Sudan Savannah zone of Nigeria, faces significant agricultural challenges that impact livestock farming, particularly goat rearing. The region's arid and semi-arid conditions is characterized by low and erratic rainfall, high temperatures, and prolonged dry seasons which limit the growth and availability of forage and other feed resources. This scarcity of feed and water poses a considerable barrier to meeting the nutritional requirements of livestock, particularly during the dry season when natural pastures are insufficient. Farmers often rely on low-quality forages and crop residues, which do not provide adequate nutrition, leading to nutrient deficiencies and imbalances (Mohammed & Abubakar, 2014).

Additionally, the limited availability of quality feed resources exacerbates the situation. The dependence on natural pastures which are often of poor nutritional quality necessitates the search for alternative feed sources and improved feeding strategies (Ademola *et al*., 2014). The reliance on traditional feeding practices which are not scientifically informed and do not cater to the specific dietary needs of goats further compounds the problem. These practices result in poor growth rates, low milk production and overall reduced productivity in goats. Transitioning from traditional to more scientifically informed feeding practices is crucial to optimize nutrient utilization and enhance livestock health and performance. The objectives of this study are to evaluate the influence of different protein sources on growth performance, nutrient intake, digestibility and nitrogen balance of growing goats.

➢ *Experimental Site*

The experiment was conducted at the Small Ruminant Unit of the Teaching and Research Livestock Farm as well as the Laboratory Unit which is part of the Department of Animal Science Faculty of Agriculture, University of Maiduguri Borno State, Nigeria. The University of Maiduguri is located in the city of Maiduguri, which is situated at latitude 11^0.15' North and longitude 13^0.09' East (Encarta, 2007). The city has an altitude of 354 meters above sea level and falls within the semi-arid zone of West Africa, which is characterized by short duration of rainfall and a long dry season. The climate in Maiduguri is typical of the semi-arid region. The ambient temperature is high, reaching its peak in the month of April and May. In contrast, the temperature is relatively low during the months of December and January. The relative humidity in the region varies, ranging from 5% to 45%, as reported by Raji *et al.*, (2014).

➢ *Source of Experimental Ingredients*

The experimental ingredients were groundnut haulms, maize bran, sorghum husk, cotton seed cake, poultry litter, rumen content, soya bean waste, bone meal and salt. All the ingredients were sourced from Maiduguri cattle market and were grounded except poultry litter and rumen content. Poultry litter was sourced from deep litter system of Poultry Unit of the Teaching and Research Farm. It was raked to remove the sawdust and sun dried for 3 – 4 days while the rumen content was sourced from Maiduguri Central Abattoir. The rumen content was sieved to remove moisture and sun dried for 4-5 days to prevent the growth of mold. Thereafter, they were all stored in bags and kept in a dry place for further use. The feed ingredients were mixed following the proportion in Table 1 below:

Table 1 Composition of Experimental Ingredients

Ingredients (kg)	T1 (CSC)	T2 (PL)	T3 (RC)	T4 (SBW)
GH	30.00	30.00	30.00	30.00
MB	37.90	29.15	23.32	25.56
SH	15.00	15.00	15.00	15.00
CSC	14.59	-	-	-
PL	-	23.35	-	-
RC	-	-	29.18	-
SBW	-	-	-	26.93
BM	02.00	02.00	02.00	02.00
TS	00.50	00.50	00.50	00.50
TOTAL	100.00	100.00	100.00	100.00

GH = groundnut haulms, MB = maize bran, SH = sorghum husk, CSC = cotton seed cake, PL = poultry litter, RC = rumen content, SBW = soya bean waste, BM = bone meal, TS = table salt, T1 = treatment 1, T2 = treatment 2, T3 = treatment 3, T4 = treatment 4 and kg = kilograms.

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Experimental Animals and Management

Sixteen (16) growing goats (bucks) with an average body weight of 11.50 kg were used for this study. The animals were obtained from the Small Ruminants Unit of the Teaching and Research Farm, University of Maiduguri. The goats were weighed and identified using plastic ear tags and randomly assigned to four different treatment groups with four replicates. The animals were given prophylactic treatment against internal and external parasites, which included the administration of albendazole, oxytetracycline, ivermectin and multivitamin injections. The animals undergo two weeks adaptation period prior to the commencement of the experiment in which their respective experimental diets were provided at 3% of their body weight and clean water was provided *ad-libitum.*

II. EXPERIMENTAL DESIGN

The experiment was conducted in a Completely Randomized Design (CRD) of four treatments each with four replicates and the feeding trial lasted for eight weeks.

