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INFLUENCE OF FEEDING GRADED LEVELS OF UREA ENSILED SUGARCANE PEEL ON GROWTH AND NUTRIENT DIGESTIBILITY OF YANKASA RAMS

[1]Ibrahim N.O., [2]Aruwayo, A. and [2]Garba M. G.
[1]College of Agriculture and Animal Science, Division of Agricultural Colleges, Ahmadu Bello University, Mando Road, Kaduna State.
[2]Department of Animal Science, Faculty of Agriculture, Federal University Dutsin-Ma, Dutsin-Ma, Post Code 821221, Katsina State
*Corresponding Author's e-mail address: aaruwayo@fudutsinma.edu.ng

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Abstract
The Experiment was conducted at the Small Ruminant Unit of Prof. Lawal Abdu Saulawa Livestock Teaching and Research Farm, Department of Animal Science, Federal University Dutsin-Ma, Katsina State. The study evaluated performance, digestibility and nitrogen utilization of Yankasa rams fed different levels of urea ensiled sugarcane peels. Sixteen Yankasa rams were adjusted for weight to achieve non-significant differences and was randomly allocated into four (4) dietary treatments consisting of 0%, 5%,10% and 15% inclusion levels of ensiled sugarcane meal. Data obtained were analyzed using SAS (2000) and significant differences of the treatment means were determined using the Duncan multiple range test. No significant differences ($P > 0.05$) were observed in growth performance metrics, such as final body weight, total weight gain, average daily weight gain, and feed efficiency, despite numerical variations. Conversely, dry matter digestibility, crude protein, crude fiber, and ether extract demonstrated significant differences ($P < 0.05$), with 5% UESP exhibiting superior values. Nitrogen balance and retention were significantly enhanced ($P < 0.05$) in 5% UESP. These findings show the potential of urea ensiled sugarcane peels as a viable, nutritionally valuable feed supplement for Yankasa rams, optimizing nutrient digestibility and nitrogen utilization without compromising health. It is therefore recommended that ensiled sugarcane peels could be included in the feed of rams especially in periods of feed scarcity, but 10% inclusion level is the most economical.

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INTRODUCTION

Ruminant livestock are raised worldwide, providing essential economic and social benefits to communities around the globe. Small ruminant production plays a critical role in livestock farming, offering several benefits (Aruwayo *et al.,* 2024). Nigeria's livestock population is considerable, comprising around 19.5 million cattle, 72.5 million goats, and 41.3 million sheep, making it the largest livestock producer in West Africa (FMARD, 2016). Small ruminants like sheep and goat production are viable ventures in Nigeria in view of the obvious benefits and the ease of the production. Aruwayo *et al.* (2016) highlighted that ruminant constitute a noteworthy part of livestock production in Nigeria. The compact size of small ruminants is a key factor in their importance, as it enables low-cost investment, reduces the risk of loss, and makes them a preferred choice over larger ruminants due to their efficient food utilization, high reproductive rate, and effective land use (Omoike, 2006). They play vital functions in the lives of households in the rural areas, offering distinct advantages over other livestock. It constitutes one of the major protein sources to the urban and rural populace. Aruwayo and Muhammad (2018) reported that small ruminant production performs a crucial function in the provision of protein of animal origin in Nigeria, in addition to possessing an outstanding capacity to mitigate the shortage
However, Aruwayo *et al.* (2022) reported that productivity of sheep is low despite the large

population leading to a significant gap between the demand for and supply of goat meat and other goat-derived products. These issues are largely due to feed shortages, poor quality of available feed, slow feed digestibility, and inconsistent weight gain, all of which are exacerbated by seasonal feed imbalances (Aruwayo, 2025). Small ruminant farmers are particularly affected, especially when the forage is dry, scarce and nutritionally inadequate. In tropical regions, ruminants rely heavily on cut grasses and agricultural by-products as feed sources, particularly during the dry season when pasture availability is scarce (Winugroho, 1999; Sarnklong *et al*., 2010). One of the promising ways of ameliorating feed shortage is through the use agricultural waste. Example of this agricultural waste is sugar cane waste. They are abundant during harvesting period at a very cheap cost. Sugarcane peels is high in fibre; on average dry matter basis sugarcane peels which is fibrous in nature contains; Dry matter (DM) 91.6%, Crude protein (CP) 6.5%, Crude fibre (CF) 28.34%, Acid detergent fibre (ADF) 36.85%, Ether extract (EE) 4.1%, Ash 9.31%, Nitrogen free extract 51.28%. Sale and Maigandi (2014). The nutrient composition revealed the potentials of sugarcane peels which will be serving as an alternative feed ingredient for large number of ruminant livestock especially during the dry season in the North-western Nigeria. However, like many other agricultural wastes, are high in crude fibre but poor in many other nutrients. They cannot therefore be fed alone to the ruminants without supplementing or mixed concentrate. One of the ways of improving the quality of feed is the use of chemical treatment such addition of urea and enzyme. Some studies have shown substantial improvement of feed digestibility and animal performance traits (Mijinyawa *et al*., 2016). The digestibility and utilization then need to be improved through treatments hence, the use of urea to ensile sugarcane waste in this study. Therefore, this study examined the impact of diets containing graded levels of urea ensiled peels on growth performance, digestibility and nitrogen utilization of Yankasa rams.

MATERIALS AND METHODS

The research took place at the Small Ruminant Unit, Prof. Lawal Abdu Saulawa Livestock Teaching and Research Farm, Department of Animal Science, Federal University Dutsin-Ma, Katsina State. The Farm's geographical coordinates are 12°27ˈ18ˈN and 7°29ˈ29ˈE, with an elevation of 605 meters above sea level. The area receives an average annual rainfall of 700mm and falls within the Sudan savannah ecological zone (Garba *et al*., 2024).

Sourcing and Preparation of the test diets

Sugarcane peels were collected from sugarcane market and other sales centres in Dutsin-Ma, Katsina State. The peels were sorted and cleaned against debris and other dirts such as polythene bags, stone, irons, sticks and leaves. The sugarcane peels were chopped using farm crushing machines for easy mixing with urea solution and to be compactable in the container during ensilage.

Test Ingredient Preparations

The sugarcane peels were mixed with dissolved solution of urea and water at ratio 4% (4kg of urea was dissolved in 60 litres of water and mixed with 100kg of sugarcane peel). The solution was sprayed and thoroughly mixed with the sugarcane peels. The treated sugarcane peels were ensiled in airtight sacs that was well tied and then stored in plastic drums for a period of 21 days. The resultant ensiled sugarcane peels were shade dried for seven (7) days for proper aeration and drying before being used in the formulation of the experimental diets.

Experimental Animals and Management

A total of twenty (20) Yankasa rams were purchased from Dutsin-Ma market. The rams were quarantined for two (2) weeks before the commencement of the experiment and dewormed with Albendozol and also given Oxytetracycline (antibiotics). Ivermectin was also administered to treat external parasite. They were fed with groundnut hay, maize offal, cotton seed cake, salt and bone meal throughout the period. Water was also provided *ad libitum*.

Experimental Design

The research was carried out in a Completely Randomized Design (CRD) that involved the use of twenty (20) Yankasa rams, constituting five (5) per treatment in a random distribution into four (4) experimental treatments namely A, B, C, and D and each of them constituted a replicate.

Formulation of Experimental Diet

Four experimental diets were formulated with varying levels of urea-ensiled sugarcane peel, specifically 0%, 5%, 10%, and 15%, and labeled as diets A, B, C, and D, respectively. Other ingredients are cotton seed cake, maize offal, groundnut hay, salt and bone meal. Table 1 provides the gross composition of the experimental diets used in this study.

Table 1: Gross Composition of the Experimental Diets

Ingredients (%)	Treatments			
	A (0%)	B (5%)	C (10%)	D (15%)
Sugar cane peels	0.00	5.00	10.00	15.00
Maize offal	63.50	58.50	52.50	46.00
Cotton seed cake	14.00	14.00	15.00	16.50
Groundnut hay	20.00	20.00	20.00	20.50
Bone meal	2.00	2.00	2.00	2.00
Salt	0.50	0.50	0.50	0.50
Total	100	100	100	100
Calculated energy (Kcal/kg)	2139.40	2180.60	2142.50	2161.25
Calculated CP (%)	12.25	12.05	12.00	12.03
Calculated CF (%)	22.24	22.16	22.21	22.31
Feed cost (₦/kg)	253.56	247.37	241.21	233.76

Growth performance

Feed intake: Daily feed intake was measured throughout the experiment by weighing the feed offered and feed leftover the previous day.

Feed intake = feed consumed – leftover feed

Weight gain: Each animal was measured at the beginning of the experimental trial and on weekly basis after overnight fasting. This was always carried out between 8:00 to 9:00 am throughout the feeding trial. Weight gain was calculated by subtracting the initial body weight from the final body weight within the period of the feed trial.

Feed efficiency was obtained by dividing weight gain by the feed intake.

$$FE = \frac{\text{Weight gain}}{\text{Feed intake.}}$$

Digestibility and Nitrogen utilization

At the conclusion of the feeding trial, a digestibility study was conducted with three representative animals from each treatment. The animals were placed in individual metabolic cages and fed the identical experimental diets used during the feeding trial. The study lasted for 21 days with 14 days adjustment period in the metabolic cages and one (1) week collection of the faeces with harness bag. Daily feed intake and total faecal output from each animal were recorded. After thorough mixing, they were bulked and 5% of the samples were taken to the laboratory for proximate and crude fibre fraction analysis.

The nitrogen utilization study was conducted using urine that was collected via urinary funnel piped into the bottle containing 2 ml 10% sulphuric acid to trap the nitrogen content. 10% of the total daily urine from each animal was stored in a refrigerator at 4ºC for nitrogen determination.

The formula used to calculate apparent digestibility is presented as:

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

Statistical Analysis

The data generated was subjected to analysis of variance (ANOVA) using SAS Package (2000). Where significant differences between the means existed, Duncan Multiple Range Test (DMRT) (Duncan, 1955) was used to separate the means. The following model was used:

$Yij = \mu + Tj + eij$

Where:

μ = Overall mean

T_j = Effect of the j^{th} treatment diet (j = 1… 5)

eij = Random error.

Results and Discussion

Proximate Composition of Experimental Diets

The proximate composition and crude fibre fraction of the experimental diets is shown in Table 2.

Table 2: Proximate Composition and crude fibre fraction of Experimental Diet

Parameters (%)	Treatments				
	A (0%)	B (5 %)	C (10%)	D (15%)	USCP
Dry Matter	95.54	96.24	95.88	96.54	94.20
Ether Extract	2.59	2.16	2.16	2.00	0.89
Crude Protein	16.13	16.70	16.94	16.64	7.75
Crude Fibre	22.23	22.13	22.41	22.18	28.80
Ash	9.00	9.60	9.63	9.32	6.81
NFE	50.05	49.41	48.86	49.86	55.75
Acid Fibre Fraction					
ADF	31.59	32.45	30.16	32.23	36.01
NDF	72.70	72.81	70.28	72.48	73.59
Lignin	12.21	10.30	11.10	10.89	20.89

NFE= nitrogen free extract, ADF= acid detergent fibre, NDF= neutral detergent fibre, USCP = Urea Ensiled Sugar cane peel

This study found that the crude protein (CP) levels in the diets varied from 16.13% treatment A to 16.94% in treatment C. The values obtained here supported the report 15 – 18% crude protein (CP) level by Adu (1985) in growing sheep; but were higher than the 11% CP for fattening sheep (30-55kg) reported by ARC (1998) and 12% CP level for growing rams as reported by Roberts (2021). The higher levels of CP in the experimental diets could have influenced the higher feed intake of the experimental diets observed across the treatments in this study. This result is consistent with the findings of Chriya *et al*. (1997) that high CP and low CF levels in ruminants' diets increase voluntary feed intake. The range of CF levels of 22.18 – 22.41% obtained across the treatments was slightly lower than the levels of 23 – 32% reported by Muhammad *et al*. (2008) in Sokoto red goat. The slight increase in contents of CF, NDF, ADF and ADL of the diets might be due to the higher CF of sugarcane waste 28.80% as shown in the study. Njidda (2011) reported that semi-arid browse plants are generally high in fiber and their inclusion in diets tends to increase its fiber level. The results also conformed to that of Ganovoski and Ivanov (1982) who reported 22% to 25% CF for small ruminants. The ether extract (EE) values (2.0 – 2.59%) obtained here were lower than 3.90% EE value reported by Maigandi (2001) when he fed 20% FSD as replacement for cowpea husk in diets of Uda sheep in Sokoto. The nitrogen free extract (NFE) values ranged from 48.86% in 10% UESP to 50.05% in 0% UESP. These values were slightly higher than the range values of 39.02 – 41.15% reported by Aruwayo *et al.* (2011) and 36.20% NFE value reported by Maigandi (2001) in Uda rams. The values obtained here were however in agreement with the report of Rogosic *et al*. (2006) that the balance of energy and essential nutrients in a diet plays a crucial role in determining both the average intake and the efficiency of nutrient utilization in animals.

Table 3: Growth performance of the Yankasa rams fed the experimental diets

Parameters	**Treatments**				
	A (0%)	B (5%)	C (15%)	D (10)	SEM
IBW (kg)	20.00	20.00	19.75	20.00	1.53
FBW (kg)	32.6	31.97	34.24	31.79	4.00
TWG (kg)	12.60	11.97	14.49	11.79	1.50
AWG (g/day)	150.00	142.50	172.50	142.50	17.14
FE (g/day)	0.20	0.19	0.21	0.16	0.02
TFI (kg)	64.72	64.85	74.03	76.80	4.21
TFI/DM (%)	62.48	62.47	71.16	72.36	4.01
AFI (g/day)	770.56	772.10	881.36	903.07	48.79
AFI/DM (%)	743.75	743.85	845.04	850.77	40.56
Cost of feed/Kg (N)	253.56	247.37	241.21	233.76	-
COFDC (N)	16465.67	16043.62	17857.01	18261.30	1019.49

COF/LWG (N/kg)	1359.58	1362.56	1265.57	1616.91	144.92

abc=Means within the same row with different superscripts differ significantly (P<0.05).
IBW= Initial Body Weight, FBW= Final Body Weight, TWG= Total Weight Gain, AWG=Average Weight Gain, FE= Feed Efficiency, TFI= Total Feed Intake, TFI/DM= Total Feed Intake/Dry Matter, AFI=Average Feed Intake, COFDC= Cost of Feed Consumed, COF/LWG=Cost of Feed /Live Gain

Growth Performance of Yankasa rams fed the experimental diets

The growth performance of Yankasa rams fed the experimental diets are shown in Table 3.

The lack of significant difference in final body weight and live weight gain suggests that the experimental animals utilized the test ingredients (ensiled sugarcane peel) similarly. Other parameters were not significantly difference across the treatments (P>0.05). Notably, the average daily body weight gain observed in this study exceeded the range reported by Wada *et al*. (2014) for Yankasa rams fed graded levels of *P. biglobosa*. The observed differences may be due to the breed or age of the animals. The average daily weight gain (AVDG) values obtained in this experiment ranged from 0.15kg/day to 0.17kg/day. These values were better than 0.05kg/day reported by Abil *et al.* (1992) when they replaced cotton seed cake (CSC) and maize with wheat bran in the diet of sheep. The dry matter intake of the animals provided further insight into the growth performance trends. The lack of significant differences in live weight gain and dry matter intake was mirrored by non-significant differences (P<0.05) in feed efficiency, indicating a direct relationship between these parameters.

Nutrient Digestibility of the Yankasa Rams fed the Experimental Diets

The nutrient digestibility of the Yankasa rams fed the experimental diets is shown in Table 4.

Table 4. Nutrient digestibility of Yankassa Rams fed the experimental diets

Parameters (%)	Treatments				SEM
	A (10%)	B (5 %)	C (10 %)	D (10%)	
DMD	75.64^{ab}	91.29^{a}	88.25^{a}	71.45^{ab}	3.49
CPD	85.17^{c}	95.33^{a}	90.38^{b}	86.56^{bc}	1.54
CFD	88.28^{b}	91.98^{ab}	95.73^{a}	94.95^{a}	1.16
EED	93.25^{b}	97.69^{a}	96.14^{ab}	96.09^{ab}	0.66
NFED	64.96	85.50	69.53	80.82	3.68
ADFD	82.73	93.66	88.78	90.45	1.86
NDFD	74.14	91.97	88.60	94.34	3.63
LGD	82.41^{b}	95.24^{a}	87.63^{ab}	82.30^{b}	2.15

^{abc}Mean within the same rows with different superscripts differ significantly (P<0.05) DMD= Dry matter digestibility CPD= crude protein detergent digestibility CFD= crude fibre digestibility EED= ether extract digestibility ADFD= acid neutral detergent fibre digestibility NDFD= neutral detergent fibre digestibility LGD= lignin digestibility.

