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Growth Performance and Nutrient Utilization of Balami and Yankasa Rams Fed *Leucaena leucocephala* and Dried Poultry Manure Based Concentrates Diets

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In this work, two feed concentrates—dried poultry manure concentrate (DPMC) and *Leucaena leucocephala*-based concentrate (LLBC)—fed to rams of two breeds (Yankasa and Balami) were assessed for their proximate composition, digestibility, and nitrogen utilization. In comparison to LLBC, which has more crude protein (15.26%), lower fiber (12.33%), and somewhat higher ether extract (3.21%), DPMC has higher dry matter (90.54%) and fiber (20.55%) but lower crude protein (13.58%) and ether extract (3.84%). Additionally, LLBC exhibits a greater nitrogen-free extract

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(46.23%) and ash content (8.45%) in comparison to DPMC, which results in a slightly higher total energy content (18.96 MJ/kg against 17.76 MJ/kg). Breed, feed, or breed × feed interaction impacts on performance indicators are not significant (P>0.05). Breed effects (P<0.05) were noted on digestibility, with Balami rams outperforming Yankasa rams in the digestibility of dry matter, crude protein, and nitrogen-free extract. LLBC increased(P<0.05) the digestibility of nitrogen-free extract and dry matter compared to DPMC. The findings indicate that as compared to Yankasa rams fed LLBC, Balami rams fed DPMC showed greater (P<0.05) digestibility of dry matter, crude protein, and nitrogen-free extract. The effects of breed, feed, and breed × feed interaction on nitrogen utilization were significant (P<0.05). Breed has a significant (p<0.05) impact on nitrogen intake, digestion, and retention; Yankasa has greater values than Balami. In comparison to DPMC, LLBC resulted in increased nitrogen intake and retention. Interestingly, the interaction effect reveals that whilst Balami rams retained more nitrogen with DPMC, Yankasa rams retained more nitrogen with LLBC. With implications for optimizing feed strategies based on breed-specific requirements, this study highlights the impact of both feed type and breed on nutritional efficiency.

Keywords: Dried poultry manure concentrate; Leucaena leucocephala-based concentrate; Yankasa; Balami; proximate composition; nitrogen digestibility and retention.

1. INTRODUCTION

Agricultural research has increasingly focused on enhancing the productivity and sustainability of farm animals, particularly small ruminants, through improved dietary regimens [1]. Integrating alternative feed resources that offer both nutritional value and economic feasibility is crucial for promoting growth performance and efficient nutrient utilization in these animals [2]. Two promising resources are *Leucaena leucocephala*, a leguminous tree with high protein content, and dried poultry manure, a nutrient-rich byproduct [3].

Leucaena leucocephala has garnered interest due to its favorable amino acid profile, digestibility, and potential to enhance performance in ruminants. However, its use is limited by the presence of mimosine, a toxic amino acid that can disrupt metabolism and animal health when consumed in large quantities [3]. Mimosine has been linked to adverse effects on animal health, including impaired growth, hair loss, and goiter, due to its impact on thyroid function [4].

However, ruminants possess a unique digestive system that enables them to tolerate antinutritional factors, making *Leucaena leucocephala* a viable feed option for sheep (Kumar *et al*., 2022). Gradual introduction of *Leucaena leucocephala* into their diet allows rumen microbiota to adapt and increase the population of mimosine-degrading microorganisms [5]. Strategic incorporation of *Leucaena leucocephala* at safe levels, combined with other forages or feeds, can mitigate the adverse effects of mimosine (Shelton*et al*., 2020). Various detoxification methods, including breeding low-mimosine strains, using sulphur-containing compounds, ensiling, and adding polyethylene glycol (PEG), can further reduce mimosine content [6,7].

Conversely, dried poultry manure offers a cost-effective supplement rich in nitrogen and organic matter, but its use requires careful management to prevent pathogen load and nutrient imbalance issues [8,9]. The findings of this study will contribute significantly to the development of sustainable feeding strategies that enhance the productivity of small ruminants in tropical regions, aligning with global efforts towards sustainable agriculture and food security [10,11,12].

Therefore, this study aims to investigate the growth performance and nutrient utilization of Balami and Yankasa rams fed diets incorporating *Leucaena leucocephala* and dried poultry manure-based concentrates.