Parameters Measured

- *Feed Intake*

Feed intake was determined by given a measured quantity of feed to the animals and the leftover was weighed the following morning. The leftover values were subtracted from the quantity given to obtain the actual feed consumed.

- *Live Weight Change*

Live body weight was recorded by weighing each of the animal weekly. Weight change was determined by subtracting the body weight of the previous week from the current week. The difference between the two is the live weight change.

- *Feed Conversion Ratio*

Feed conversion ratio was calculated as the total feed intake per day per animal divide by the body weight change for the said as follows.

FCR= Total feed intake/weight change

Nutrient Digestibility and Nitrogen Balance

Nutrient digestibility and nitrogen balance were determined at the end of the feeding trial using metabolic cages. Twelve (12) animals were randomly selected three (3) from each treatment and place in a metabolic cage. The animals were allowed fourteen (14) days adjustment period in the cages. Total feed intake, faecal and urine output were recorded for seven (7) days. Samples of feed and faecal output were air dried bulk and sub-samples were taken for chemical analysis. Urine sample collected was measured and sub-samples was kept in a bottle containing hydrochloric acid (2mls / 10mls sample) to prevents evaporation and caking of the sample before further use. The nutrient digestibility and nitrogen balance were determine using the formula below.

$$\text{Nutrient digestibility} = \frac{\text{Nutrient in feed} - \text{Nutrient in faeces}}{\text{Nutrient in feed}} \times 100$$

$$\text{Nitrogen balance} = \frac{\text{Nitrogen in feed} - (\text{Nitrogen in faeces} + \text{Nitrogen in urine})}{\text{Nitrogen in feed}} \times 100$$

Proximate Analysis

The feed and faecal samples collected were analyze on dry matter (DM) basis for crude protein (CP), crude fibre (CF), ether extract (EE) and Ash according to A.O.A.C. (2010) methods. Urine was analyzed for nitrogen (crude protein = N×6.25) while nitrogen free extract was calculated.

Statistical Analysis

The data collected were subjected to analysis of variance using general linear model of SAS and significant treatment means were separated using Least Significant Difference (LSD).

III. RESULT AND DISCUSSION

Proximate Composition of the Experimental Diets

The proximate composition of experimental diets is represented in Table 2 which reveal significant ($P<0.05$) differences across the various treatments (T1, T2, T3, and T4) in all the parameters (dry matter, moisture content, organic matter, crude nitrogen, crude fibre, ether extract, ash, nitrogen free extract and metabolizable energy).

The dry matter is low in T4 (77.7%) compared to T1, T2, and T3 with the following values 92.4%, 92.3%, and 92.4%, respectively. This indicates a higher moisture content in T4 (22.3%) diet and may be linked to the test material (soya bean waste) in the feed formulation or processing method. These results align with findings by Adebiyi *et al.* (2020) who reported that diets with higher moisture contents often result from liquid or semi-liquid feed ingredients hence reduces the overall dry matter. However, Makkar *et al.* (2008) reported that high moisture levels in certain feedstuffs or ingredients can limit nutritional efficacy and lead to spoilage.

The organic matter is high in T2 (81.30%) as compared to T1, T3 and T4. The reduced organic is attributed to high ash content. Similar, Smith *et al.* (2019) highlighted that an increase in ash content inversely influence organic matter in feed formulations. However, feed in treatment 4 had the lowest organic which reflect its less favourable nutritional profile. This variability emphasizes the importance of organic matter as an indicator of feed quality.

The crude protein content was highest in T1 (17.99%) and decreased progressively in T2 (16.54%), T3 (15.64%) and T4 (14.7%). This variation reflects differences in nitrogen-rich ingredients across the treatments. According to Ekenyem and Madubuike (2021) diets with higher nitrogen content often enhance animal growth and productivity while lower nitrogen levels may reduce growth efficiency. This finding is consistent with Nwokolo (1996) who highlighted the nutritional benefits of cotton seed cake reinforcing the

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importance of selecting high-quality protein sources for optimal animal health and productivity.