The dry matter digestibility (DMD) value of 71.5 - 91.3% obtained in the present study showed significantly varied (P<0.056) and were within the range reported by Maigandi and Abubakar (2004); and Aruwayo and Muhammad (2018). The CP digestibility depicts significantly higher (P<0.05) values in rams fed ensiled sugarcane peels and may be attributed to fermentation losses during the ensiling process, which is consistent with previous research indicating that biochemical changes during ensiling lead to proteolysis and result in minor losses of soluble carbohydrates, dry matter, and energy due to the actions of lactic acid bacteria and the production of high-energy compounds like ethanol (McDonald *et al.*, 2002). The crude protein digestibility (CPD) digestibility showed that dietary protein is highly utilized by the animals. The general high digestibility values in all the treatments in this study was supported by the reports of Fajemisin *et al.* (2008) that adequate nitrogen in diets enhanced the activities of rumen microbes which eventually improved the crude protein (CP) digestibility in diets. The CF digestibility values treatments that contained the test ingredients in the present study significantly improved (P<0.05) compared with the control and higher than 56.99 – 69.28% reported by Maigandi and Abubakar (2004). The superior digestibility of ADFD and EED in the 15% UESP diet could be due to the ability of linamarase to maintain its stability at low pH values under sun drying and ensiling

conditions. The high digestibility values recorded for animals on the diets generally was reflected in the higher body weight gains of the animals. The results show non-significant difference in CFD, NFED, NDFD and LGD digestibility for animals fed diets containing ensiled sugarcane peel.

Nitrogen Utilization of the Yankasa Rams fed the Experimental Diets

The nutrient utilization of the Yankasa rams fed the experimental diets is shown in Table 5.

Table 5: Nitrogen Utilization of ensiled sugarcane peels

Parameters (%)	Treatments				
	A (10%)	B (5 %)	C (10 %)	D (15%)	SEM
Nitrogen Intake (g)	21.16^{b}	26.35^{a}	23.96^{ab}	23.99^{ab}	0.75
Nitrogen in Feaces (g)	3.39^{ab}	1.20^{b}	3.04^{ab}	4.44^{a}	0.49
Nitrogen in Urine (g)	1.69	1.06	1.06	1.04	0.09
Nitrogen Absorbed (g)	17.77^{b}	25.12^{a}	20.93^{b}	19.55^{b}	1.07
Nitrogen Balance (g)	16.08^{b}	24.06^{a}	19.87^{b}	18.51^{b}	1.06
Nitrogen Retained (%)	75.99^{b}	91.30^{a}	82.92^{ab}	77.16^{b}	2.08

^{abc}=Mean within the same rows with different superscripts differ significantly (P<0.05)

The nitrogen intake shown in Table 5 revealed means that varied from 21.6 to 26.35g/day with significant differences (P<0.05) were higher than the values (12.89 to 21.35g/day) obtained by Abdullazeez *et al*., (2020) and lower than 27.52 to 32.44g/day recorded by Adamu *et al.,* (2021), when the author determined the effects of *Parkia biglobosa* pulp inclusion levels on nitrogen balance of growing red sokoto bucks. Faecal nitrogen was affected by the treatment means, the values ranged from 1.2 to 4.44g/day and were lower than the values (6.17 to 6.72g/day) obtained by Salisu *et al.* (2018). Ruminant nutrition emphasizes the importance of synchronizing protein and dietary carbohydrate availability in the rumen to optimize microbial synthesis and minimize nitrogen loss (Bastos *et al*., 2014). Notably, the greatest nitrogen loss was observed in the control and T4 treatments. The presence of a large proportion of non-protein nitrogen (NPN) from dietary urea, combined with nitrogen produced in the liver during metabolism, probably contributed to this observation (Santos *et al.,* 2014). The percentage of nitrogen retained was higher to that of Abubakar *et al*. (2010). Nitrogen retention is widely regarded as a key indicator of protein status in ruminants, providing a reliable estimate of the nitrogen available for incorporation into body tissues (Bastos *et al*., 2014; Yulistiani *et al*., 2015). The observation of positive nitrogen retention in rams supplemented with ensiled sugarcane peel in this study implies that the diets provided sufficient nitrogen, with ample protein available for the animals' requirements. The positive nitrogen retention observed across all treatments indicates minimal protein or nitrogen loss, confirming efficient dietary protein absorption and utilization for tissue growth and maintenance.".

Conclusion and Recommendation

The proximate composition and the crude fraction obtained in the study were within ranges that satisfied the nutrient requirements of the experimental animals. Based on the growth performance indices such as feed intake, weight gain and feed efficiency did not indicate any significant differences (P>0.05) across the treatments. However, 10% inclusion levels of UESP were numerically higher in weight gain than other treatments. The cost of feed per unit of live weight gain (COF/LWG) was numerically lower in 10% UESP than all the treatments (N1265.57). The digestibility of the nutrients showed significant differences (P<0.05) in some of the parameters with CP digestibility being better in 5% UESP. Urea ensiled sugarcane peel inclusion in the diets of rams up to 15% is recommended but the most economic level of inclusion is 10%.

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IMPACT OF LIVELIHOOD ACTIVITIES ON THE CONSERVATION OF IPINU-IGEDE COMMUNITY FOREST RESERVE, OJU LOCAL GOVERNMENT AREA, BENUE STATE, NIGERIA.

Aondoakaa, M.A.[1]; Sambe, L.N.[2]; Origbo, B.U.[3] and Ityonum B.I.[4]

[1234]Department of Social and Environmental Forestry, Joseph Sarwuan Tarka University, Makurdi, Nigeria

***Corresponding author:** *alumuntor@gmail.com*; +2347032349303

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ABSTRACT

A Survey on the impact of livelihood activities on conservation of Ipinu-igede community forest reserve, Oju Local Government Area, Benue State, Nigeria was carried out to determine the socio-demographic characteristics and effects of livelihood activities of the study area. Data was collected using purposive and random sampling methods, with 388 semi-structured questionnaires distributed to respondents. Descriptive statistics were used to analyze socio-economic data, while a five-point Likert scale assessed the impact of livelihood activities on the forest reserve and the contribution of forest resources to local livelihoods. Results showed that 33.4% of respondents were men, while 66.6% were women, indicating higher female participation in livelihood activities. While 63.2% were aware of the negative consequences of forest resource exploitation, 36.8% were unaware. The results also showed that, based on weighting mean score (WMS), collecting fuelwood (2.20), growing plants for food (2.53), hunting (2.02), and fodder (2.05) were rated lower, while gathering timber (3.82) and cultivating crops (3.29) were rated higher. Additionally, the results showed that, respondents' livelihood activities were significantly influenced by fuelwood (3.81) timber (3.31), medicinal plants (3.56), charcoal production (3.95), game hunting (4.28), cultivation of more crops (4.13) plant food (4.29), and wood products (3.13). The study concluded that while local livelihoods are closely tied to forest resources, these activities often harm forest conservation efforts. The study recommends that enhancing conservation education, implementing sustainable harvesting practices, promoting community-based management, improving revenue streams, strengthening monitoring, and supporting legislation to balance resource use and forest conservation.

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INTRODUCTION

The sequestration of carbon and other global ecological services, such as the supply of food, fresh water, wood, fiber, genetic resources, and medicines, as well as the control of climate, risk of natural hazards, water purification, and waste management, depend on forests (Agbogidi and Eshegbeyi, 2008). They provide raw materials from more than 5,000 products, totaling 23 million dollars, according to Chand (2011). According to Attah (2014), forest products and services provide US$450 billion in economic benefits each year. To guarantee that these benefits endure for next generations, effective forest conservation measures are required (Ashley *et al.,* 1999; West and Brockington 2006; Forester *et al.,* 2011). Rural households already have to deal with a resurgence of large-scale infrastructure projects, the purchase of land for commercial agriculture and biofuels, the exploitation of natural resources through mining and forestry, the emergence of terrestrial carbon markets in the form of reducing emissions from deforestation and forest degradation (REDD+), and, on occasion, conflict. These pressures can lead to major changes in land tenure, labor relations, and modes of production and are a symptom of the expansion of capitalism markets into rural economies (Harvey, 2010).

The 600 million people who call Africa home, rely on forests for everything from their food security to their daily life. Wood provides the primary energy source for at least 70% of homes in Africa (CIFOR, 2005). Forest communities rely

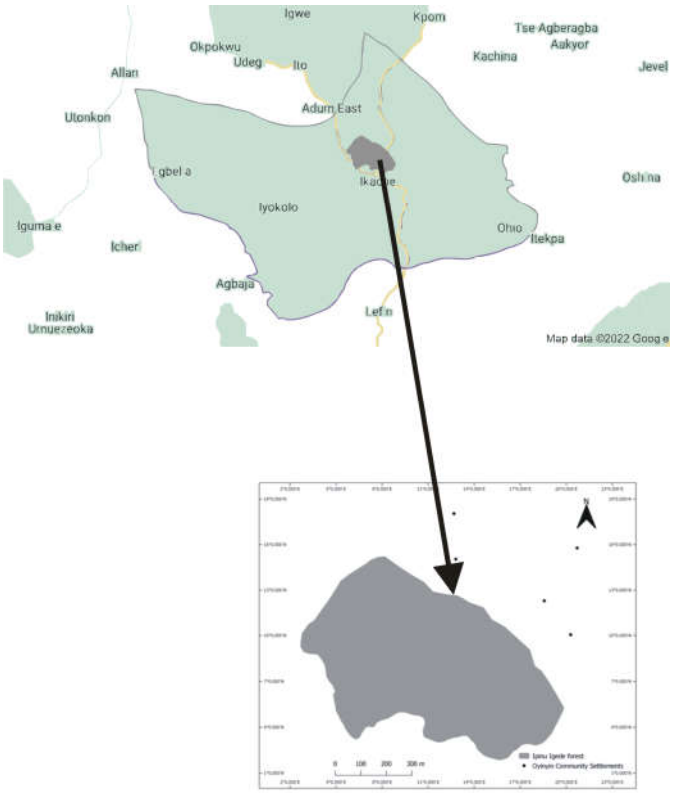
heavily on forest resources for their subsistence, despite being primarily agricultural. For a variety of goods and services, the inhabitants of these forest villages depend on forest products. For food and medicine, these include gathering edible fruits, flowers, tubers, roots, and leaves; gathering firewood for cooking (some are also sold in the market); gathering materials for agricultural tools, houses, and fences; gathering grass and leaves for livestock to graze in the forest; and gathering a range of non-timber forest products that are commercially viable. Because of the vast population and widespread pattern of dependence, any overexploitation and unsustainable harvesting methods could potentially harm the forest (Saha and Guru, 2003). Furthermore, the majority of the country's underprivileged people live in its forested areas because most woods are found in rural, frequently isolated locations that are cut off from infrastructure, government services, employment opportunities, and marketplaces. Therefore, it is not unexpected that populations residing in and near forests and savannahs have high rates of poverty and limited means of subsistence (Wunder, 2005).

According to a number of African studies, including taboos and cultural norms into conservation initiatives may encourage communities to protect their natural resources (Infield and Adams, 1999). For example, several studies have documented the relevance of taboos and cultural norms on the persistence of forest biodiversity in Madagascar (Lingard et al. 2003; Schachenmann, 2006; Tengo et al. 2007; Jones et al. 2008 and Rabearivony et al. 2008). Ghanaian studies have also shown how clans protect their natural resources by usinETg taboos (Abayie-Boaten, 1998; Hens, 2006; Saj *et al.,* 2006; Sarfo-Mensah and Oduro 2007; Kobina and Kofi, 2009; Nganje, 2009). Furthermore, taboos and societal norms have been shown to help save East African wildlife (Kweka, 2004; Kideghesho, 2008). The effective use of taboos and customs in wildlife conservation has also been observed in other parts of the world (Berkes *et al.,* 2000; Colding and Folke 2001; Berkes, 2003; Becker and Ghimire, 2003). This was based on the notion that these traditions control how people behave (Saj *et al.,* 2006; Kobina and Kofi, 2009). Similar instances have also been reported in Nigeria; Dagba *et al*. (2013) examined the Tiv people of Benue State, Nigeria's totemic beliefs and biodiversity protection, while Tee et al. (2014) examined the state's traditional forest conservation methods. Jimoh et al. (2012) discussed the role of taboos and customary laws in the Oban hill sector of Cross River National Park (CRNP), Nigeria; Banjo et al. (2006) discussed taboo as a means of plant and animal conservation in South-Western Nigeria; and Akindele S.O. (2010) wrote on Forest Restoration through Traditional Institutions in Nigeria: Challenges and Prospects. Ipinu Igede Community Forest in Oju Local Government Area is one of the most biodiverse forests in Benue State. Ipinu Igede Community Forest in Oju Local Government Area of Benue State is one of the reserves that is rich in biodiversity, though had no appreciable ecological survey of the resources, hence, the dearth of information necessary for the development of the reserve.

MATERIALS AND METHODS

The Research Area

The study was conducted at the Ipinu-Igede Community Forest Reserve in Benue State, Nigeria's Oju Local Government Area. The community forest, which stretches through Odaleko, Oyinyi, Ikachi, Andibilla, and Uchenyim, is an ancestral heritage site for the Igede people of Benue State. Although the old religious worship activities are no longer powerful and valued because of the embrace of Christianity, there remain remnants of these practices in the forest. Nonetheless, the Igede people continue to abide by the rules and taboos that govern the forest. Both lowland and hilly regions make up the forest in the southern Guinea savanna belt, which is situated between latitudes 6° 51' 0' N and 6° 85' 0' N and longitudes 8° 25' 0" E and 8° 41' 67" E (Okwoche, 2017). The four main, seasonally flowing streams (Abadehe, Otuhukwu, Ekpaa, and Ugbunwu) that drain its roughly 4 km2 area are tributaries of the River Ogbugwu. The mean annual rainfall is between 1200 mm and 1500 mm. 30°C is the average annual temperature. In the early months of the dry season, the relative humidity drops from 60% to 80% moist. With a high riparian forest composition and lush vegetation, this derived tropical rainforest is home to huge trees like *Cola gigantean, Elaeis guinensis, Ficus exasperatea, Khaya spp*., and *Afzelia africana* (Okwoche, 2017). *Sphenoclea zeylanica*, *Ageratum conyzoides, Pentodon pentandrus, Nymphaea lotus*, and *Asystasia gangetica* are among the most common herbaceous species.



Source: Ministry of Lands and Survey, Benue State

Figure 1: Map of Oju showing Ipinu-Igede Community Forest Reserve

Population, sampling procedure, sampling size and Data Collection

Using a 2.8% growth rate, the 1991 population numbers of the nearby municipalities were projected to 2019 (George *et al.,* 2004). The impact of livelihood activities on forest conservation and the role that forest resources play in the livelihoods of the people living in the research area were assessed using a semi-structured questionnaire. A framework of multiple-choice questions was used to gather data on the people's livelihood activities. In order to administer the questionnaire, local folks provided assistance. Over the course of a month, 388 respondents from five communities—Odaleko, Oyinyi, Ikache, Andibilla, and Uchenyum—were chosen and interviewed. Journals and article publishing provided secondary data.

Methodology

Five communities were specifically chosen because of how close they were to the forest reserve. Households in each community were chosen using a methodical random procedure. Each community's first household was chosen for an interview, and then every fourth household was chosen. In order to gather information for the study, two adults—one male and one female—from each family were specifically chosen to be interviewed. This process was continued until the community's sample size was determined.

Data Analysis

The acquired data was analyzed using both descriptive and quantitative methods. Frequency, percentages, mean, and tabular results presentation were the descriptive methods employed. The socioeconomic traits of the residents in adjacent areas were described using descriptive statistics, including frequency, percentage, mean, and tabular forms. The impact of livelihood activities on the protection of Ipinu-Igede community forest reserve was assessed using a five-point Likert scale rating format, as described by Dagba (2017). Regarding how livelihood activities affect conservation, the following values were used to create the weighting scale: Very High Effect (VHE) = 5, High Effect (HE) = 4, Moderate Effect (ME) = 3, Low Effect (L) = 2, and Very Low Effect (VLE) = 1. The contribution of forest reserves to people's livelihoods was measured using a five-point Likert scale. The following values about the contribution of forest resources were used to create the weighting scale: Very High Contribution (VHC) = 5, High Contribution (HC) = 4, Moderate Contribution (MC) = 3, Low Contribution (LC) = 2, and Very Low Contribution (VLC) = 1.