2. MATERIALS AND METHODS

2.1 Experimental Site

The study was conducted at the Ruminant Section of the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, Nigeria (7°37'15" N, 5°13'17" E). The region experiences a humid tropical climate with an average humidity of 75%, temperature ranging from 20 to 28 °C, and annual rainfall of 1,367 mm.

2.2 Experimental Materials

Panicum maximum: Locally harvested, pruned, and dried to serve as the basal diet.

Fresh Poultry Manure: Collected from the Department's poultry unit, dried to remove moisture and destroy harmful bacteria.

Leucaena leucocephala: Collected from Radio Nigeria site, Ilokun, Ado-Ekiti, dried, and ground for use in the experimental diets.

2.3 Experimental Diets

Two diets were formulated:

Diet 1: 26% dried poultry manure, 30% corn, 10% rice husk, 2% groundnut cake, 18% dry brewer's grain, 12% groundnut hulls, 1.5% grower's premix, and 0.5% salt.

Diet 2: 26% Leucaena leucocephala, 30% maize, 10% rice husk, 2% groundnut cake, 18% dry brewers grain, 12% groundnut hulls, 1.5% grower premix, and 0.5% salt.

2.4 Pens' Preparation

The experimental chambers and equipment were thoroughly cleaned and disinfected before animal arrival to prevent contamination.

2.5 Experimental Animals

Twenty-four healthy yearling rams (12 Balami and 12 Yankasa) were used in this study. Animals were identified, isolated for two weeks, and monitored for diseases. Medication and injections were administered as needed.

2.6 Experimental Design

A randomized complete design (CRD) with a 2 × 2 factorial arrangement was used. Four treatments with three replicates each and one animal per replicate were tested.

2.7 Feeding Trial

A 7-day acclimatization period was followed by an 84-day feeding trial. Animals received clean water *ad libitum* and were fed basal and experimental diets at 3% body weight twice daily.

2.8 Digestibility Trial

After the feeding study, four rams (two Balami and two Yankasa) were placed in metabolism compartments for a 14-day adjustment period followed by a 7-day digestibility trial.

2.9 Data Collection

Feed intake, feed rejection, and animal body weight were recorded daily and weekly, respectively. Average daily feed intake, weight gain, and average daily gain (ADG) were calculated.

2.10 Chemical Analysis

Samples were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), and nitrogen-free extract (NFE) according to AOAC (2020). The apparent digestibility coefficient was calculated based on these measurements.

2.11 Statistical Analysis

Data were analyzed using a 2 × 2 factorial arrangement under CRD (SPSS, 2020). Duncan's multiple test was used to separate means when significant differences were found.

3. RESULTS

3.1 Proximate Composition of Concentrates

Table 1 presents the proximate composition of two test concentrates: one based on dried poultry manure (DPMC) and the other on *Leucaena leucocephala* (LLBC). The results show numerical differences in various nutritional parameters between the two concentrates.

The dry matter content: of DPMC (90.54%) is slightly higher than LLBC (86.87%), indicating lower moisture content in DPMC. The crude protein of LLBC (15.26%) has higher protein content than DPMC (13.58%), making LLBC a richer protein source. The fiber content of DPMC (20.55%) has higher fiber content than LLBC (12.33%), which may affect digestibility and energy use. Ether extract (oil content) of DPMC (3.84%) is slightly higher than LLBC (3.21%), indicating a slightly higher energy contribution from fat in DPMC.

Table 1. The proximate composition of experimental concentrates

Parameters (%)	**Dried Poultry Manure-based concentrate**	***Leucaena leucocephala*-based concentrate**
Dry Matter	90.54	86.87
Crude Protein	13.58	15.26
Crude Fibre	20.55	12.33
Ether Extract	3.84	3.21
Ash	7.68	8.45
Nitrogen free extract	37.54	46.83
Gross Energy (MJ Kg-1)	17.76	18.96

Table 2. The performance characteristics of rams as influenced by the main effects of breed, feed and feed x breed interactions