Diet 4 had the highest crude fibre content (28.000%) than the other diets which could negatively hinder digestibility and nutrient absorption. Although, the levels in this research are not up to the harmful level as stated by Aregheore (2000) that high fibre levels can lead to reduced feed efficiency. Fibre content is beneficial for ruminants but could limit digestibility in monogastric animals, as noted by Agunbiade *et al*. (2018).

Ether Extract showed a significantly (P<0.05) variation within the diets with T1 having the higher value of 9.525% indicating a better fat content, which is crucial for energy supply in ruminants. In contrast, T2 had the lowest ether extract (1.500%) value suggesting a less energy-dense option. This discrepancy highlights the importance of fat in diets for enhancing energy availability. Mahmood *et al*. (2020) emphasized that higher fat levels improve energy density in diets which is beneficial in performance but should not exceed the recommended level

The ash content in this experiment ranges between 11 to 18% with diet in treatment 3 (T3) had the highest value of 18.00%, which could indicate potential quality issues or excessive mineral content. High ash levels may not contribute to nutritional value and could reflect the presence of non-nutritive fillers.

Nitrogen-free extract (NFE), present the available digestible carbohydrates in feed, diet of T2 (39.81%) was high while T3 had the lowest (24.06%) content. The metabolizable energy (ME) followed a similar trend, with T1 (2425.3 kcal/kg) exhibiting the highest energy level, while T4 (1689.7 kcal/kg) had the lowest. This corresponds with studies by Onwudike (2020), who noted that energy levels are positively correlated with carbohydrate content. Moreover, the result of T2 indicates better carbohydrate availability which is important for energy metabolism in goats. This supports the findings of Aregheore (2000) regarding the role of carbohydrates in energy provision.

Diet in T1 provided the highest metabolizable energy (2425.3 kcal/kg) reinforcing its status as the most beneficial nitrogen source for enhancing ruminant performance. Diet in T4 had the lowest metabolizable energy (1689.7 kcal/kg) suggesting that it may not meet the energy requirements for optimal growth and production. The results of this study align with those of Adebiyi *et al*. (2020) who reported that diets with higher crude nitrogen and energy levels promote better growth performance in monogastric animals rather than ruminants. The lower ME in T4 indicates that it may not support optimal growth compared to T1 which is cotton seed cake.

Table 2 Proximate Composition of the Experimental Diets

Parameters (%)	T1	Treatments T2	T3	T4	SEM
Dry matter	92.40^{a}	92.30^{a}	92.40^{a}	77.70^{b}	0.077*
Moisture content	07.60^{b}	07.70^{b}	07.60^{b}	22.30^{a}	0.077*
Organic matter	80.87^{ab}	81.30^{a}	74.40^{b}	66.20^{c}	0.409*
Crude protein	17.99^{a}	16.54^{b}	15.64^{c}	14.70^{d}	0.411*
Crude fibre	25.50^{b}	23.50^{c}	24.00^{c}	28.00^{a}	0.621*
Ether extract	09.53^{a}	01.50^{d}	07.00^{b}	02.50^{c}	0.268*
Ash	11.53^{b}	11.00^{b}	18.00^{a}	11.50^{b}	0.431*
Nitrogen free extract	27.84^{b}	39.81^{a}	24.06^{b}	26.57^{b}	0,483*
Metabolizable energy (kcal/kg)	2425.30^{a}	2146.70^{ab}	1999.90^{bc}	1689.70^{c}	169.01*

^{abcd} = Mean in the same row with different superscripts differ significantly (P<0.05). where T1=cotton Seed Cake, T2= Poultry Litter, T3= Rumen Content, T4=Soya Bean Waste, SEM= Standard Error of Mean, ME = [(37 x % CP) + (81 x % EE) + (35.5 x %NFE)] according to Pauzenga (1985)

➢ *Performance of Bucks Fed Ratio with Different Protein Sources*

The growth performance of bucks fed with different dietary protein sources is shown in Table 3. The parameters assessed include dry matter intake, live weight changes, weight gain, feed conversion ratio and intake relative to body weight.