RESULTS

Socioeconomic characteristics of Respondents in Ipinu-Igede Community Forest Reserve Oju LGA, Benue State

The results in table 1 shows that 66.6% and 33.4% were recorded for women and men respectively. Women were the majority. In terms of age ranges, the plurality (31%) of them were between the ages of 51 and 60, while 7.2% of them were older than 60. 43.2% of the participants were farmers, and 8.1% were civil servants. Educational background revealed that 54.6% of them had completed primary school, and 1.6% had earned a tertiary degree in the field. Respondents' marital status, the majority (80.3%) were married, followed by single people (7.5%), divorced people (6.6%), and widows or widowers (5.5%). About 48% of the respondents had four children living in their home, 31.2 percent had more than four children, 13.2 percent had two children, and 7.3% had no children at all. The majority of respondents (92.2%) named Christianity as their religion, followed by traditional religion (7%) and Islam (0.5%) in the region. When the distance between the forest reserve and the surrounding communities was measured, the majority of respondents (60.7%) lived about 2 km away from the reserve, followed by 29.7% who lived less than 1 km away, and 4.9% who lived about 3 km away. One percent of the respondents reside more than four kilometers from the reserve, while 3.6% of the respondents live less than one kilometer away.

Table 1: Socioeconomic attributes of the Respondents in Ipinu-Igede Community Forest Reserve Oju LGA, Benue State

Attributes	Option	Frequency	Percent (%)
Gender	Male	122	33.4
	Female	243	66.6
	Total	365	100.0
Age categories	<30	15	3.9
	30-40	114	29.5
	41-50	110	28.4
	51-60	120	31.0
	>60	28	7.2
	Total	387	100.0
Occupation	Civil Servants	18	8.1
	Hunting	86	38.7
	Farming	96	43.2
	Trading	21	9.5
	Others	1	0.5
	Total	222	100.0
Educational Status	Primary	207	54.6
	Secondary	114	30.1
	Tertiary	6	1.6
	Non-Formal	52	13.7
	Total	379	100.0
Marital Status	Unmarried	27	7.5
	Married	290	80.3
	Divorce	24	6.6
	Widow	20	5.5
	Total	361	100.0
Number of children	2	51	13.2
	4	186	48.3
	Above 4	120	31.2
	Nil	28	7.3
	Total	385	100.0
Religion	Christianity	353	92.2
	Islam	2	0.5
	Traditional	27	7.0
	Total	383	100.0
Distance to forest reserve (km)	<1	115	29.7

	1	14	3.6
	2	235	60.7
	3	19	4.9
	4 and above	4	1.0
	Total	387	100

Source: Field survey, 2020

Impacts of livelihood activities on conservation of Ipinu-Igede community forest reserve

The result presented in table 2 shows that 63.2% of respondents recorded yes while 36.8% recorded no, 16.6 percent of respondents collected medicinal plants, followed by gathering plant food (15.6 percent), collecting fodder for livestock (16.1 percent), collecting fuel wood (15.1%), and producing charcoal (13.2 percent). Hunting and timber collection were the least common activities in the study area (3% and 0.7%, respectively).

Extent of the effects of livelihood activities on conservation of Ipinu-Igede community forest reserve

Table 3 shows the degree to which livelihood activities impact forest reserve protection. The findings showed that among the livelihood activities, harvesting timber and growing crops were ranked higher. The gathering of fuelwood, plants, food, hunting, and fodder came next, and these were all ranked as low-quality livelihood activities in the research area.

Table 2: Awareness on Effects of Livelihood Activities on Conservation of Ipinu-Igede Community Forest Reserve, Benue State

Variables		**Frequency**	**Percent (%)**
If livelihood activities have negative effect on conservation of forest reserve	Yes	232	63.2
	No	135	36.8
	Total	**367**	**100.0**
Activities carried out in the forest	Collection of fuel wood	348	15.1
	Collection of timber	16	0.7
	Collection of medicinal plant	382	16.6
	Gathering of plant food	360	15.6
	Hunting of game	69	3.0
	collection of fodder for livestock	372	16.1
	Cultivation of more crops	283	12.3
	Collection of wood products	73	3.2
	Collection of honey/bee wax	100	4.3
	Production of charcoal	304	13.1
	Total	**2307**	**100**

Source: Field survey, 2020

Table 3: Extent of the Effects Level of Livelihood Activities on Conservation of Ipinu-Igede Community Forest Reserve Oju LGA, Benue State

Livelihood activities	VHE (5)	HE (4)	ME (3)	LE (2)	VLE (1)	Total	WMS	Remark
Collection of fuel wood	0	20(80)	27(81)	227 (454)	10(10)	284	625	2.20ns
Collection of timber	13(65)	56 (244)	3(9)	8(16)	3(3)	83	317	3.82*
collection of medicinal plant	0	5(20)	181 (54)	90 (180)	10(10)	286	264	0.92ns
Gathering of plant food	1(5)	16(64)	170 (510)	35 (70)	58(58)	280	707	2.53ns
hunting of game	1(5)	5(20)	52 (156)	13 (26)	62(62)	133	269	2.02ns
collection of fodder for livestock	0	15(60)	40(120	169 (338)	57(57)	281	575	2.05ns
cultivation of more crops	4(20)	73(292)	12(36)	27 (54)	9(9)	125	411	3.29*
collection of wood products	0	7(28)	57(17)	3(6)	9(9)	76	60	0.79ns
collection of honey/bee wax	0	3(12)	8(24)	58 (116)	62(62)	131	214	1.63ns
production of charcoal	5(25)	38(152)	171 (51)	56 (112)	10(10)	280	350	1.25ns

Source: Field Survey, 2023

Very High Effect (VHE) = 5, High Effect (HE) = 4, Moderate Effect (ME) = 3, Low Effect (L) = 2, Very Low Effect (VLE) =1.

Contribution of Forest Resources to the Livelihoods of the People in Ipinu-Igede Community Forest Reserve, Oju Local Government Area Benue State

Table 4 shows fuelwood and charcoal (21.5%). Medicinal plants (15.2%), animal and forest products (11.3%), and plant foods (11.2%). The least number of respondents (1.4%) gather soap, cosmetics, and colorants from the community reserve, whereas the other forest resources obtained were industrial timbers (8.7%), honey (5.8%), and livestock feed (9.6%). The results on table 5 showed that, according to the weighing mean score (WMS), the following livelihood activities were rated higher: collecting fuelwood (2.20), growing plants for food (2.53), hunting (2.02), and fodder (2.05). The weighing mean score (WMS) also showed that gathering timber (3.82) and cultivating crops (3.29). Additionally, the results showed that, according to the WMS, the respondents' livelihood activities in the study area were significantly influenced by fuelwood (3.81) timber (3.31), medicinal plants (3.56), charcoal production (3.95), game hunting (4.28), cultivation of more crops (4.13) plant food (4.29), and wood products (3.13). This finding suggested that the respondents sourced their timber and non-timber forest products (NTFPs) from forest reserves.

Table 4: Forest Resources Collected from Ipinu-Igede Community Forest Reserve Oju Local Government Area, Benue State

Forest resource collected	Frequency	Percent
Fuelwood and charcoal	529	21.5
Construction material	182	7.4
Medicinal plant	374	15.2
Industrial wood	215	8.7
Plant food	276	11.2
Animal/Animal products	278	11.3
Fodder for livestock	237	9.6
wood products	193	7.8
Honey	142	5.8
soap, cosmetics, colorant	34	1.4
Total	**2460**	**100.0**

Source: Field survey, 2020

Table 5: Contribution of Forest Resources to the Livelihood of the People in Ipinu-Igede Community Forest Reserve, Oju Local Government Area, Benue State

Forest resources	VHC(5)	HC (4)	MC (3)	LC (2)	VLC (1)	Total	WS	WMS
Fuel wood	76 (380)	141 (564)	147 (441)	0	0	364	1385	3.81*
Timber	32(160)	43 (172)	60 (120)	4 (8)	0	139	460	3.31*
Medicinal plant	44 (220)	115 (460)	200 (600)	1 (2)	0	360	1282	3.56*
Production of charcoal	60 (300)	43 (172)	62 (186)	4 (8)	1 (1)	169	667	3.95*
Hunting of game	115 (575)	171 (688)	22 (66)	3 (6)	1 (1)	312	1336	4.28*
Fodder for livestock	2 (10)	73 (292)	101 (303)	165 (330)	0	341	935	2.74ns
Cultivation of more crops	67 (335)	247 (988)	20 (60)	1 (2)	1 (1)	336	1386	4.13*
Plant food	123 (615)	214 (856)	11 (33)	1 (2)	1 (1)	351	1507	4.29*
Honey/bee wax	9 (45)	45 (180)	82 (246)	12 (24)	0	184	495	2.69ns
Wood products	1 (5)	15 (60)	66 (198)	6 (12)	0	88	275	3.13*

Very High Contribution (VHC) = 5, High Contribution (HC) = 4, Moderate Contribution (MC) = 3, Low Contribution (LC) = 2, Very Low contribution (VLC) = 1.

DISCUSSION

Socioeconomic characteristics of the Respondents in Ipinu-Igede Community Forest Reserve Oju LGA, Benue State

According to the socioeconomic characteristics of the study respondents, a greater proportion of women participated in subsistence activities within the forest reserve. The gender status result contradicts the findings of Owonobi (2014) and Mohammed et al. (2019), who found that men were more likely than women to use forest resources across the majority of Nigeria. Men's dominance over women in the exploitation and use of forests is associated with the demanding and tiresome stress that comes with using and exploiting forest resources, such as harvesting timber, while women are more skilled at non-timber forest exploitation. The majority of the responders were in the 30–50 age range. This suggests that the young, nimble people in the research area are active and capable of participating in any kind of forest conservation action. Tsue et al. (2016) state that the majority of people in this age group are actively engaged in agricultural pursuits. The majority of respondents had primary school certificates, and several had completed secondary school. This is a common feature of rural Nigeria, where the majority of people have primary school certificates and non-formal education (Lamino *et al.,* 2016; Omale *et al.,* 2019). The primary occupation of the majority of respondents was farming. This suggests that there may be a high level of farming activity and farmland extension in the Ipinu-Igede Community Forest Reserve, along with hunters. The majority of those surveyed had four children and were married. This suggests that the area may have a high level of livelihood activities and forest resource use to meet household needs. The research area could see rapid population growth. Additionally, a high marital status was a clear sign of family growth, which will encourage them to look for additional forest resources to supplement their incomes. The availability of family labor for the exploitation and use of forest resources is indicated by the large number of children or household sizes (Mohammed *et al.,* 2019). On the other hand, large households may make it more difficult for farmers to make a living, especially if they have a lot of dependents. (Bola *et al.*, 2012) stressed that a large household with no alternative income rely more on forest resources for livelihood. The results are consistent with Dau and Elisha's (2014) finding that a significant portion of rural populations reside close to forestlands and make their living by extracting, collecting, and selling Non-Timber Forest Products (NTFPs), which raises their standard of living. The majority of respondents reside approximately 2 km from the forest reserve.

Effects of livelihood activities on conservation of Ipinu-Igede community forest reserve

According to the results of the study on how livelihood activities affect the conservation of forest reserves in the study area, the majority of respondents (63.2%) knew that livelihood activities can negatively impact the Ipinu-igede Community Forest Reserve, whereas 36.8% were unaware of this. As many respondents affirm, the media, sensitization, or formal educational information acquired at a certain moment and location are the direct sources of their awareness. This finding suggested that there is a high level of environmental education regarding the consequences of deforestation and forest degradation in the research area. Among other things, gathering fuel wood, medicinal plants, fruits and foods, fodder, honey, and charcoal were found to be the primary sources of income in the research region. The top activities in the research region were the gathering of wood and growing more crops, followed by the manufacturing of charcoal and the gathering of wood products. The majority of the world's poorest nations own the bulk of the world's biodiversity (Koziell, 2001; Blockhus *et al.,* 1992). People mostly rely on local ecosystems for their livelihoods, which makes them partially accountable for the decline in biodiversity and primarily impacted by its effects (CBD, 2006 and 2007). The majority of current deforestation occurs in developing nations, especially in tropical regions (Mukul, 2007). Many individuals, including indigenous people who rely on trees for their subsistence, are indirectly threatened by livelihood activities. As stated by Benhin and Barbier (2004) and Appiah et al. (2009) Anthropogenic activities in the tropics cause the loss of almost 15 million hectares of natural forest annually. There are a number of internal and external reasons contributing to the ongoing loss of forests. Unsustainable agriculture, conversion to agriculture, wanton logging, wildfires, gathering firewood and producing charcoal, mining, population pressure, and ill-defined land and resource tenure are some of the internal reasons. Conversely, market failures, global trade, and the implementation of economic initiatives like the Structural Adjustment Program are examples of external forces. This result is consistent with the FAO (2012) study, which found that forest resources like timber and charcoal directly affect rural communities' means of subsistence in Nigeria's Kogi and Niger States.

Contribution of forest resources to the livelihoods of the people in the study area

Fuel wood/charcoal, medicinal plants, fodder, plant foods, wood products, honey, and animal products were among the forest resources recognized from the study region, according to the findings of this study on the forest resources gathered by the respondents in the area. The conclusion of this study suggested that the respondents obtained both timber and non-timber resources from the forest reserve. The social and economic advancement of humanity depends heavily on forests. Timber and non-timber items like bamboo, game, and chew sticks are among the goods that forests provide, and they assist most communities satisfy the needs of the rural economy (Amisah *et al.,* 2009). About 20 million people depend on the forest for their livelihood, especially in rural areas, according to Blay et al. (2008). Despite being vital for a vast array of products and services, forests are threatened by disturbances, particularly those caused by humans (Appiah *et al.,* 2009; Gupta *et al.,* 2005; Kozlowski, 2000).

More than 300 million people worldwide, particularly the impoverished, rely heavily on forest harvesting for their everyday life and livelihood, according to Fonta et al. (2010). Daily survival and subsistence from collecting forest products, income redistribution and poverty alleviation, recreational amenities, firewood, timber, and medicine are some of the possible advantages. Rural residents rely heavily on forest resources for subsistence materials and foods, according to Agarwal (2011). More than 90% of rural homes depend on forests to provide for their families. An estimated 200 million indigenous rural groups are nearly entirely dependent on forests, and between 1.095 billion and 1.745 billion people worldwide rely on a variety of forest products for their livelihoods (Chao, 2012). The average annual value of forest goods collected in Nigeria, including fuel wood, building materials, wild fruits, and leaf litter, was estimated by Olujimi and Adekunle (2015) to represent 39% of the average gross cash income annually.

CONCLUSION

The study on the Ipinu-Igede Community Forest Reserve in Benue State, Nigeria, revealed that while local livelihoods depend heavily on forest resources, these activities usually have a detrimental effect on forest protection. The survey also revealed the high degree of community understanding of conservation issues and the community's heavy reliance on forest resources for fuelwood, medicinal plants, and other uses.

RECOMMENDATIONS

1. Increasing community members' knowledge of sustainable practices and the importance of forest protection will improve conservation education.
2. Using and advocating for sustainable harvesting practices that lessen their negative effects on the ecosystem and guarantee the long-term availability of forest resources.
3. Encouraging community-based management to guarantee the long-term availability of forest resources by incorporating local communities in decision-making and management.
4. Promoting alternate revenue streams, including eco-friendly companies or farming, to reduce dependency on forest resources.
5. To stop illegal logging, strengthening and enhancing the mechanisms for keeping an eye on the health of forests and implementing conservation regulations.

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GENETIC CHARACTERIZATION OF THE GROWTH HORMONE GENE IN CAMEL (*Camelus dromedarius*) POPULATIONS IN NIGERIA

Rotimi, E.A., *Yusuf, A., & Aruwayo, A.

*Department of Animal Science, Faculty of Agriculture, Federal University Dutsin-Ma Katsina State Nigeria

Corresponding Author: binyusuf01@gmail.com, +2347066571298

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Nucleotide,
Sequence.