Parameters	**TFI (kg)**	**TFI/D (kg)**	**TCI (g/d)**	**ATCI (g/d)**	**TBI (kg/d)**	**ADBI (g/d)**	**DMI (kg)**	**IBW (kg)**	**FBW (kg)**	**BWG (kg)**	**MBWI (kg)**	**FCR**
Breed												
Yankasa	81.22^b	0.97^b	36.80^a	3.35^a	44.43	4.04^b	0.36^b	15.56^b	22.74^b	7.18^b	2.01	0.14
Balami	85.93^a	1.23^a	34.97^b	3.18^b	45.96	4.63^a	0.43^a	17.73^a	26.05^a	8.32^a	2.17	0.12
					Feed							
LLBC	82.34^a	0.98^b	35.47^b	3.22	48.52	4.41	42.71^a	15.06^b	22.40^b	7.34^b	2.01	0.12
DPMBC	84.81^a	1.01^a	36.30^a	3.31	48.68	4.26	36.19^b	17.07^a	25.45^a	8.38^a	2.17	0.10
Interactions												
Y/DPMBC	83.93^b	0.99^b	3.58^b	3.20	4.81	4.37^b	42.71^b	16.07^b	23.28^b	7.21^b	2.01	0.12
Y/DPMBC	78.51^c	0.93^b	5.75^a	3.43	4.08	3.71^C	36.19^c	15.10^b	22.20^b	7.00^b	2.00	0.11
B/DPMBC	85.69^a	1.02^a	3.68^b	3.34	4.89	4.45^{ab}	47.05^a	18.13^a	26.70^a	8.57^a	2.29	0.10
B/LLBC	86.18^a	1.03^a	3.32^b	3.08	5.30	4.82^a	43.46^b	17.33^a	25.40^a	8.07^a	2.13	0.11
P-values												
Breed(B)	**0.02**	**0.02**	**0.04**	0.02	**0.94**	**0.03**	**0.03**	**0.04**	**0.05**	**0.02**	**0.20**	**0.30**
Feed (F)	0.02	**0.04**	**1.86**	**0.17**	**0.94**	**0.85**	**0.02**	**0.03**	**0.04**	**0.03**	**2.00**	**0.20**
B x F interaction	0.05	**0.03**	**2.61**	**0.07**	**1.33**	**0.01**	**0.03**	**0.03**	**0.03**	**0.04**	**0.72**	**0.08**

a, b, c, = Means on the same column with different superscripts differ (p<0.05)

TFI = Total feed intake; TFI/D = Total feed intake per day; TCI = Total concentrate intake; ATCI = Average total concentrate intake ; TBI = Total basal intake; ADBI = Average daily basal intake; DMI = Dry matter intake; IBW = Initial body weight; FBW = Final body weight; BWG = Body weight gain; MBWT = Mean body weight gain; FRC = Feed conversion ratio

Additionally, the ash content (total mineral content) of LLBC (8.45%) is slightly higher than DPMC (7.68%), suggesting higher mineral content in LLBC. The nitrogen-free extract (NFE, including sugar, starch, and other carbohydrates) of LLBC (46.23%) is higher than DPMC (37.54%), while the total energy content of LLBC (18.96 MJ/kg) is slightly higher than DPMC (17.76 MJ/kg), suggesting LLBC may be more effective in providing energy to animals.

3.2 Performance Characteristics of Rams

Table 2 shows the performance characteristics of rams influenced by breed, feed, and breed x feed interactions. The results indicate significant effects (p>0.05) of breed, feed and breed x feed interaction on all the metrics investigated except total basal intake (TBI), mean body weight gain (MBWI) and feed conversion ratio (FCR). The Balami breed showed higher values in total feed intake, total feed intake per day, average daily basal intake, dry matter intake, initial body weight, final body weight and body weight gain while Yankasa showed higher values only in total concentrate intake, and average concentrate intake.

The rams fed LLBC recorded lower values in total feed intake (TFI), total feed intake per day (TFID), total concentrate intake (TCI), initial body weight (IBW), final body weight (FBW), and body weight gain (BWG) but higher value only in dry matter intake (DMI) compared to the group of rams fed DPMC.

The interaction effect was significant in all cases except in average total concentrate intake (ATCI), total basal intake (TBI), mean body weight gain (MBWT), and feed conversion ratio (FCR).