Dry matter intake (DMI) is an important determinant of nutrient availability for growth and maintenance. In this study T1 and T2 showed significant (P<0.05) higher DMI values of 339.58 g/day and 328.89 g/day respectively compared to T3 (278.34 g/day) and T4 (234.61 g/day). The lowest DMI in T3 and T4 suggests reduced palatability and digestibility which may have limited feed intake. El-Sayed *et al*. (2017) emphasized that feed palatability and nutrient composition significantly affect DMI. The current result of this study aligns with findings by Ndlovu *et al*. (2016) who noted that high-quality protein sources enhance feed intake and overall performance in ruminants.

The initial live weights were similar across treatments, indicating that the goats were comparable at the start of the experiment. The final live weights also showed no significant (P>0.05) differences. This consistency in final weights suggests that dietary protein sources influenced DMI and weight gain as well as the overall growth outcome was not significantly different across the treatments

Total weight gain (TWG) and daily weight gain (DWG) followed a declining trend from T1 to T4. Treatment 1 recorded the highest TWG and DWG of 533.33 g and 09.52

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g/day while T4 had the lowest values of 316.67 g and 05.66 g/day respectively. The present finding agreed with Gao *et al.* (2020) who reported that high-protein feeds with good digestibility such as cottonseed cake promote better weight gain compared to less digestible protein sources. The reduced weight gain in T4 may reflect the presence of anti-nutritional factors or lower protein quality in soya bean waste (Kiran *et al*., 2021). This supports the work of Afolayan *et al*. (2017), who found that goats fed higher protein diets demonstrated superior weight gain which is attributed to better nutrient absorption and utilization.

The intake as a percentage of body weight (IPBW) was highest in T2 (03.62%) and lowest in T4 (02.55%). This indicates that animals in T2 consumed more relative to their body weight, potentially due to its balanced nutrient composition. Conversely, the lower intake in T4 suggests reduced feed efficiency or palatability. He also highlighted that the intake of unconventional feed sources like poultry litter could vary significantly based on processing methods and nutrient availability.

Feed conversion ratio (FCR) measures the efficiency of converting feed into body weight. T1 had the best FCR indicating higher feed efficiency. Animals in T3 recorded the poorest FCR suggesting that goats on this diet required more feed to achieve similar weight gains. Sánchez *et al.* (2020) observed that protein sources with higher digestibility improve FCR which corroborates the better performance of T1 compared to T3 and T4. The high FCR in T4 may reflect the challenges associated with metabolizing soya bean waste possibly due to anti-nutritional factors (Kiran *et al*., 2021).

Table 3 Growth Performance of Goats (Bucks) Fed Ration Containing Different Protein Sources

Parameters	T1	T2	T3	T4	SEM
Dry matter (g/day)	339.58^{a}	328.89^{a}	278.34^{b}	234.61^{c}	12.11*
Initial live weight (kg)	11.37	11.07	11.23	11.23	00.89^{Ns}
Final live weight (kg)	11.90	11.47	11.58	11.55	00.84^{Ns}
Total weight gain (g)	533.33	400.00	350.00	316.67	155.0^{Ns}
Daily weight gain (g)	09.52	07.14	06.25	05.66	02.77^{Ns}
Intake per % body weight (g)	03.59	03.62	03.01	02.55	00.30^{Ns}
Feed conversion ratio	38.46^{a}	54.52^{a}	58.84^{b}	52.57^{a}	23.52*

^{abc} = Mean in the same row with different superscripts differ significantly **(**P<0.05), T1=Cotton Seed Cake, T2= Poultry Litter, T3= Rumen Content, T4=Soya Bean Waste, SEM= Standard Error of Mean.

➢ *Nutrients Intake of Bucks Fed Different Protein Sources*

The nutrient intake of bucks fed different protein sources is presented in Table 4. There was significant (P<0.05) difference in all the parameters of nutrient intake. The dry matter and organic matter intake were significantly (P<0.05) varied within the treatments with T1 and T2 having the highest values while T4 recorded the least value. These differences suggest the protein sources in T1 and T2 were more digestible and palatable (Yusuf *et al.*, 2020). Higher OM intake generally improves microbial activity in the rumen hence, supporting better digestion and nutrient absorption (Okoro *et al.*, 2022).