Abstract

This study characterized the growth hormone (GH) gene in Nigerian camel populations sampled from Zamfara and Katsina states, using molecular techniques. Blood samples were aseptically collected randomly selected camel population in Zamfara and Katsina States, Nigeria. Genomic DNA was extracted from the blood samples collected and Polymerase Chain Reaction (PCR), using primers KGH3-F and KGH3-R, was carried. A 687-bp fragment of the camel Growth Hormone (GH) gene extracted was evaluated via gel electrophoresis. Nucleotide sequence obtained from sequencing, were analyzed, using Bioinformatics comparison (NCBI), revealed 99.67% similarity between Nigerian *Camelus dromedarius* GH sequences and the reference sequence AJ575419 from *Camelus dromedarius* in the United Kingdom. BLAST alignment of the sequenced fragments against NCBI references revealed 99.67% similarity and 99% query coverage with the reference GH sequence from a UK-derived *Camelus dromedarius* (AJ575419). The alignment overlapped intron 4 and exon 5 of the gene, with two minor gaps observed at positions 6 and 15. These indels, representing only 0% of the sequence, may reflect either natural polymorphisms or minor sequencing artifacts. No single nucleotide polymorphisms (SNPs) were detected in the sampled population, suggesting low genetic variability and a common ancestry among Nigerian camels. The findings suggest high conservation of the GH gene across geographically distinct camel populations, highlighting its potential role in adaptation and productivity. The study establishes baseline genetic data for Nigerian camels, with implications for improving camel productivity and informing breeding programs in arid regions. It however, highlights the need for further studies with larger sample sizes to assess the relationship between GH gene variations and phenotypic traits such as growth rate and milk yield for targeted breeding programs in arid regions.

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INTRODUCTION

Camels (*Camelus dromedarius*) are vital to livelihoods in arid regions like Northwest Nigeria, contributing to milk, meat, and transportation, this is due to their drought resilience and economic value (Rotimi *et al*., 2023).

The growth hormone gene (GH) is known to significantly influence key production traits, such as growth rate, muscle mass, and milk yield in animals. Growth hormone gene has proven to be the major regulator of postnatal growth and metabolism in mammals including camels and thus affects growth rate, body composition, health, milk production and aging by modulating (regulating) the expression of many genes (Mohammad *et al*., 2021; Carnicella *et al*., 2003). In livestock, growth hormone genes are of economic importance because they are often associated with faster growth and reduced fat stores (McMahon *et al*., 2001). Investigating the GH gene in Nigerian camels is expected to reveal genetic variations that can be harnessed for breeding programs designed to enhance these traits.

Research in other livestock species has demonstrated that genetic screening for the GH gene can effectively identify individuals with superior growth potential (Zhou *et al.,* 2014). This knowledge is essential for developing targeted breeding strategies that prioritize productivity and adaptability. A preliminary screening of the GH gene could yield valuable insights into the genetic profile of these camels, facilitating selective breeding and

ultimately improving their productivity (Bertolini *et al.,* 2018).

The growth hormone gene regulates key physiological traits, including growth, metabolism, and lactation (Mohammad *et al*., 2021). The growth hormone, known as somatotropin, is a protein hormone made up of roughly 190 amino acids. It is synthesized and secreted by somatotroph cells in the anterior pituitary gland. This hormone plays a crucial role in regulating various physiological processes, such as growth, metabolism, lactation, and the development of mammary glands in animals. The camel growth hormone (GH) gene is approximately 1900 base pairs in length and, similar to other mammalian GH genes, contains five exons and four introns (Ishag *et al*., 2010). Despite its importance, genetic studies on Nigerian camels are scarce, and existing research focuses on populations outside Africa (Maniou *et al*., 2004). Most research on candidate genes has focused on cattle (Ishag, 2009), sheep (Bastos *et al.,* 2001), and goats (Rotimi *et al.,* 2020), while studies on the growth hormone gene in camels remain limited. This trend leaves gaps in understanding local genetic diversity. This information gap limits efforts to optimize camel productivity through genetic selection.

There is insufficient molecular data on the genetic diversity of growth hormone genes in Nigerian camel populations. This hinders evidence-based breeding programs and understanding of camel adaptation to local environmental stressors, especially in regions like Zamfara and Katsina, where camels are economically significant.

This study addresses the gap in genetic characterization of Nigerian camels, providing actionable insights for agricultural and biotechnological applications. The GH genes role in growth and lactation makes it a strategic target for improving camel-derived resources in arid economies. Therefore, the objectives of this study were to amplify and sequence the GH gene region in Nigerian camels and to compare with global sequence references (NCBI).

MATERIALS AND METHODS

Study location

The study was conducted in two states located in the northern region of Nigeria: Katsina and Zamfara. These states were purposively selected due to the significant population of camels in the area. Consequently, three Local Government Areas (LGAs) were chosen for the study: Mai-Adua and Charanchi LGAs in Katsina State, and Gusau LGA in Zamfara State. These LGAs were selected based on their relative security levels. Mai-Adua is found within latitude of 13.1799° N and a longitude of 8.2304° E, Charanchi within latitude of 12.6716° N and a longitude of 7.7293° E, while Gusau is located at a latitude of 12.1702° N and a longitude of 6.6641° E (Geodatos.net).

Experimental animals and their management

A total of fifty-one (51) camels, consisting of 24 females and 27 males, were randomly sampled from the three selected Local Government Areas in Katsina and Zamfara States. The camels were randomly selected from various locations within the study area. Only healthy, unrelated, and non-pregnant camels were included in this study.

Data collection

Blood Samples Collection

About 2 mL of whole blood samples were aseptically collected from the jugular veins of healthy individual camels. The samples were preserved in blood collection tubes containing EDTA as an anticoagulant. To prevent spoilage during collection and transportation, the blood samples were stored in an ice pack, transported to the laboratory, at -4°C until nucleic acid extraction.

Genomic DNA Extraction Procedure

Genomic DNA was extracted from whole blood samples using the phenol-chloroform extraction method described by Sambrook and Russell (2006). Initially, blood samples were thawed at room temperature.

Tris-EDTA lysis buffer was added to the thawed samples, followed by the addition of approximately 20 mg/mL of proteinase K. The mixture was thoroughly mixed and incubated at 55°C for 30 minutes to 1 hour.

Next, an equal volume of phenol-chloroform was added to the sample and mixed thoroughly. The mixture was then centrifuged at 10,000 x g. The aqueous phase was carefully collected and transferred to a new tube. To the aqueous phase, 2-3 volumes of ice-cold 95% ethanol were added, and the mixture was thoroughly mixed before incubating at -20°C. The sample was subsequently centrifuged at 10,000 x g for 10-15 minutes. The supernatant was carefully discarded, leaving the DNA pellet behind. The DNA pellet was washed

with 70% ethanol and then re-suspended in TE buffer (10 mM Tris-HCl, 1 mM EDTA, pH 8.0). Finally, the extracted DNA was stored at -20°C.

Polymerase Chain Reaction (PCR) and gel electrophoresis

Polymerase Chain Reaction (PCR) was performed using a pair of primers of the Camel Growth Hormone (GH) gene based on published nucleotide sequence information (GenBank accession no. AJ575419, Maniou *et al*., 2004). The primer sequences are presented in Table 1. High annealing specificity (57°C) and GC content (57.89%) contributed to successful amplification. The resulting fragments were visualized using chromatogram analysis to determine the precise genetic sequence of the DNA samples.

Gel Electrophoresis

The quality of the extracted DNA samples was assessed using 1.5% agarose gel electrophoresis. DNA samples, dyed with ethidium bromide, were loaded onto the gel alongside a standard gene ladder. The contents were subjected to electrophoresis at a specified voltage for about one hour. DNA bands were visualized using a UV light box.

DNA Sequencing

The purified extracted fragments were sequenced using a BigDye Terminator v1.1 Ready Reaction Cycle Sequencing kit (Muhammad *et al*., 2021) and an ABI Prism 310 Genetic Analyzer (Applied Biosystems, USA). The results were submitted for alignment on NCBI website. The sequences were aligned and the presence and position of SNPs were evaluated with reference sequence of accession number AJ575419 as reported by Maniou *et al.* (2004). This work was carried out at the DNA Laboratory, Kaduna, Kaduna state, Nigeria.

Data analysis

The basic information on the gene sequences obtained was analyzed using Basic Local Alignment Search Tool (BLAST) procedures. This tool compares nucleotide sequences against sequence databases maintained by the National Center for Biotechnology Information (NCBI), facilitating the identification of genetic similarities and variations.

Table 2: The primer sequences and size (bp) of Camel GH amplified fragments

Name	Sequence (5'-3')	GC Content	Tm	Product size	T_A
KGH3-F	CTTCTCGCTGCTGCTCATC	57.89 %	60 ^{0}C	687 bp	57^{0}C
KGH3-R	GCACTGGAGTGGCACTTTC				

Tm = Melting Temperature, T_A = Annealing Temperature

RESULT AND DISCUSSION

Polymerase Chain Reaction (PCR) Result

Figure 1 shows the PCR gel image obtained through agarose gel electrophoresis. Gele electrophoresis is a fundamental technique in molecular biology used to separate DNA fragments based on their size. A molecular marker of 100 bp size was employed during gel electrophoresis in this study, as a reference for estimating the size of the PCR products.

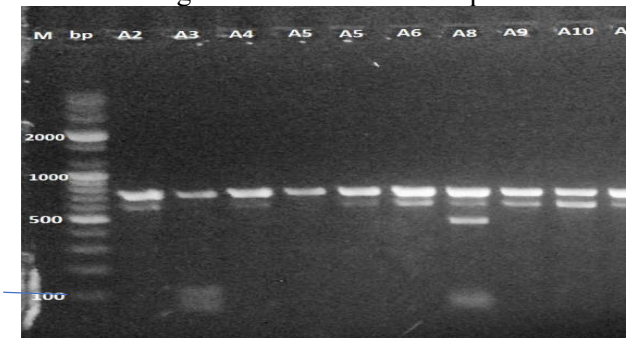

Plate 1: Electrophoretic image of the amplified region of the camel growth hormone gene.

The bands at the expected sizes confirm the correct amplification of the target DNA sequence. A 687-bp GH fragment was successfully amplified (Plate 1, Table 3). This is close to the report of Ishag (2009), who amplified a 613-bp fragment that encompasses the mutation site containing single nucleotide polymorphisms (SNPs) in the camel growth hormone (cGH) gene of Sudan population.

Sequence Result

Nucleotide sequencing was performed using the dideoxy nucleotide chain-termination technique of Sanger *et al.* (1977). The DNA sequence results from the samples are presented in chromatogram format (Plate 2).

Table 3 presents detailed basic information of the amplified region of the camel growth hormone (cGH) gene. This amplified region was submitted to the National Center for Biotechnology Information (NCBI) website to

access fundamental information regarding the amplified gene region. The Basic Local Alignment Search Tool (BLAST) procedures was employed to identify regions of similarity between the sequences and the various sequences submitted to the NCBI. The result of the BLAST is presented in Table 3. The results revealed that the size of the amplified gene was 687 bp. More than one hundred sequences from other species were found to be similar to this sequence, with similarity percentages ranging from 86.51% to 99.67% (Table 3). The nucleotide information aligns with the published nucleotide sequence of the camel GH gene (GenBank accession no. AJ575419) as reported by Maniou *et al.* (2004).

The second sequence in the search table, with Accession No. AJ575419.1, was employed as the reference sequence. A query coverage of 99.00% was obtained for this search. Querry coverage is used to evaluate the extent of similarity between a query sequence and sequences in a database. The result shows a high degree of similarity which implies that the query sequence and the reference sequence selected are highly identical. An expected value (E-value) of 0.00 was also obtained in the query search. This indicates a more significant matches in the search result. The nucleotide information aligns with the published nucleotide sequence of the camel GH gene (GenBank accession no. AJ575419) as submitted by Maniou *et al.* (2004). 99.67% sequence similarity to AJ575419 (UK-derived GH sequence) suggests high evolutionary conservation. Minor variations may reflect regional adaptations or sequencing artifacts.

The results of the alignment also reveals that the alignment between the amplified sequence and the query sequence (Accession No. AJ575419.1) coincides with intron 4 and exon 5 of the queried sequence, covering approximately 687 bp. The alignment results of the submitted sequence with the GenBank sequence (AJ575419) derived from dromedary camels, show two gaps at positions 6 and 15 in the sequences. In BLAST alignment, gap represents an insertion or deletion (indel) of one or more nucleotides in either the query or subject sequence. Two gaps were observed in this alignment, 2 out of 601 nucleotides (0%). Since the alignment spans exons 1–5 of the growth hormone (GH) gene, gaps in coding regions can be significant. The two gaps, presents possible frameshift mutation, as they occur within a coding exon. But given the 99% identity, this may be a sequencing error, natural polymorphism, or species-specific variation (Primus, 2010). However, the two gaps might represent small evolutionary changes between the query and subject sequences.

The absence of SNPs in the GH gene of the sampled camels suggests that these ecotypes originated from a common or closely related stock, and not enough time has elapsed for segregation and the emergence of new mutants (Ishag, 2009).

Ishag (2009) observed one SNP in Sudanese camels located in a non-coding region (intron 1) at position 419C>T. Shah (2006) also reported the presence of SNPs in Pakistani dromedary camels. Numerous authors have documented various mutations (manifestations of SNPs) in Nigerian goat breeds (Rotimi *et al*., 2020), and SNPs in Black Bengal goats (Gupta *et al.,* 2007) and sheep (Marques *et al.,* 2006).

Presence of SNPs in gene sequence possess potential significance on various aspects such as growth rate, reproduction, milk production.

Table 3: Basic information of the Nucleotide Sequence of the camel GH gene region amplified in NCBI search

Isolate	Closest ancestor	Similarity	Query coverage	Query length	E value	Accession No	Reference
Camel blood sample	*Camelus dromedarius* growth hormone, exons 1-5 Location – United Kingdom	99.67%	99%	687bp	0.00	AJ575419	Maniou *et al.* (2004)

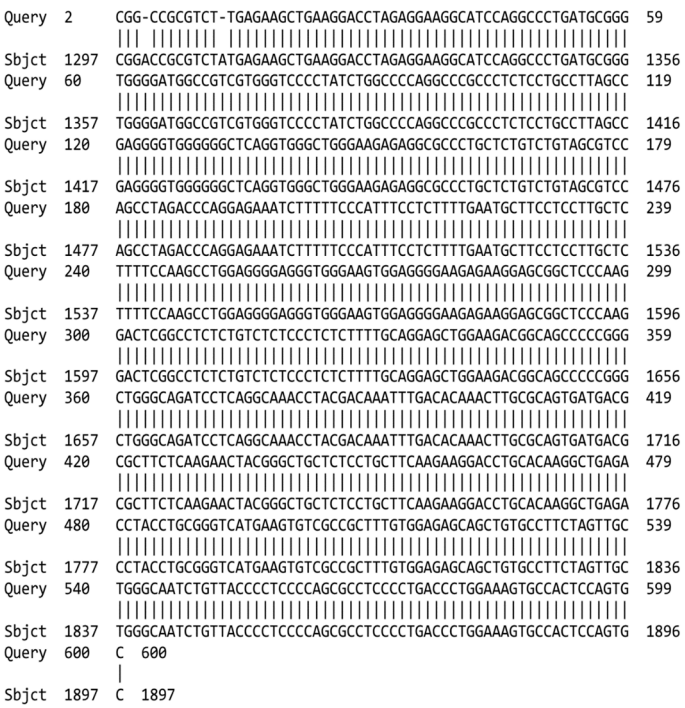

Plate 2: Nenucleotide alignment with NCBI database

CONCLUSION

The results revealed that the GH gene in Nigerian camels is highly conserved, with near-identical sequences to global counterparts. This shows a remarkable genetic conservation with global populations. This stability may reflect demographic confinement. Further study involving expanded sample size is recommended to investigate the associations between GH gene variants and phenotypic traits such as milk yield.

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EFFECT OF FEEDING ENSILED GROUNDNUT (*Arachis hypogaea*) SHELL WITH YEAST (*Saccharomyces cerevisiae)* AND MOLASSES ON PERFORMANCE AND NUTRIENT DIGESTIBILITY OF YANKASA RAMS

[1]Adam, I. G., [2]Aruwayo, A. and [2]Garba M. G.

[1]Department of Animal Science, Faculty of Agriculture, Federal University of Agriculture, Zuru, Kebbi state

[2]Department of Animal Science, Faculty of Agriculture, Federal University Dutsin-Ma, Dutsin-Ma, Post Code 821221, Katsina State

*Corresponding author's e-mail address: aaruwayo@fududtsinma.edu.ng

Key words: Yankasa ram, ruminant, performance, digestibility, utilization

Abstract

This study investigated the effect of ensiled groundnut (*Arachis hypogaea*) shell with fungi (*Saccharomyces cerevisiae*) and molasses on growth performance, nutrient digestibility and nitrogen utilization of twenty (20) Yankasa rams at Prof. Abdu Lawal Saulawa Livestock Teaching and Research Farm, Department of Animal Science, Federal University Dutsin-Ma, Katsina State. The experimental diets T1, T2, T3, and T4 contained Yeast (*Saccharomyces cerevisiae)* and Molasses ensiled groundnut shell (EGNS) at 0%, 5%, 10 and 15%. The EGNS was prepared by mixing 60g of *Sacchromyces cerevece* (Yeast) and 100ml of molasses with a kg of groundnut shell and dissolved 1000ml of water and then ensiled for a period of three (3) weeks. The animals were purchased from Dutsin-Ma market and quarantined for two (2) weeks during which they were given prophylactic treatment against infection and also treated against ecto and endoparasites. They were balanced for weight at the beginning of the study and then randomly allotted into four (4) dietary treatments. in a Completely Randomized Design (CRD). The experiment lasted for 84days, data collected during the experiment to evaluate the feed consumed, weight gain, feed efficiency, nutrient digestibility, nitrogen utilization and cost per liveweight gain. Data obtained were analyzed using SPSS Version 20 and means of the treatments were separated using Duncan multiple range test. Results showed significant variations ($P<0.05$) in all the parameters but T4 performed better than other ones. Based on the outcome of the study, *Sacchromyces cerevecea* ensiled groundnut shell inclusion level of 15% is recommended in the diets of sheep.