3.3 Apparent Digestibility of Nutrients

Table 3 shows the effect of breed, feed and breed x feed interaction effects on the apparent digestibility of DPMC and LLBC. The results indicate that breed significantly influenced (p<0.05) the digestibility of dry matter, crude protein, crude fiber, and nitrogen-free extract, with Balami rams outperforming Yankasa rams. Feed type had a significant effect (p<0.05) on dry matter and nitrogen-free extract digestibility, with higher values observed in LLBC. At interaction level, Balami rams fed DPMC diet showed significantly higher digestibility of dry matter, ether extract, and nitrogen-free extract than Yankasa rams fed LLBC.

3.4 Nitrogen Utilization

The results of the study on nitrogen utilization in rams revealed significant effects of breed, feed, and their interactions on various parameters as shown in Table 4. The breed of ram had a significant (P<0.05) impact on nitrogen digested, nitrogen balance, and retention, with one breed (Yankasa) showing higher values than the other (Balami). The type of feed also influenced nitrogen utilization, with the LLBC diet resulting in lower (P<0.05) faecal nitrogen, nitrogen balance, and retention compared to the DPMC diet. The interaction between breed and feed was also significant (P<0.05) with Balami showing better performance. For example, the Balami breed had higher nitrogen intake, nitrogen digested, nitrogen balance, and nitrogen retention when fed the LLBC diet with similar trend when fed DPMC diet with the exception of nitrogen retained which had similar values.

4. DISCUSSION

In animal feed studies, dry matter (DM) content is crucial for assessing nutrient concentration [13,14]. The *Leucaena leucocephala*-based concentrate (LLBC) with 90.54% DM indicates a more concentrated nutrient source compared to the dried poultry manure-based concentrate (DPMC) with 86.87% DM. This higher DM content in LLBC suggests better feed efficiency, storage stability, and cost-effectiveness [9,5].

The crude protein (CP) content of LLBC (15.26%) falls within the recommended range for heavy fattening Assaf lambs [15], and exceeds the requirements for growing sheep and goats. In contrast, DPMC (13.58% CP) meets the minimum requirement for heavy fattening Assaf lambs and is adequate for growing sheep and goats [15,5].

Crude fiber content is essential in ruminant diets for maintaining healthy rumen function and preventing digestive disorders [16]. The ideal crude fiber content for fattening rams ranges from 10% to 15% [17]. LLBC (12.33% crude fiber) falls within this ideal range, while DPMC (20.55% crude fiber) may be excessive for optimal fattening purposes.

Table 3. Effect of breed, feed, and interactions of breed x feed on apparent digestibility nutrients of rams in %

Parameters	Dry matter	Crude protein	Crude fibre	Ether extract	Nitrogen free extract
Breeds					
Yankasa	73.21^b	71.16^b	82.22^b	66.58	68.49^b
Balami	83.10^a	86.08^a	92.02^a	76.66	91.74^a
Feed					
LLBC diet	76.21^b	77.65	85.90	71.34	78.51^b
DPMC diet	80.27^a	79.60	88.34	71.90	81.73^a
Interactions					
Yankasa x LLBC diet	71.47^d	70.62	80.87	64.62^b	66.38^b
Balami x LLBC diet	80.95^b	83.60	90.93	75.27^a	90.63^a
Yankasa x DPMC diet	75.29^c	71.71	83.57	68.53^b	70.38^b
Balami x DPMC diet	85.26^a	88.58	93.12	78.06^a	90.86^a
P-values					
Breed(B)	0.02	0.01	0.03	0.33	0.04
Feed (F)	0.02	0.81	0.33	0.58	0.03
B x F interaction	0.01	1.14	0.47	0.02	0.04

Means on the same column with different superscripts differ statistically (p<0.05)

Table 4. Effect of breed, feed, and interactions of breed x feed on Nitrogen utilization of rams