Crude protein intake (CPI) is essential for muscle growth, tissue repair, and reproductive efficiency in ruminants. The CPI is significantly (P<0.05) across the treatments with T1 (78.13g/day) having the higher value followed by T2 then T3 and lastly T4. Adequate protein intake improves rumen microbial synthesis, leading to better nitrogen utilization (Adeyemi *et al.*, 2018). Diets deficient in protein, like T4 (51.95g/day) can lead to poor microbial activity and reduced digestibility of fibrous feeds (Ajayi *et al.*, 2019).

Crude fibre intake (CFI) affects rumen function, chewing activity and gut motility. In this study, T1 (110.72) indicates highest CFI while T4 (85.66) had the lowest value. Higher CFI is often linked with better rumen buffering capacity and improved microbial activity (Yusuf *et al.*, 2020). Fibre is essential for maintaining rumen health by stimulating saliva production and preventing acidosis (Okoro *et al.*, 2022). However, excessive fibre, especially low-quality fibre can limit intake and nutrient absorption due to longer retention time in the rumen. The low CFI in T4 shows lower fibre content or improved digestibility, which can benefit young or lactating animals requiring higher energy levels (Abubakar *et al.*, 2021).

Ether extract intake (EEI) measures the fat content of the diet contributing to energy density and absorption of fat-soluble vitamins. Animals in treatment 1 (41.34g/day) showed the highest EEI over T2, T3 and T4 and are statistically (P<0.05) different. Diets rich in fat can enhance energy supply especially during high production phases (Adeyemi *et al.*, 2018).

Ash intake indicates the mineral content of the diet which is vital for bone development, metabolic functions and overall health. Animals in T3(64.25g/day) had the highest ash intake while T4 recorded the lowest value. Higher ash intake in T3 could be due to mineral supplementation or higher mineral content in the diet (Yusuf *et al.*, 2020). Adequate mineral intake supports enzyme activity, bone growth and metabolic efficiency (Okoro *et al.*, 2022). Deficient mineral intake, as seen in T4, could result in poor metabolic efficiency and weaker skeletal development. Excessive ash intake without proper nutrient balance can however affect palatability and reduce voluntary feed intake (Abubakar *et al.*, 2010).

Nitrogen-free extract (NFE) Represents the non-fibrous carbohydrate content of the feed, which provides readily available energy for maintenance and production. T2

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(176.69) had the highest NFE intake, while T3 (85.98g/day) and T4 (94.33g/day) showed lower values. Higher NFE supports rumen fermentation and microbial growth by supplying rapidly fermentable carbohydrates (Adeyemi *et al.*, 2018). Diets low in NFEI may not provide sufficient energy, leading to reduced productivity (Ajayi *et al.*, 2019). However, excessive focus on NFEI without enough structural carbohydrates can lead to digestive disorders such as acidosis (Oladunjoye and Ojebiyi, 2017).

Table 4 Nutrients Intake of Bucks Fed Different Protein Sources

Parameters	**T1**	**T2**	**T3**	**T4**	**SEM**
Dry matter intake (g)	434.29^{a}	443.62^{a}	356.89^{b}	353.53^{b}	05.25*
Organic matter intake (g)	351.24^{a}	360.65^{a}	265.52^{b}	234.04^{c}	04.45*
Crude protein intake (g)	78.13^{a}	73.31^{b}	55.82^{c}	51.95^{d}	01.28*
Crude fibre intake (g)	110.72^{a}	104.22^{b}	99.00^{b}	85.66^{c}	02.50*
Ether extract intake (g)	41.34^{a}	06.66^{d}	24.98^{b}	08.83^{c}	00.92*
Ash intake (g)	50.04^{b}	48.81^{b}	64.25^{a}	40.66^{c}	01.81*
Nitrogen free extract Intake (g)	120.93^{b}	176.69^{a}	85.98^{b}	94.33^{b}	18.04*

^{abc} = Mean in the same row with different superscripts differ significantly **(**P<0.05), T1=Cotton Seed Cake, T2= Poultry Litter, T3= Rumen Content, T4=Soya Bean Waste, SEM= Standard Error of Mean.

- *Nutrients Digestibility of Bucks Fed Diets Containing Different Protein Sources*

The current result indicate that growth performance is closely related to nutrient digestibility with significant (P<0.05) differences observed among the various protein sources fed to animals. As shown in Table 5, animals in treatment 1 (T1) consistently exhibited the highest nutrient digestibility across multiple parameters: dry matter (48.39%), organic matter (45.82%), crude protein (70.60%), crude fibre (53.36%), and ether extract (94.57%). This superior digestibility underscores its role as an effective protein source for promoting growth and maintenance in goats.