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INTRODUCTION

In Nigeria, livestock especially ruminant animals suffer from serious shortage of feeds and feeding stuffs, particularly during the long dry season, where the quantities available are limited, the quality of roughages is poor and nutrients are not enough to cover maintenance and productive requirements of animal species including sheep. Aruwayo *et al.* (2025) reported feed shortages, poor quality of available feed, slow feed digestibility, and inconsistent weight gain, all of which are exacerbated by seasonal feed imbalances. The situation is further aggravated by scarcity of feed, overgrazing of the available feed ingredient, farmers-herder's conflict and banditry activities. This reduction of feeding cost necessitated the search for non-conventional sources of feed for ruminant. Shortage of feeds and feeding stuff has also been recognized as one of the major challenges of improved animal production (Aruwayo *et al.,* 2016).

Roughages from crop residues and waste from processing of crops constitute a major source of feed during the periods of feed shortage. They are abundant and relatively cheap but with poor digestibility and nutrient utilization. There have been efforts to improve the utilization and nutrient composition of these roughages. Aruwayo and Muhammad (2018) reported that roughages with poor digestibility and

utilization can be improved with treatments as shown in urea treatment of rice milling waste. Yeast supplementation in diets of ruminants is one option to increase utilization of poor-quality roughages, grains and by-product-based diets (Shriver-Munsch, 2011). Previous researchers (Moallem *et al.,* 2009) outlined some benefits of live yeast supplementation as increase in milk yield, milk protein, fibre digestion and stabilization of rumen pH in dairy cattle. Mosoni *et al.* (2007) also reported that live yeast addition may balance rumen ecosystem and increase cellulolytic bacteria numbers in cattle and sheep respectively. The study examined effect of ensiled groundnut (*Arachis hypogaea*) shell with fungi (*Saccharomyces cerevisiae*) and molasses on growth performance of Yankasa rams.

MATERIALS AND METHODS

Experimental Site

The venue of the research was Prof. Lawal Abdu Saulawa Livestock Teaching and Research Farm, Department of Animal Science, Federal University Dutsin-Ma, Katsina State which is sited within the latitude 2˚97 and longitude 17˚27 with an elevation of 600 meters above sea level with 700mm annual rainfall and falls within the Sudan savannah ecological zone (Garba *et al.,* 2024).

Preparation of Test Ingredient and Diets

Groundnut shell was acquired from Dawanau groundnut threshing center. The foreign materials (stones, irons, plastic and polyethene) were removed. The groundnut shells were milled separately through 8mm mash in a hammer mill. The milled groundnut shells were ensiled by treating the shells with *Saccharomyces cerevisiea* and molasses at a rate of 20, 40 and 60g of *Saccharomyces cerevisiae* /kg and 100ml of molasses/kg and then dissolved in 1000mls of water/kg, thoroughly mixed, filled and compressed in plastic tank. The content was compacted as fast as possible to expel trapped air from the ensilage and kept in that state for 21 days. Masking tape was used for further sealing the tank. At the expiration of the ensiling period, the fermentation tank was opened and the topmost 5cm material was scooped off to avoid contamination with partially ensiled materials. These ensiled materials were dried for two (2) weeks and then constituted the test ingredients used in the research at graded levels of 0, 5%, 10% and 15% as treatments 1, 2, 3 and 4 respectively. Other ingredients are maize offal, cotton seed cake, groundnut hay, groundnut shell, wheat meal, bone meal and salt. The gross composition is shown in Table 1.

Table 1: Ingredient Composition of the Experimental diets

Ingredient %	Treatments			
	T1	T2	T3	T4
Maize offal	45.00	42.5	37.50	33.75
Cotton seed cake	25.00	23.75	22.50	21.25
Groundnut hay	2.00	2.00	2.00	2.00
Groundnut shell	0	5.00	10.00	15.00
Wheat meal	25.00	25.00	25.00	25.00
Bone meal	2.00	2.00	2.00	2.00
Salt	1.00	1.00	1.00	1.00
Total	100	100	100	100

Experimental Animal and Treatment

Twenty (20) Yankasa rams were utilized in the study. They were procured from local markets in Dutsin-Ma and were in good condition of health. The animals were quarantined for two (2) weeks prior to the starting of the investigation during which prophylactic treatment was given with the use of broad-spectrum antibiotics and albendazole against the possible infection and parasitic infestation. They were fed *ad libitum* with groundnut hay, wheat offal, cotton seed cake, salt and bone meal in a mixture. Sufficient water was offered to them.

Experimental Design and Management

Yankasa rams that summed up to twenty (20) and obviously wholesome were used for the experiment. They were balanced for weight and then apportioned randomly to the four (4) dietary treatments in a Completely Randomized

Design (CRD). Each treatment contained five (5) animals and each one constituted a replicate. They were accommodated individually in pens with dimension of 2m x 1m. They were fed the experimental diets for 84 days. The feed was increased when the feed served is completely consumed. They were given sufficient water.

Determination of ensiled proximate composition and crude fibre fraction

A sub samples of the treatments diets and the test ingredient were taken, and oven dried at 60ºC for 48 hours for dry matter determination. The proximate composition comprising of dry matter, crude fiber, crude protein, ash, ether extract and nitrogen free extract was determined by AOAC (2000) while the crude fibre fraction were done by the method of Van Soest (1994).

Growth Performance parameters

The experimental animals were fed the experimental diets *ad libitum* twice in a day, morning, and afternoon to avoid waste. The leftover was measured the following morning by 7am before being fed. The feed intake was measurement by subtracting feed left over from feed given the proceeding day.

The weight was measured by deducting the final weight from the initial weight. The initial weight was obtained by weighing the animals at the beginning of the study while the final weight was taken at termination of the 84 days growth trial.

Weight gain (kg) = Final Weight- Initial Weight

Feed Intake = Feed given to the animal - left over

$$\text{Feed efficiency} = \frac{\text{Weight gain}}{\text{Feed intake}}$$

Statistical Analysis

The data obtained were analysed using analysis of variance (ANOVA) in a Completely Randomized Design (CRD) according to Steel and Torrie (1980). Significant variations between treatment means were separated using Duncan Multiple Range Test (DMRT) (Duncan, 1955). SPSS was utilized to run the statistical data analysis.

RESULTS AND DISCUSSION

Chemical Composition of the Experimental Diets and Test Ingredients

The chemical composition of the test ingredient and the experimental diets used in the study are shown in Tables 2.

Table 2: Chemical Composition of the Experimental Diets and Test Ingredient

Parameters	Treatments				
	T1(0%)	T2 (5%)	T3(10%)	T4 (15%)	EGNS
DM (%)	90.20	90.36	91.1	90.41	93.08
CP (%)	16.88	16.95	17.18	17.50	1.00
CF (%)	11.52	11.48	12.25	11.36	49.45
EE (%)	3.56	2.98	2.87	2.88	0.40
ASH (%)	5.36	5.40	4.89	4.95	2.46
NFE (%)	63.73	63.19	62.81	63.31	46.69
LIG (%)	17.90	16.80	17.80	17.68	28.00
ADF (%)	29.84	28.81	28.42	29.44	27.31
NDF (%)	52.26	54.39	53.78	52.88	44.69

DM= Dry Matter, CP = Crude Protein, EE = Ether Extract, NFE=Nitrogen Free Extract, LIG = Lignin, ADF = Aid Detergent Fibre, NDF=Nitrogen Free Extract

The results show that both the ensiled (EGNS) and groundnut shell had high dry matter (DM) content with a range of 90.2 to 90.41%. For crude fibre, treatments T3 and T4 also had higher crude protein content of 17.18% and 17.50% respectively. Ether extract and ash values were higher in treatment T1 which is un-ensiled. Nitrogen free extract ranged from 62.81 to 63.73%. Nitrogen free extract, acid detergent fibre and ligin values ranged from 52.26 to 54.39%, 28.42 to 29.44% and 16.80 to 17.90% respectively. The proximate composition and the acid fibre fraction obtained in this study showed that the nutrient requirements of the Uda sheep were fulfilled. The dry matter content of the experimental diet is adequate for a male sheep, although it is lower than the 93.05 to 96.01% reported by Aruwayo *et al*. (2022) and Aruwayo *et al.* (2024). The crude protein was within the 15 to 18% recommended for a growing sheep (ARC, 1990) and Aruwayo *et al*. (2024) report of and

was therefore adequate for their nutritional requirement. High CP could increase voluntary feed intake as reported by Chriyaa *et al*. (1997).

Table 3: Growth performance of Yankasa rams fed the experimental diet

Parameters	Treatments				
	T1 (0%)	T2(5%)	T3 (10%)	T4(15%)	SEM
IWT (kg)	43.59	43.95	43.98	43.29	1.40
FW (kg)	50.36	50.35	49.06	52.45	4.02
DFI (g)	890.870^{a}	881.02^{b}	890.35^{a}	884.71^{ab}	1.59
TWG (kg)	7.77^{ab}	6.40^{b}	5.08^{ab}	9.16^{a}	1.19
DWG (g)	92.50^{b}	76.19^{c}	60.47^{d}	119.62^{a}	7.55
FE	0.10^{b}	0.09^{b}	0.07^{b}	0.14^{a}	0.01
CF/KG	255.15	262.75	269.69	277.04	-
CFC (N/kg)	21155.82^{d}	21472.47^{c}	22083.82^{b}	22771.61^{a}	187.99
CFLWG	3009.33	2726.33	2882.33	1919.40	310.89

abc= means within the same row with superscripts differ significantly ($p<0.05$)
IWT = Initial weight, FW= Final weight, DFI= Daily feed intake, TWG = Total weight gain, DWG =Daily weight gain, FE = Feed efficiency, CFC = Cost of consumed, CFLWG = Cost of feed per live weight gain, CF/KG = Cost of feed per KG, SEM=Standar Error of Mean

Growth Performance of the Experimental Animals

Table 3 indicates the growth performance of the experimental animals fed Yeast (Saccharomyces cerevisiae) and molasses ensiled groundnut shell.

The initial weight of the Yankasa rams used in the experiment were not significantly different ($P>0.05$) across treatments. Final weight varied numerically with T4 having the highest (52.45kg) and T3 the lowest (49.06kg). T1 and T3 have the highest dry matter feed intake values of 890.87g and 890.35g respectively and were statistically similar ($P>0.05$). T2 has a lower intake (881.02g) and were significantly different ($P0>0.05$) from T1 and T3. The TWG is highest in T4 (9.16kg) and lowest in T3 (5.08kg). Treatments T1, T3, and T4 did not differ significantly ($p<0.05$) but T2 is significantly different ($P<0.05$) from T4 that shows the highest daily weight gain (119.620g), followed by T3, T2, and then T1. These values suggest that T4 treatment may enhance daily weight gain more effectively. T4 has the significantly higher feed efficiency (0.14) which might indicate that this treatment better in feed efficiency while other treatments did not show any significant differences ($P>0.05$). T4 had significantly higher cost of feed consumed (N22771.610) while T1 has the lowest (N21155.820). Cost of feed consumed per kilogram liveweight gain showed highest cost (N3009.333) and T4 the lowest (N1919.403). Numerical lower CFLWG in T4 indicates it may be more economical. Final weight differences are more pronounced, with T4 yielding the highest final weight and T2 the lowest. This suggests that the specific treatment in T4 (groundnut shell with *Saccharomyces cerevisiae* and molasses) had a more substantial positive effect on growth, supporting that T4 is the most effective at improving final body weight in Yankasa rams. DFI measures how much feed each group consumed daily. T1 and T3 have higher DFI values than T2, suggesting that the rams on these treatments consumed more feed on average. The labels indicate that T1 and T3 are statistically similar in DFI, while T2 differs significantly, potentially consuming less due to the composition of its feed. This could imply that the feed composition in T1 and T3 was more palatable or nutritious, encouraging greater intake. The highest TWG in T4, followed by T1 and T3, suggests that the combination of fortified groundnut shell, *Saccharomyces cerevisiae*, and molasses in T4 effectively supports substantial weight gain.

The daily weight gain metric aligns with the TWG findings, showing that T4 yields the highest DWG. This consistency confirms that the T4 treatment is efficient at promoting regular, sustained weight gain on a daily basis. This is in accordance with the report of Millam *et al*. (2016) and Kade (2020) who reported higher daily weight gain when treated groundnut shell was fed to ram lamb. Aruwayo

et al. (2024) also reported similar trend in Sokoto red goats fed treated groundnut shell. The higher DWG in T4 highlights the effectiveness of *Saccharomyces cerevisiae* and molasses in improving utilization treated groundnut shell through enhanced digestive efficiency and nutrient absorption. This is in consonance with the investigation report by Musa *et al*. (2024) when *Saccharomyces cerevisiae* treated groundnut haulm was fed to small ruminants.

Feed efficiency is a key metric of how well the rams convert feed into body weight. T4 demonstrates the highest FE, indicating that it allows rams to utilize the feed more effectively for growth. This could be an indication better optimized nutrient profile or better digestibility in T4 that might have resulted from improved hydrolysis of the cell wall content. Aruwayo *et al.* (2024) asserted that treatment of groundnut shell improved feed utilization and ultimately, feed efficiency as a result improved hydrolysis of the cell wall.

Cost of feed per liveweight gain (CFCLW) examines the cost-efficiency of each treatment in terms of total feed cost per live weight gained. The lower CFCLW in T4 suggests that although it was costlier in terms of feed consumed, this was justified by the significant gains in body weight. This might be appealing for producers focusing on minimizing feed costs. CFLWG provides a clearer view of the cost relative to the actual weight gained. Here, T4 shows the lowest value, suggesting it is the most economical option in terms of feed cost per unit of weight gain. This result highlights T4 as the most effective and economically viable treatment option for improving growth at the lowest per-unit cost of gain. The fortified groundnut shell with *Saccharomyces cerevisiae* and molasses in T4 appears to be the most effective treatment which have resulted from better feed efficiency and growth in the experimental animals. For producers, T4 offers a more viable option for maximizing growth performance in Yankasa rams, potentially offsetting the higher initial feed cost with more efficient and economically beneficial gains. This analysis helps underscore the value of nutritional supplementation with yeast and molasses to enhance growth performance and feed efficiency in small ruminant production systems.

Nutrient Digestibility of the Experimental Animal

Table 4 indicates the nutrient digestibility of the experimental animals fed Yeast (Saccharomyces cerevisiae) and molasses ensiled groundnut shell

Table 4: Nutrient digestibility by the Yankasa rams fed the experimental diets

Parameters	Treatments				
	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	SEM
DM (%)	79.370^{a}	77.620^{b}	79.580^{a}	78.530^{a}	0.300
CP (%)	83.885^{d}	84.835^{c}	86.525^{b}	89.685^{a}	0.836
CF (%)	86.680^{d}	87.685^{c}	89.430^{b}	91.255^{a}	0.667
EE (%)	85.600^{c}	86.420^{c}	91.420^{b}	93.490^{a}	1.256
NFE (%)	71.240^{d}	72.890^{c}	74.630^{b}	79.520^{a}	1.172
LIG (%)	80.390^{d}	83.285^{c}	85.390^{b}	89.665^{a}	1.279
ADF (%)	74.240^{d}	77.390^{c}	78.440^{b}	79.450^{a}	0.742
NDF (%)	73.100^{d}	76.640^{c}	78.570^{b}	79.530^{a}	0.933

DM= Dry Matter, CP = Crude Protein, EE = Ether Extract, NFE=Nitrogen Free Extract, LIG = Lignin, ADF = Aid Detergent Fibre, NDF=Nitrogen Free Extract

Dry Matter (DM) digestibility of T1 and T3 (79.37% and 79.580%) showed significantly higher ($P<0.05$) values, followed by T4 and then T2 (77.62%) having the lowest digestibility. Crude Protein (CP) digestibility increased with increasing level of the test ingredient, with T4 showing significantly higher ($P<0.05$) value. This suggests that the combination of groundnut shell with *Saccharomyces cerevisiae* and molasses in T4 may enhance crude protein digestibility, possibly due to the improved breakdown of proteins and nitrogen utilization. Crude Fiber (CF) digestibility follow the same trend as that of crude protein digestibility. Higher fiber digestibility indicates that *Saccharomyces cerevisiae* and molasses might be aiding in fiber breakdown, likely by enhancing microbial fermentation in the rumen. Ether Extract (EE) digestibility was significantly higher ($P<0.05$)

in T4 (93.490%), followed by T3, indicating an improved ability to utilize fats from the feed. This could be beneficial for energy supply in Yankasa rams, as a higher digestibility of ether extract translates to better energy absorption. The nitrogen-free extract, which represents digestible carbohydrates, increases progressively with each treatment. The highest value in T4 suggests that the fortified diet may enhance carbohydrate utilization, potentially supporting growth and energy metabolism.