Parameters	Nitrogen intake (%)	Faecal nitrogen (%)	Nitrogen digested (%)	Urinary nitrogen (%)	Nitrogen balance (%)	Nitrogen retained (%)
Breeds						
Yankasa	3.19	1.52	2.21^a	0.67	1.53^a	36.34^a
Balami	4.18	1.98	1.65^b	0.58	1.05^b	33.39^b
Feed						
LL diet	3.62	1.67^b	1.90	0.62	1.26^b	33.95^b
DCW diet	3.73	1.83^a	1.96	0.64	1.31^a	35.78^a
Interactions						
Yankasa x LL diet	3.06^b	1.46	1.59^d	0.55	1.04^c	32.38^d
Balami x LL diet	4.16^a	1.89	2.10^b	0.63	1.47^b	35.30^b
Yankasa x DCW diet	3.31^c	1.59	1.71^c	0.61	1.05^c	34.19^b
Balami x DCW diet	4.20^a	2.06	2.33^a	0.73	1.58^a	$37,38^b$
P-values						
Breed(B)	0.54	0.20	0.01	0.60	0.05	0.03
Feed (F)	0.62	0.02	0.10	0.08	0.04	0.02
B x F interaction	0.04	0.11	0.03	0.60	0.04	0.04

a,b,c,d = Means on the same column with different superscript differ (P<0.05)

Both LLBC and DPMC exceed the standard gross energy requirement for fattening rams (9.6-16.3 MJ/kg DM) [8], with DPMC offering a higher energy density.

The low growth performance in Yankasa and Balami rams may be related to palatability issues, pollutants, or anti-nutritional components in the diets [19]. A study on Balami rams found CP levels ranging from 12.1% to 14.5% and crude fiber content between 11.4% and 14.1% [20]. In Yankasa rams, CP levels ranged from 13.4% to 15.6% and crude fiber content was between 12.2% and 15.1% [17]. These studies suggest that the CP and crude fiber content in LLBC and DPMC are within the ranges found in other studies on Balami and Yankassa rams.

The positive growth rate in all treatment groups supports the need for supplementation of ruminant diets with agro-industrial waste and fodder crops, especially during the off-season [21]. The feed conversion ratio (FCR) values indicate that supplementation has a positive impact on live weight gain and FCR by ensuring good rumen activity in sheep [22].

Digestibility values varied significantly among treatments, with Balami rams fed DPM-based diets showing greater apparent digestibility of DM and NFE [23]. The CP content of the test feeds positively impacted dry matter digestibility, while the presence of mimosine in *Leucaena leucocephala* leaf meal may have affected palatability and digestibility [24]. The significant differences in nitrogen utilization and balance among treatment groups suggest that nitrogen intake and retention were affected by the diets [25]. The positive nitrogen balance in animals fed DPM-based diets indicates that the diets met the protein needs for maintenance and production purpose and Micic [26].

The study's findings on nitrogen utilization in rams highlight the significant impact of breed, feed, and their interactions on various parameters. The breed of ram had a substantial effect on nitrogen intake, digestion, and retention, with the Yankasa breed exhibiting higher values than the Balami breed [19]. This is consistent with previous research that has shown significant genetic variation in nitrogen utilization efficiency among different sheep breeds [27].

Furthermore, the type of feed also played a crucial role in nitrogen utilization, with the LL diet resulting in higher nitrogen intake and retention compared to the DCW diet. This supports the findings of a recent review article that discussed the impact of different feed types on nitrogen utilization in ruminants [28].

Notably, the interaction between breed and feed was also significant, indicating that the effect of feed on nitrogen utilization varied depending on the breed of ram. For instance, the Yankasa breed had higher nitrogen retention when fed the LL diet, while the Balami breed had higher nitrogen retention when fed the DCW diet [29,30,31].

5. CONCLUSION

The rising costs and shortage of conventional protein sources in livestock rations necessitate the search for alternative feed materials. *Leucaena leucocephala* and dried poultry manure may be viable alternatives to minimize feed costs in livestock production, especially in countries like Nigeria.

6. RECOMMENDATIONS

1 Use LLBC and DPMC as supplemental feeds for ruminants during the dry season to mitigate the adverse effects of forage scarcity.
2. Educate farmers on the benefits of feeding LLBC and DPMC, addressing concerns about ammonia toxicity.
3. Develop technologies for incorporating these feed materials into production systems.

DISCLAIMER (ARTIFICIAL INTELIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models and text-to-image generators have been used during writing or editing of this manuscript. However, COPILOT and CharGPT were used as tools to locate the literature sources perused before writing this article. Language and grammar checker was also employed in the course of editing the manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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