In comparison, animals in T2 which include poultry litter demonstrated the lowest digestibility for both dry matter (33.54%) and ether extract (33.06%). This suggests that anti-nutritional factors may hinder nutrient absorption, corroborating findings by similar authors like Adebowale *et al*. (2018) who noted the adverse effects of certain feed components on nutrient utilization. Animals in T4 (soya bean waste) also exhibited low digestibility values particularly for organic matter (19.47%) and crude fibre (40.11%) which limits nutrient absorption and is in consistent with observations by Oduguwa *et al.* (2007) regarding the impact of fibre on digestibility.

While animals fed with rumen content protein source showed relatively efficient mineral absorption with the highest ash digestibility in T4 (63.29%) it did not exhibit significant differences in nitrogen-free extract digestibility across treatments. This finding aligns with the work of Nwokolo (1996), who emphasized the importance of nutrient quality over quantity in optimizing growth performance. The findings shows that the nutrient digestibility of goats fed different protein sources each supported by relevant research findings. T1 exhibited the highest digestibility across multiple parameters aligning with Nwokolo (1996), who stressed cotton seed cake as a superior protein source due to its high nutritional value.

Table 5 Nutrients Digestibility of Bucks Fed Diets Containing Different Protein Sources

Parameters	**T1**	**T2**	**T3**	**T4**	**SEM**
DM Digestibility	48.39^{a}	33.54^{d}	40.56^{b}	37.96^{c}	00.50*
OM Digestibility	45.82^{a}	30.19^{c}	39.85^{b}	19.47^{d}	00.50*
CP Digestibility	70.60^{a}	54.78^{b}	69.11^{a}	50.19^{c}	01.61*
CF Digestibility	53.37^{a}	42.30^{bc}	45.52^{b}	40.11^{c}	02.09*
EE Digestibility	94.57^{a}	33.06^{c}	91.49^{a}	74.37^{b}	03.18*
ASH Digestibility	52.98^{b}	57.58^{ab}	61.92^{a}	63.29^{a}	02.85*
NFE Digestibility	06.48	12.65	28.01	36.42	16.17^{Ns}

^{abc} = Mean in the same row with different superscripts differ significantly **(**P<0.05), T1=Cotton Seed Cake, T2= Poultry Litter, T3= Rumen Content, T4=Soya Bean Waste, SEM= Standard Error of Mean, DM = Dry Matter, OM = Organic Matter, CP = Crude Protein, CF = Crude Fibre, EE = Ether Extract, NFE = Nitrogen Free Extract.

- *Nitrogen Balance of Bucks Fed Ration Containing Different Protein Sources*

The nitrogen balance of bucks fed diets containing different protein sources was presented in the Table 6. Significant (P<0.05) differences exist across the animals in all the parameters. Nitrogen intake (NI) was higher in animals that were fed cotton seed cake (T1) and the least in group fed rumen content (T3). This observation confirms the findings of Chana (2023) who fed rams with different nitrogen sources and the higher NI was in group fed cotton seed cake alone than CSC and its combination. It also agrees with the result of Rao *et al.* (2019) who reported that goat fed diet with CSC had higher nitrogen intake compared to other nitrogen sources. However, Jokthan *et al.* (2013) reported an increase in NI with replacement of broiler litter and Asrat *et al.* (2008)

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stated that NI increases at 14 and 28% then decreases at 45% inclusion level of broiler litters which was not in conformity with the present work.

Faecal nitrogen (FN) was significantly (P<0.05) different across the treatment with animal in T2 with a highest value of 5.30g/day and lowest in T3 (02.76g/day). The higher FN in T2 could be a sign of poor nitrogen utilization, leading to excess nitrogen being excreted in the faeces. Studies by Cruz *et al.* (2017) suggest that lower-quality protein sources can result in higher nitrogen excretion as the animal cannot fully digest or utilize the nitrogen, leading to increased nitrogen losses. Urinary nitrogen was statistically (P<0.05) different among the treatment ranging from 00.07 to 00.28g/day for T3 and T4 respectively. This result was supported by findings by Allen *et al*. (2018) testified that high-nitrogen sources give rise to in higher excretion in urine, likely due to an excess of nitrogen not fully utilized by the animals.