These ingredients can enhance the rumen environment, making nutrients more accessible and digestible. Research has shown that *Saccharomyces cerevisiae* supplementation enhances DM digestibility in ruminants by optimizing rumen pH and promoting beneficial microbial populations, which in turn improves fiber breakdown (Elghandour *et al.,* 2022). Molasses, rich in readily fermentable sugars, supports microbial activity, further aiding DM digestibility (Yang *et al.*, 2023). The significantly higher CP digestibility in T4 indicates that the fortified diet enhances nitrogen retention and protein utilization. Improved CP digestibility translates to better growth performance and muscle development in rams. Bach *et al*. (2023) reported that yeast cultures in ruminant diets enhance CP digestibility by promoting the growth of cellulolytic and proteolytic bacteria, which contribute to effective nitrogen utilization in the rumen. It was further documented by Zhang *et al*. (2023) that molasses as an energy source has been shown to complement protein metabolism, leading to higher CP digestibility. The increased CF digestibility, particularly in T4, suggests that the diet supports fiber degradation, which is crucial for ruminants that rely on fibrous feed sources. Improved fiber digestibility supports energy intake and nutrient absorption. Research highlights that *Saccharomyces cerevisiae* aids in fiber breakdown by increasing fibrolytic microbial populations, allowing ruminants to utilize fiber more effectively (Mao *et al.,* 2021). Molasses further enhances fiber digestion by boosting microbial energy supply, supporting effective fermentation (Gado *et al*., 2022).

Higher EE digestibility in T4 indicates that the ensiled diet enhances fat utilization. Improved fat digestibility is advantageous as it increases energy density in the diet, beneficial for animals requiring higher energy for growth and metabolism. The presence of yeast in ruminant diets has been linked to improved EE digestibility, attributed to its ability to stabilize rumen fermentation and enhance microbial efficiency (Zhou *et al*., 2023). Molasses has also been shown to support fat digestion by providing an energy source that complements microbial activity in the rumen (Abdel-Rahman *et al*., 2023).

Higher NFE digestibility in T4 suggests enhanced carbohydrate utilization, an essential factor for providing energy to ruminants. This is likely due to the availability of fermentable sugars in molasses which enhances microbial fermentation. Molasses a rich source of NFE, boosts carbohydrate digestion by promoting microbial efficiency in the rumen. Combined with yeast, it supports sustained fermentation, leading to improved energy availability from NFE (Chen *et al*., 2023). Molasses, by enhancing the energy supply, further complements this effect, aiding in more effective fermentation of fibrous components (Huang *et al*., 2023).

The digestibility of the cell contents digestibility recorded better values in T4. This is beneficial because the higher the digestibility of these parameters, the better for the animals. Yeast and molasses combination might have enhanced the breakdown of lignin, which could be advantageous for overall fiber digestion as well as NDF and ADF. Higher lignin digestibility in T4 indicates that the ensiled diet supports the breakdown of complex fibers, which are usually resistant to digestion. This result suggests that yeast and molasses may promote microbial species that can partially degrade lignin, improving feed efficiency. Studies have shown that yeast and molasses increase the digestibility of complex plant fibers by enhancing rumen microbial diversity, which can modify the breakdown of lignin and other complex fibers (Tang *et al*., 2022). The higher ADF and NDF digestibility in T4 suggests that the ensiled diet aids in breaking down cellulose and hemicellulose, key components of fiber that contribute to energy release. The report of Li *et al*. (2022) revealed that yeast supplementation improves ADF and NDF digestibility by promoting fibrolytic bacteria that facilitate fiber breakdown.

Nitrogen Utilization of Yankasa rams fed the Experimental diets

Table 5 indicates the nitrogen Utilization of Yankasa rams fed the Experimental diets

Table 5: Nitrogen Utilization of Yankasa rams fed the Experimental diets

Parameters	Treatments				
	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	SEM
NITK (g)	26.56^{bc}	26.25^{c}	26.81^{b}	27.33^{a}	0.15
NIF (g)	2.76^{c}	3.35^{a}	2.57^{bc}	2.99^{b}	0.08
NIU (g)	0.93^{b}	0.90^{b}	0.96^{a}	0.98^{a}	0.12
NA (g)	23.80^{b}	22.90^{c}	23.61^{b}	24.34^{a}	0.20
NB (g)	22.87^{b}	22.00^{c}	22.65^{b}	23.36^{a}	0.18
NRT (%)	86.22^{b}	87.15^{a}	84.69^{c}	86.10^{b}	0.33

NITK=Nitrogen Intake, NIU=Nitrogen in urine, NIF= Nitrogen in feed, NA=Nitrogen Absorbed, NB=Nitrogen Balance, NRT=Nitrogen Retained

Treatment T4 had the highest nitrogen intake, followed by T3, T1, and T2. This suggests that the addition of *Saccharomyces cerevisiae* and molasses in T4 enhanced feed intake and nitrogen availability. The differences among treatments are statistically significant, indicating the effectiveness of the ensiled diet in increasing nitrogen consumption. Higher nitrogen intake correlates with improved protein availability, supporting growth and production in ruminants. T2 recorded the highest nitrogen excretion through urine, followed by T4, T3, and T1. This may suggest less efficient nitrogen utilization in T2, as more nitrogen is being excreted rather than retained. Lower nitrogen losses through urine are desirable for reducing environmental nitrogen emissions and improving nitrogen retention for growth. and T3 showed higher nitrogen excretion in feces compared to T1 and T4. This may indicate incomplete digestion or absorption of dietary nitrogen in T2 and T3. T4 demonstrated lower fecal nitrogen loss, reflecting improved nitrogen absorption due to the ensiled diet. Lower nitrogen in feces suggests better nutrient absorption and utilization. T4 showed the highest nitrogen absorption, followed by T1 and T3, with T2 being the lowest. This indicates that T4's diet is more effective in supporting nitrogen digestion and absorption in Yankasa rams. The differences are statistically significant. Higher nitrogen absorption supports better protein synthesis, growth, and maintenance. T4 demonstrated the highest nitrogen balance, while T2 showed the lowest. A positive nitrogen balance, as seen across all treatments, indicates that nitrogen intake exceeds nitrogen excretion, which is essential for growth and tissue repair. Higher nitrogen balance in T4 reflects improved protein retention and utilization. T2 had the highest nitrogen retention percentage, closely followed by T4 and T1. T3 recorded the lowest nitrogen retention, suggesting slightly less efficient nitrogen utilization in this group. Despite the variations, all treatments exhibit high retention rates, which indicate efficient use of dietary nitrogen. High nitrogen retention is crucial for maximizing growth and production, with T4 showing an optimal balance between intake and retention. The results indicate that ensiled groundnut shell diets with *Saccharomyces cerevisiae* and molasses positively influence nitrogen utilization in Yankasa rams, with T4 consistently demonstrating superior performance across parameters. The improvements can be attributed to the synergistic effects of yeast and molasses on rumen function. Yeast cultures provide a stable rumen environment by buffering pH and promoting beneficial microbial populations, which improves nitrogen utilization efficiency (Elghandour *et al*., 2022). Molasses, as a source of readily fermentable carbohydrates, supplies energy for microbes, enhancing the conversion of dietary nitrogen into microbial protein (Yang *et al.*, 2023). Lower fecal and urinary nitrogen losses in T4 suggest efficient nutrient absorption and reduced wastage, consistent with findings by Gado *et al*. (2022). These findings align with research emphasizing the role of yeast and molasses in improving nitrogen metabolism and retention in ruminants. The high nitrogen retention and positive nitrogen balance observed in T4 reflect an optimized diet that supports growth and production.

CONCLUSION

The results of the research revealed that diets with ensiled groundnut shell with *Sacchromyces cerevecea* and molasses inclusion performed better than the control.

Inclusion level of 15% of the test ingredient was better in digestibility, nitrogen utilization, feed efficiency, total weight gain and cost per live weight gain. Therefore, ensiling groundnut shell with *Sacchromyces cerevecea* and molasses up to 15% is recommended. Further, research on the use of the test ingredient is recommended.

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IMPACT OF CRYSTALLINE PROGESTERONE ON SPLEEN HISTOMORPHOMETRY AND SHELL GLAND HISTOLOGY IN LOHMANN BROWN LAYERS

[1]Ahmed, B. and [2]Yusuf, A.

[1]Department of Animal Science, Umaru Musa Yar'adua University P.M.B 2218, Katsina State

[2]Department of Animal Science, Federal University, Dutsin-Ma Katsina State

Corresponding Author: bishirahmed944@gmail.com,+2347030286505

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ABSTRACT

The experiment determined the effect of Crystalline Progesterone (CP) on spleen histomorphometry and shell gland histology in Lohmann Brown layers. Completely randomized design was used with each treatment (0, 5, 10, 15, 20 and 25 mg per bird) administered intramuscularly via the breast muscle and replicated thrice for six weeks. The birds were managed on battery cage, fed commercial diet and water was given *ad libitum* Data were analyzed using GraphPad InStat® package. Results revealed there were significant difference (P<0.05) in proportion of spleen red pulp (0 mg vs. 15 mg = 80% vs. 50%; 5 mg vs. 15 mg = 80% vs. 50% and 5 mg vs. 15 mg= 80% vs. 50%) and ellipsoids and peri-arteriolar lymphoid sheath (PALS) (0 mg vs. 15 mg = 10% vs. 50%; 5 mg vs. 15 mg = 10% vs. 50% and 10 mg vs. 15 mg = 15% vs. 50%). Whereas, (P>0.05) effect of CP proportion of spleen vascular skeleton and B follicles Histological investigation conferred similar magnitude (>10 fat cell aggregates) of shell gland fat infiltration between 10 and 15 mg CP treatment groups. It also showed non atrophic change at all doses. Beyond 15 mg CP, the magnitude of shell gland fat infiltration decreased to 6-10 fat cell aggregates and subsequently remained the same. Shell gland in the 5 mg CP group had no fat infiltration when compared to those in the control group which had 1-3 fat cell aggregates. It has been concluded that, CP affected proportion of spleen red pulp and ellipsoids and PALS., In the same vein affected, shell gland fat infiltration.

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INTRODUCTION

Productivity is the key to growth and reproduction status of our farm animals (Verma *et al*., 2012). Sexual maturity and egg production in birds is controlled by many factors including hormones especially oestrogen that plays important role in reproductive performance while progesterone is related to ovulation process (Rozenboim *et al*., 2004; Rozenboim *at al*., 2007). Synthetic hormones have been used in animal agriculture to improve reproduction and performance (Ledda *et al*., 1999). Spleen in avian species is a round or oval structure lying dorsal to and on the left side of the proventriculus (Payne, 1971). Eerola, et al. (1987) observed that splenic development occurs after hatching, following exposure to antigens. Spleen is a principal organ of systemic immunity and its importance in disease resistance is accentuated by the scarcity of avian lymph nodes (John, 1994). It also used as primary organ of systemic body defense and plays important role against invasion of pathogenic organisms into the animal's body (Kannan *et al.,* 2015). The main function of the spleen is filtering of blood and production of immunoglobulins and lymphocytes (T-help) involved in body defense (Kopp, 1990). It does not function as a reservoir of blood as in mammals and its function is not oriented towards supply of oxygen (Jeurissen, 1991). Spleen in birds has attracted the interest of many scientists (Corbin *et al*., 2008). Thus, the spleen is a greater asset in the study of immune response as producer and a store for lymphocytes (Smith & Hunt, 2004).

Shell gland is the segment of the oviduct immediately succeeding the isthmus and of similar diameter but after a short course, expands to form a pouch in which the egg is retained during the entire period of shell formation (Mohammadpour *et al.,* 2012). The shell gland is

involved in deposition of albumen which occurs within 19 to 20 hours before oviposition and strengthening of shell membrane (inner layer) of the egg (Nys & Guyot, 2011). The hard shell is formed in the shell gland 1.5 to 2.0 hours before oviposition (Nys & Guyot, 2011). Despite the important role of progesterone in egg production, the information on its impact on spleen histomorphometry and gland histology is still scanty. The specific objective of the study is to evaluate spleen histomorphometry and assess changes in shell gland histology induced by Crystalline Progesterone administration in Lohmann Brown laying hens.

MATERIALS AND METHODS

Experimental Birds and their Management

A total of eighteen 24-week old Lohmann Brown strain of layers were purchased from Sovet International Farm Limited, Tarauni, Kano. Two weeks before purchase of the layers, the poultry house and associated facilities were inspected, cleaned and sanitized. On arrival to the Poultry unit of the Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture, Bayero University Kano (GPS Coordinates: 11.97643ºN, 008.42995ºE), the hens were given water with multivitamins (Anupco Vitalyte Extra®, Anglian Products Company, UK) at 0.5 g per litre and Oxytetracycline Hydrochloride powder (Oxywin®, Sellwell Pharmaceuticals Ltd, India) at 1 g per litre as prophylactic for stress and secondary bacterial infections, respectively. Topical spray of cypermetrin butycarbityl 6-properonol (Zee on®, Dappo Limited, Farm Centre, Kano) was used on the birds against external parasites before the commencement of the study. The birds were allowed to acclimatize to the new environment for two weeks before commencement of the experiment. The experimental birds were fed layer mash (Super Layer®) which contained 16.0% crude protein, 5.0 % fat, 6.0 % fibre, 3.5 % calcium, 0.4 % phosphorus, and 2600 kcal/kg energy and water was provided *ad libitum* throughout the period of acclimatization and experimentation. Drinkers were washed and water replaced periodically.

Sample Size Determination and Experimental Design

Sample Size

The procedure of Mead, Gilmour and Mead (2012) was used to determine the sample size.

Experimental Design

The experiment was laid in a single factor completely randomized design with six treatment groups replicated three times. Six treatments were assigned as 0, 5, 10, 15, 20 and 25 mg Crystalline Progesterone levels corresponding to treatments A, B, C, D, E and F, respectively.

Progesterone Administration

Crystalline Progesterone (Gesteron-25®) was purchased in 1 ml ampoules of 25 mg per ml from Wellcare Pharmaceuticals, Kano. The treatment groups received Crystalline Progesterone injections intramuscularly via the breast muscle at 5, 10, 15, 20 and 25 mg/bird. The control group was injected with 1 ml normal saline. Injections were being given on Mondays and Thursdays in the morning between 10.00 am and 11:00 am throughout the experimental period of six weeks.

Spleen and Shell Gland Harvesting and Histological Processing

At the end of the experiment, the birds were weighed before slaughter using weighing scale (HANA®, model J1603444602, China). After slaughter, the spleen and shell gland were harvested using the procedure of Thierry (2000) for organ harvesting in birds. After harvesting, both organs were immersed into 10% Neutral Buffered Formalin. The fixed samples were taken to laboratory for histological processing. Samples fixed in 10% Neutral Buffered Formalin were processed using standard histological techniques as described by Bancroft and Gamble (2008) and histological slides were prepared.

Spleen slides were subjected to histomorphometry while shell gland slides were observed for qualitative changes. Both procedures were carried following the method of Maas and Orthel (1976) with modifications by the use of an Olympus CX21 microscope at x100 total magnification (eyepiece + nosepiece) for visual percentage analysis. Five fields were examined and observer-dependent percent composition of each component visible on hematoxylin and eosin only stained slides were noted and the averages were recorded as percentages. Vascular skeleton was identified as medium- and small-sized arterioles with their branches visible at x100 magnification. Red pulp includes all red pulp areas including capillary and sinusoids. Ellipsoids and peri-arteriolar lymphatic sheath (PALS) were evaluated as ellipsoids merged with PALS without added histochemical staining (reticulin stain) to separate them. B follicles were identified as circular aggregates of small-sized lymphocytes.