The total nitrogen output (TNO) was the sum of FN and UN which was significantly (P<0.05) different across the treatments, it follows similar trend with FN. The result of this study is in line with Muller *et al*. (2025) where he reported that total nitrogen output was influenced by nitrogen quality and digestibility of feed. The range of nitrogen output for this study were lower than 11.71 to 16.31g/day for *Balami* rams according to Chana (2023). In general, high-protein and less digestible feed leads to higher nitrogen output.

The retained nitrogen of this study was significantly (P<0.05) high in animal of T1 (13.91g/day) and the lowest in T3 (10.87g/day). However, the nitrogen retained as percentage of intake were higher in T3 and T1 indicating better nitrogen efficiency, while T2 had low percentage due to significant nitrogen loss in faeces and urine. The higher percentage showed in treatment 3 indicate high efficiency in utilizing the nitrogen despite its lower intake. This could be explained by the high fermentation and microbial digestion in the rumen which is consistent with the report of Pang *et al*. (2017) who observed that ruminants often retain a higher percentage of nitrogen when fed with rumen-derived materials.

Table 6 Nitrogen Balance of Bucks Fed Ration Containing Different Nitrogen Sources

Parameters	T1	T2	T3	T4	SEM
Nitrogen Intake (g/day)	17.72^{a}	16.68^{b}	13.71^{c}	15.84^{b}	00.40*
Faecal Nitrogen (g/day)	03.68^{c}	05.30^{a}	02.76^{d}	04.14^{b}	00.20*
Urinary Nitrogen (g/day)	00.13^{b}	00.12^{b}	00.07^{c}	00.28^{a}	00.01*
Total Nitrogen Output (g/day)	03.81^{c}	05.43^{a}	02.83^{d}	04.43^{b}	00.20*
Nitrogen Retained (g/day)	13.91^{a}	11.25^{b}	10.87^{b}	11.41^{b}	00.46*
Nitrogen Retained (as % of intake)	78.51^{a}	67.43^{c}	79.34^{a}	72.00^{b}	01.48*

^{abc} = Mean in the same row with different superscripts differ significantly (P<0.05), T1=Cotton Seed Cake, T2= Poultry Litter, T3= Rumen Content, T4=Soya Bean Waste, SEM= Standard Error of Mean

IV. SUMMARY

The present study evaluates the effects of various protein sources inclusion in the diet of growing bucks. The protein sources were cotton seed cake, poultry litter, rumen content and soya bean waste for T1, T2, T3 and T4 respectively on proximate composition of the experimental diets, growth performance, nutrient intake, digestibility and nitrogen balance of bucks. The proximate composition results revealed that diet with cotton seed cake (T1) had the highest crude protein and metabolizable energy, making it the most nutrient-dense diet while diet with soya bean waste (T4) exhibited the highest crude fibre and moisture content indicating reduced nutrient density. Poultry litter (T2) provided balanced nitrogen-free extract and energy whereas rumen content diet (T3) had the highest ash content, suggesting its potential as a mineral source. In terms of growth performance, bucks fed T1 diet showed superior dry matter intake, weight gain and better feed conversion ratio, emphasizing the effectiveness of cottonseed cake as a high-quality protein source. Bucks fed with soya bean waste (T4) had the lowest performance which may be due to anti-nutritional factors. The nutrient intake and digestibility results showed animals in T1 consistently outperformed the other treatments across several parameters, confirming its role as an optimal protein source for goats reinforcing its effectiveness in promoting growth. Nitrogen utilization was also more efficient in animals of T1 with higher nitrogen retention and lower nitrogen losses. However, animals in T2 resulted in poor nitrogen utilization, as evidenced by higher faecal nitrogen excretion. These results emphasize the importance of selecting nitrogen-rich diets like cotton seed cake to enhance productivity in livestock.

V. CONCLUSION

Cotton seed cake and poultry litter are suitable protein sources for bucks, supplying superior nutritional profiles and positive effects on growth performance, nitrogen balance and better digestibility. However, soya bean waste should be used with caution due to its lower metabolizable energy and lowest performance reflecting poor nutrient availability and utilization.

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