Data Analysis

Data generated were subjected to analysis using GraphPad InStat Statistical Package (GraphPad InStat®, version 3.05, 32 bit for Win 95/NT, GraphPad Software Inc., 2000). Kruskal-Wallis test was used to determine the effect of different levels of Crystalline Progesterone on proportion

of splenic red pulp, and proportion of ellipsoids and periarteriolar lymphoid sheath. Significant differences in mean rank differences across Crystalline Progesterone treatment groups were separated using the Dunn's Multiple Comparisons test. One-Way Analysis of Variance was used to determine the effect of different levels of Crystalline Progesterone on the proportion of splenic vascular skeleton and B follicles. Significant mean differences across treatments were separated using Tukey's test.

RESULTS AND DISCUSSIONS

Splenic red pulp

The effect of Crystalline Progesterone on the proportion of red pulp in the spleen of Lohmann Brown layers is shown in Table 1. There was a statistically significant ($P<0.05$; mean rank difference = 17.900; Kruskal-Wallis statistic = 22.708) difference in median proportion of red pulp in the spleen (80% *vs*. 40%) between birds administered Crystalline Progesterone at 0 and 15 mg. Also, a significant ($P<0.001$; mean rank difference = 22.100; Kruskal-Wallis statistic = 22.708) median proportion (80% *vs*. 40%) of red pulp in the spleen was recorded between birds administered 5 and 15 mg Crystalline Progesterone as well as significant ($P<0.05$; mean rank difference = 17.000; Kruskal-Wallis statistic= 22.708) spleen red pulp proportion (80% *vs*.50%) between birds administered 5 and 25 mg Crystalline Progesterone.

Effect of crystalline progesterone on ellipsoids and PALS

The effect of Crystalline Progesterone on proportion of ellipsoids and PALS in the spleen of Lohmann Brown layers is highlighted in Table 2. There was a statistically significant ($P<0.01$; mean rank difference = -19.700; Kruskal-Wallis statistic = 22.711) difference in median proportion of ellipsoids and PALS (10% *vs*. 50%) between birds administered Crystalline Progesterone at 0 and 15 mg. Also, a significant ($P<0.01$; mean rank difference = -19700; Kruskal-Wallis statistic = 22.711) proportion of spleen ellipsoids and PALS (10% *vs*. 50%) was recorded between birds administered 5 and 15 mg Crystalline Progesterone as well as significant ($P<0.05$; mean rank difference = -16.800; Kruskal-Wallis statistic = 22.711) median ellipsoids and PALS proportion (15% *vs*. 50%) between birds administered Crystalline Progesterone at 10 mg

Effect of crystalline progesterone on B. follicles of lohman brown hens

The effect of Crystalline Progesterone on proportion of B follicles in the spleen of Lohmann Brown layers is presented in Table 3. There was no statistically significant ($P>0.05$) difference in mean proportion (0.0, 0.0, 1.6, 0.0, 0.0 and 2.6 %) of B follicles in the spleen of Lohmann Brown layers is across respective Crystalline Progesterone treatments levels (0, 5, 10, 15, 20 and 25 mg).

Vascular skeleton

The effect of Crystalline Progesterone on the proportion of vascular skeleton in the spleen of Lohmann Brown layers is presented in Table 4. There was no statistically significant ($P>0.05$) difference in mean proportion (10.4, 6.0, 8.0, 11.0, 11.0 and 7.0 %) of vascular skeleton across respective Crystalline Progesterone treatment levels (0, 5, 10, 15, 20 and 25 mg).

Table 1: Selected Pairs Dunn's Multiple Comparisons for Proportion of Red Pulp in the Spleen across Crystalline Progesterone Treatment Levels in Lohmann Brown Hens

Crystalline Progesterone (mg)	N	Median (%)	Minimum (%)	Maximum (%)	Sum of Ranks	Mean of Ranks	Kruskal-Wallis (KW) Statistic, corrected for ties
0	3	80	73	80	109	21.8	
5	3	80	80	85	130	26.0	
10	3	70	70	85	95	19.1	
15	2	40	40	45	19	3.9	
20	3	60	40	80	66	13.2	22.708*
25	3	50	45	60	45	9.0	

Comparison	Mean Rank Difference	Level of Significance
0 mg *vs*. 15 mg	17.900	*
5 mg *vs*. 15 mg	22.100	***
5 mg *vs*. 25 mg	17.000	*

*P<0.05; ***P<0.001

N = number of experimental animals

Table 2: Summary Statistics, KW Statistic and Selected Pairs Dunn's Multiple Comparisons on Proportion of Ellipsoids and PALS[1] across Crystalline Progesterone Treatment Levels in Lohmann Brown Hens

Crystalline Progesterone (mg)	N	Median (%)	Minimum (%)	Maximum (%)	Sum of Ranks	Mean of Ranks	Kruskal-Wallis (KW) Statistic, corrected for ties
0	3	10	10	15	39.0	7.8	
5	3	10	10	15	39.0	7.8	
10	3	15	10	25	53.5	10.7	
15	2	50	40	50	137.5	27.5	
20	3	30	10	40	82.0	16.4	22.711*
25	3	40	35	42	114.0	22.8	

Comparison	Mean Rank Difference	Level of Significance
0 mg *vs*. 15 mg	-19.700	**
5 mg *vs*. 15 mg	-19.700	**
10 mg *vs*. 15 mg	-16.800	*

*P<0.05, **P<0.01, PALS [1]= periarteriolar lymphatic sheath N = number of experimental animals

Table 3: Effect of Crystalline Progesterone on Proportion of B Follicles in the Spleen of Lohmann Brown Hens

Crystalline Progesterone (mg)	Mean Proportion (%)	Standard Error of the Mean
0	0.0	0.000
5	0.0	0.000
10	1.6	1.030
15	0.0	0.000
20	0.0	0.000
25	2.6	1.939

P>0.05

Table 4: Effect of Crystalline Progesterone on Proportion of Vascular Skeleton in the Spleen of Lohmann Brown Hens

Crystalline Progesterone (mg)	Mean Proportion (%)	Standard Error of the Mean
0	10.4	1.631
c5	6.0	1.000
10	8.0	1.225
15	11.0	1.000
20	11.0	2.449
25	7.0	1.225

P>0.05

Histological Responses of the Shell Gland

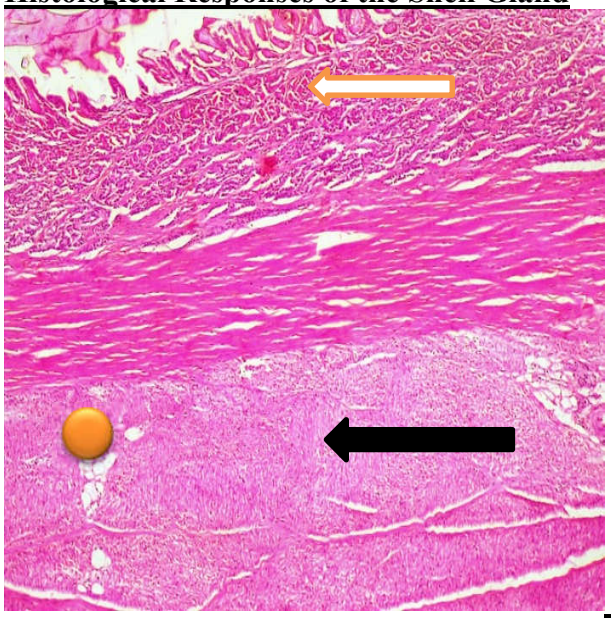

Plate 1: Shell Gland of Lohmann Brown Hens treated with Different Concentrations (A = 0 mg). White arrows show mucosal glands with mostly empty lumen; black arrows show pale staining muscularis (denoting reduced protein content). Yellow dots show fatty infiltrates.

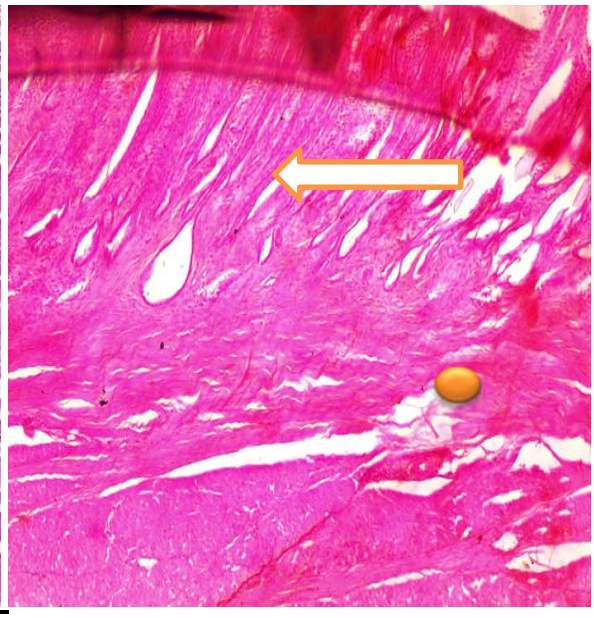

Plate 2: Shell Gland of Lohmann Brown Hens treated with Different Concentrations (B = 5 mg), of Crystalline Progesterone **B -** Mucosa: small-sized straight tubular glands lined by low cuboidal cells with abundant stroma and sparse secretions. Thickness - 0.5 mm. Muscularis: mild hypertrophy, fat infiltrates +, thickness - 10.5 mm.

Plate 3: Shell Gland of Lohmann Brown Hens treated with Different Concentrations C = 10 mg of crystalline progesterone. Mucosa: smaller-sized straight tubular glands lined by flattened cells with some secretions, moderate fibrous stroma. Thickness- 0.5 mm. Muscularis: moderate hypertrophy, cytoplasmic vacuoles in all fields, fat infiltrates ++++, thickness - not measured. blue arrows show muscularis with deeply pink cytoplasm.

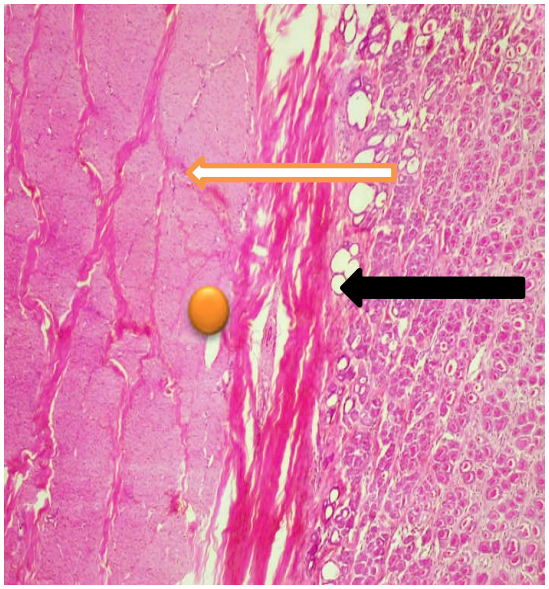

Plate 4: Shell Gland of Lohmann Brown Hens treated with Different Concentrations D = 15 mg of crystalline progesterone. **D -** Mucosa: small-sized straight tubular glands lined by cuboidal cells, abundant secretions, and fibrous stroma, thickness - 1.0 mm. Muscularis: no atrophy, cytoplasmic vacuoles in all fields, fat infiltrates ++++, thickness - not measured[2].

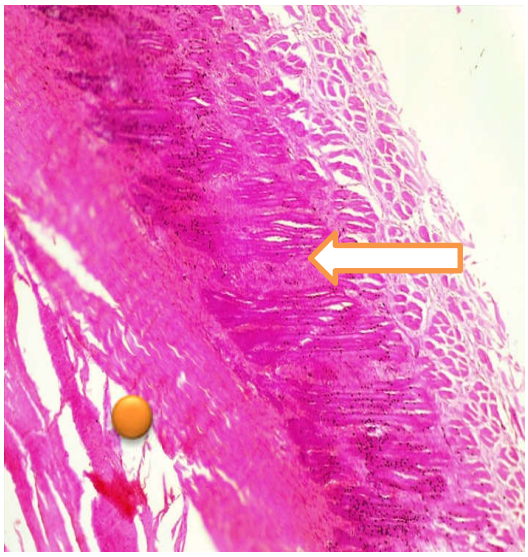

Plate 5: Shell Gland of Lohmann Brown Hens treated with Different Concentrations E = 20 mg of crystalline progesterone. **E -** Marked tissue folding obscuring slide. Mucosa: small-sized straight tubular glands lined by cuboidal cells, some secretions, abundant fibrous stroma, thickness - 0.5 mm. Muscularis: moderate hypertrophy, fat infiltrate +++, thickness - not measured.

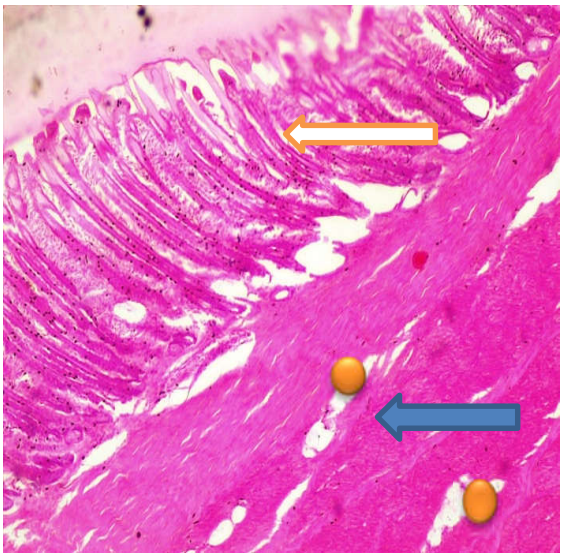

Plate 6: Shell Gland of Lohmann Brown Hens treated with Different Concentrations F = 25 mg of crystalline progesterone. **F -** Mucosa: small-sized straight tubular glands lined by cuboidal cells, some secretions, abundant fibrous stroma, thickness - 1.0 mm. Muscularis: mild hypertrophy, fat infiltrates +++, thickness - not measured.

[1] Fat infiltrate + - no fat cells present/5 (x100) fields, ++ - 1-3 fat cell aggregates/5 (x100) fields, +++ - 6-10 fat cell aggregates/5 (x100) fields, and ++++ - >10 fat cell aggregates/5 (x100) fields.
[2]No mucosa and no serosa identified on slide hence thickness is not measurable.

DISCUSSIONS

Progesterone receptor (PR) has been described in tissues where the action of progesterone is less well defined, including vascular endothelium (Perrot-Applanat *et al*., 1995) and rat thymus (Pear *et al*., 1983). Lack of well-defined action in the splenic vascular skeleton and B follicles could be responsible for the non-significant effect of Crystalline Progesterone (CP) in the present study. This trend could also be due to non-significant individual variability in hens across CP treatment groups.

Balika, et al. (1976) reported that the percentage of all splenic erythroid cells increased in newborn rats that received antenatal doses of progesterone. They also reported that the relative percentage of splenic myeloid cells in young rats fell by half under the influence of exogenous progesterone administered during the antenatal period. As the effects of progesterone are mediated by its receptor and PR is induced by estrogen in most target tissues, the delineation of specific progesterone effects, as distinct from those of estrogen, is similarly not clear (Graham & Clarke, 1997). This could be responsible for the general decrease in red pulp proportion and the corresponding increase in splenic white pulp (ellipsoid and peri-arteriolar lymphatic sheath as well as B follicles) proportion recorded in the current work. Moreover, the present experiment took place when the birds were actively ovulating; thus presenting an opportunity for adequate estrogen priming prior to administration of Crystalline Progesterone. According to Sasaki and Ito (1981), splenic white pulp showed a slight but significant increase in volume in estrogen-treated and estrogen-progesterone treated mouse. In the progesterone-treated group, however, the red and white pulps did not undergo any significant change in volume (Sasaki & Ito, 1981).

Progesterone treatment affects the differentiation of tubular gland cells (Oka & Schimke, 1969) and this depends on the stage of differentiation at which it was administered. If administered concomitantly with estrogen from inception of treatment, tubular gland cell differentiation will be abolished and by extension the growth of the oviduct (Boogaard, 1975). However, if onset of progesterone administration was delayed until when the birds are matured and actively laying as in the current study; it will not interfere with tubular gland cells because estrogen priming has already taken place (Boogaard, 1975). This sheds light on why exogenous Crystalline Progesterone (CP) in the present study showed clearly differentiated tubular glands across all CP treatment levels. The mild to moderate hypertrophy of the shell gland muscularis in the current work may point towards growth and functioning of the gland. Once the cells of the shell gland differentiate and become responsive to progesterone, they maintain this responsiveness even during the non-laying period (Yoshimura & Bahr, 1991). Progesterone receptor was reported by Yoshimura and Bahr (1991) to be present in the nuclei of the surface epithelial cells, tubular gland cells, stromal fibroblasts and smooth muscle cells in the arterial wall and myometrium of laying hens. Finally, the suggestion that estradiol and progesterone may regulate the growth of fat and fat-free tissues in female rats (Toth *et al*., 2001) may explain the pattern of shell gland fat infiltration recorded in the present study.

CONCLUSION

In conclusion, Crystalline Progesterone affected proportion of spleen red pulp and ellipsoids and peri-arteriolar lymphoid sheath. Also, the magnitude of shell gland fat infiltration was influenced by Crystalline Progesterone treatment.

RECOMMENDATION

Based on research findings, it is therefore, recommended the use of progesterone from 5 mg/bird up to 25 mg /bird as these doses meditate the activities of red pulp and differentiation of tubular gland cells.

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RESPONSE OF YANKASA RAMS TO VARIOUS INCLUSION LEVELS OF PROPAGATED BITTER LEAF (*Vernonia amygdalina*) ON PERFORMANCE AND RUMEN ECOLOGY

*Abdulrahman A., Garba, M.G., Gaddafi, S. and Yusuf, A.

Department of Animal Science, Federal University Dutsin-Ma, Katsina State, Nigeria.

*Correspondent author: Email: abdulrahmanahmed840@gmail.com; Phone: 08032336545

Keywords: Bitter leaf, Rams, Growth, Rumen, and Ecology

ABSTRACT

The experiment evaluated the response of Yankasa rams fed graded levels of propagated Bitter Leaf (*Vernonia amygdalina*) on growth performance, nutrient digestibility, rumen ecology, and blood profile. Twenty (20) rams were randomly allocated into four dietary treatments consisting of 0%, 5%, 10%, and 15% inclusion levels of dry bitter leaf. Growth performance, nutrient digestibility trail and rumen fluid were collected and analyzed accordingly. Data obtained were analyzed using statistical analysis system (SAS,2002). Growth performance results showed that T3(15%) had an outstanding ($P<0.05$) performance, especially feed intake, and final weight. Nutrient digestibility results indicated that *V. amygdalina* graded level statistically ($P<0.05$) influenced dry matter (DM) digestibility and neutral detergent fiber (NDF). T3 (10%) had statistically higher values ($P<0.05$) of acid detergent fibre (ADF), crude protein (CP) and nitrogen-free extract (NFE) values compared to control group in this study. *V. amygdalina* graded level had profound significant ($P<0.05$) differences in rumen pH and other rumen ecology parameters. It could be concluded that rams fed 10% (T3) *Vernonia amygdalina* had outstanding growth performance followed by 15% *Vernonia amygdalina* level. Bitter Leaf *Vernonia amygdalina* do not negatively affect nutrient digestibility. However, considerable changes occur in VFA and rumen concentration from 0 to 15% of *Vernonia amgydalina.* Farmers are therefore recommended to include *Vernonia amgydalina* into the ram diet up to 15% for growth performance, nutrient digestibility, and rumen fermentation.

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INTRODUCTION

The scarcity of energy and protein in feedstuffs during the dry season poses a significant challenge to ruminant livestock production in Nigeria. This scarcity leads to a marked decrease in voluntary intake, digestibility, and overall productivity (Babayemi *et al.,* 2009). Additionally, the rising prices of conventional energy ingredients, coupled with increased competition between humans and animals due to a growing population, exacerbate the situation. The high cost of maize and other conventional feed resources in Nigeria has resulted in elevated animal feed prices, prompting the need to explore unconventional feed resources as alternatives or replacements for traditional feed ingredients (Sowande, 2004; Lamidi, 2009). Bitter leaf (*Vernonia amygdalina*) is a multipurpose plant in Nigeria that plays a significant biological role (Saalu *et al.*, 2013). It possesses nutritional and phytochemical properties that offer physiological, biochemical, and morphological benefits. The consumption of vegetables is recognized as essential for a healthy life, due to their antioxidative properties (Saalu *et al.,* 2013; Akunna *et al.,* 2013). Bitter leaf has been observed to thrive in Nigeria even under harsh weather conditions; however, very bitter taste can negatively impact intake (Saalu *et al.,* 2013). This bitterness is attributed to anti-nutritional factors such as alkaloids, saponins, tannins, and flavonoids (Saalu *et al.,* 2013). These compounds significantly affect microbial

activity in the rumen, thereby modifying the fermentation process.

MATERIALS AND METHOD.

Experimental site

This experiment was conducted at the Pasture unit of Prof. Lawal Abdu Saulawa Livestock Teaching and Research Farm, Department of Animal Science, Federal University Dutsin-Ma, Katsina State. The farm is situated within the latitude 12°27'18' north and 7°29'29' east and 605 meters above sea level with an annual average rainfall of 700mm in the Sudan savannah ecological zone. (Gaddafi *et al.,* 2019).

Experimental design

A total of twenty (20) Yankasa rams, each weighing approximately 23.5 kg, were assigned to four dietary treatments consisting of inclusion levels of dry bitter leaf (*Vernonia amygdalina*) at 0%, 5%, 10%, and 15%. The rams were distributed into four treatment groups, with five rams in each group, in a Completely Randomized Design (CRD). Each animal was housed in a pen measuring 2 m x 1 m, which was disinfected prior to the commencement of the research.

Data analysis

Data were analyzed using ANOVA (SAS, 2002), and significant differences among the treatment means were determined using Duncan's Multiple Range Test.

Data collection

Growth Performance Determination

The Initial weight at the beginning of the experiments were determined and recorded, Feed Intake (Kg), Weight Gain (Kg), Feed Conversion Ratio, Average Daily Weight Gain (g) and Final Weight (Kg) were also determined.

Determination of Nutrient Digestibility

Two Yankasa rams were selected from each treatment and allocated into metabolic cage for faecal and urine samples collection. Animals were allowed to acclimatize with the cage for seven days, where fecal sample was collected daily and weighed. The urine samples was collected in a sample bottle 50mls which it contains 10% concentrated sulphuric acid to prevent bacterial or microbial activities, and nitrogen escape. The Urinealysis samples was taken to laboratory and analyzed for urine nitrogen, ammonia, billirubvin, Cl2, Na, while faecal sample was taken to determine according to procedure outline by association of analytical chemistry (AOAC, 2002) Dry matter (DM), moisture, ADF, NDF, CF, CP, EE Ash, and Lignin.

Rumen Microflora Detection

The rumen fluid was collected using a stomach tube. The tube was inserted into the rumen and pump to obtain rumen fluid. The fluid was put in sample bottles and the samples were taken to the laboratory for rumen Volatile Fatty Acid (VFA) determination which includes, the samples were divided into two portions. The 1st portion is for total volatile fatty acid (VFA) and the proportions of acetate, propionate, and butyrate. The samples were centrifuged at 3000 x g for 10 min; which the samples were allowed to settle. The decant was titrated with 0.1M of sodium hydroxide (4/1000gml H2O) solution each with 2-3 drops of Phenophtaline (1/100gml ethanol) as the indicator. The second portion of the rumen filtrate was used for microbial count and identification. 2ml of rumen liquor was subjected to microbial count. Protozoa count was obtained by direct observation using a microscope at 10 x magnification (Dehority, 1984). Colony-forming units/ml (CFU/ml) of both bacteria and fungi were observed with the pour plate technique using nutrient agar (NA) and Potato dextrose agar (PDA) respectively. The plates were then incubated for 24 hours at 37ºC. All colonies appearing at the end of the incubation period were counted using a digital illuminated colony counter. Colonies grown on nutrient agar plates were suspected to be either gram-positive or gram-negative thus; all colonies found on each plate were used for gram staining as described by Cheesbrough (2005). Colonies grown on the PDA were further incubated for three days after the first 24 hours to check for morphology and isolation of fungi. Physical characteristics of rumen liquor such as temperature, pH, color, and odour.

RESULT AND DISCUSSION

Proximate Analysis of Experimental Diet

The results on proximate analysis of experimental diet were presented in table 4.6 below. The experimental diet in this study were formulated to meet the dietary

recommendation of NRC (2002) of grower rams.

Table 4.6: Proximate Analysis of Experimental Diet

Parameters %	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)
LIG	15.98	16.51	16.54	16.51
DM	92.80	94.00	93.60	93.35
ADF	31.36	32.41	32.56	32.70
NDF	52.49	51.88	53.69	53.74
CP	12.44	12.33	12.47	12.22
OIL	3.76	3.94	3.57	3.98
Ash	7.20	7.32	8.11	8.20
NFE	67.30	66.19	64.37	64.37
Energy (Kcal/Kg)	3,601.99	3,641.95	3,685.58	3,714.69

LIG= Ligning, DM= Dry Matter, ADF= Acid Detergent Fibre, NDF= Neutral Detergent Fibre, CP= Crude Protein, NFE= Nitrogen Free Extract.

Effect of Graded Level of Bitter Leaf (*Vernonia amygdalina)* on Growth Performance of Yankasa Rams

The results on graded levels of bitter leaf *Vernonia amygdalina* on the growth performance of Yankasa Rams are presented in Table 2 below. The Experiment revealed that there were no significant (P>0.05) differences in the initial weight of animals used in this study and this clearly shows that the weight of animals was approximately balanced before the commencement of the experiment and this helped to reduce experimental error and bias. The final weight also showed that there were no significant (P>0.05) differences. However, there were considerable numerical differences between groups in which T3 had the highest final weight of (32.73kg) followed by T4 with (31.93kg), T2 (31.00kg), and T1 (30.37kg). The final weight of animals obtained in this study is higher than the final weight of Yankasa Rams of 22.51 - 23.16kg reported by Garba *et al.* (2023). A significantly (P<0.05) higher weight gain was recorded in T3 with 5.03kg followed by T4 with 3.27kg. This indicates that Bitter leaf (*Vernonia amygdalina*) had a profound effect on weight gain improvement of the animal and this may be attributed as a result of proximate constituent and Adegbola *et al.* (2020) reported that secondary metabolites contained in *Vernonia amygdalina* that are responsible for enhancing feed intake, utilization, and absorption thereby improving weight of the animals.

Table 2 Effect of Graded Level of Bitter Leaf (*Vernonia amygdalina*) on Growth Performance of Yankasa Rams

Parameters	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	SEM
Initial Weight (kg)	29.00	28.67	28.67	27.67	3.42
Final Weight (kg)	30.37	31.00	32.73	31.93	2.729
Weight Gain (kg)	1.37^{b}	2.33^{b}	4.06^{ab}	4.26^{a}	1.130
Average Daily Weight Gain (g)	22.00^{c}	38.00^{b}	67.67^{a}	71.00^{ab}	19.47
Feed Intake (kg)	1.163^{b}	1.453^{a}	1.433^{a}	1.607^{a}	0.0932
Average Daily Feed Intake (kg)	0.01933^{b}	0.02400^{a}	0.02400^{a}	0.02633^{a}	0.001616
Feed Efficiency	1.739^{ab}	1.174^{b}	3.431^{a}	2.039^{ab}	0.732
Feed Conversion Ratio	0.3580^{b}	0.8550^{a}	0.3267^{b}	0.6070^{ab}	0.2018

Effect of Graded Level of Bitter Leaf (*Vernonia amygdalina*) on Yankasa Rams Nutrient Digestibility.

The results on the graded level of *Vernonia amygdalina* on Yankasa rams nutrient digestibility are presented in Table 3 below.

The result showed that Acid Detergent Fibre (ADF), Ash, Crude Fibre (CF), Crude Protein (CP), Ether Extract (EE), and Nitrogen Free extract (NFE) were not Significantly (P>0.05) affected by the influence of *Vernonia amygdalina* graded levels across the treatment however there were considerable differences across the treatment groups. For instance, there were considerable increases in CP digestibility with increased levels of *Vernonia amygdalina* in this study. The increasing crude protein digestibility with increasing levels of *Vernonia amygdalina* in the diet could be due to the presence of condensed tannins in bitter leaves. According to Wada *et al.,* (2016) condensed tannins at low levels bind the dietary protein, thus preventing it from ruminal degradation and thus enhance its availability for enzymatic digestion and utilization by the animal tissue. This observation is consistent with the work of Giri *et al.,* (2000) and Aregbeore (2009) who affirmed that the digestibility of nutrients varies with the nutrient composition of a diet.

The result revealed that *Vernonia amygdalina* graded levels in Yankasa rams greatly (P<0.05) influence Dry Matter Digestibility (DM) and Neutral Detergent Fibre (NDF). The relatively decreasing DM with increasing *Vernonia amygdalina* levels in the diets may be attributed to the increasing content of fibre fractions especially NDF in the diet. Bakshi and Wadhwa, (2004) reported that high NDF and ADF depress DM intake and DM digestibility. Minson, (1990) reported that lignin is bound to all plant cell walls and is a significant limiting factor in their digestion in the rumen. The higher values of ADF, CP and NFE at T3 the most probable explanation for this phenomenon is that diet at T3 graded level might have resulted in high palatability, increased activity of rumen microorganisms for rapid fibre digestion in the rumen, and better utilization of the nutrients by the animals.

Table 3: Effect of Graded Level of Bitter Leaf (*Vernonia amygdalina)* on Yankasa Rams Nutrient Digestibility

Parameters	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	SEM
DM	68.64[a]	70.59[b]	74.30[a]	74.25[b]	1.042
ADF	12.21	17.62	22.14	9.31	7.53
NDF	20.180[a]	2.300[c]	7.705[b]	5.670[b]	1.141
NFE	6.830	4.690	11.300	10.100	2.99
CP	28.49	19.82	57.89	56.91	14.55
CF	30.00	35.02	27.96	26.00	7.35
ASH	23.08	28.07	24.41	31.09	5.69
EE	42.28	34.89	32.91	45.34	4.49

ADF= Acid Detergent Fibre, CF= Crude Fibre, CP= Crude Protein, DM= Dry Matter, EE= Ether Extract, NDF= Neutral Detergent Fibre, NFE= Nitrogen Free Extract

Effect of Bitter Leaf (*Vernonia amygdalina)* on Volatile Fatty Acids and Rumen Microbes of Yankasa Rams

The rumen Volatile Fatty Acids and Microbial Counts Result of Yankasa rams are presented in the Table 9 below. The result revealed that the graded level of *Vernonia amygdalina* had a significant (P<0.05) role in changing the rumen liquor pH was a progressive linear increase trend with *Vernonia amygdalina* in which T4 had the highest pH value (6.300) while T1 had the lowest (6.150). pH provides a conducive and enabling environment for rumen microbes to work efficiently. Van Soest (1994) states that the pH range for optimal microbial activity was 6.2 - 7.2 which is in line with the value found in this study. The values recorded in this study fell within the range of 6.00 - 7.20 suitable for the growth and activities of microbes reported by Jallow and Hsia (2011). The Result showed that there were significant (P<0.05) differences in Acetic Acid, Butyric Acid, Propionic Acid, and total volatile fatty acid. The highest acetic acids

were recorded in T1 (75.38) which is good for energy but it may reduce the level of testostrone reported by (Wagner *et al.,* 2008), followed by T3 (47.62) while T2 had the lowest acetic acid value (42.84) lower acetic acid can lead to energy deficiency and poor sperm quality reported by (Safari *et al.,* 2018). The graded level of *Vernonia amygdalina* greatly influenced the Butryric Acid concentrations with a linear trend with increased levels of *Vernonia amygdalina*. The Total Volatile Fatty Acids (VFA) recorded in this study are higher than VFA reported by Jokthan *et al.,* (2013), Ngele (2008) and Eleman *et al.,* (2009).

Table 4.9: Effect of Bitter Leaf (*Vernonia amygdalina*) on Volatile Fatty Acids and Rumen Microbes of Yankasa Rams

Parameters	T1(0%)	T2(5%)	T3(10%)	T4(15%)	SEM
Ph	6.150^{b}	6.200^{ab}	6.250^{ab}	6.300^{a}	0.0500
AA (mmol/l)	75.38^{a}	42.84^{a}	47.62^{b}	45.16^{b}	2.103
BA (mmol/l)	26.89^{c}	32.05^{b}	35.65^{a}	35.23^{a}	0.549
PA (mmol/l)	43.28^{b}	51.21^{ab}	54.45^{a}	49.98^{ab}	3.38
Bacteria ($x10^{3}$cfu)	7.465^{b}	7.685^{b}	7.795^{a}	8.615^{a}	0.2675
Fungi ($x10^{3}$cfu)	1.720	1.775	1.510	1.735	0.2212
Protozoa ($x10^{3}$cfu)	1.700^{a}	1.490^{b}	1.570^{b}	1.550^{b}	0.0332
NH3(nmol/l)	20.68	20.20	20.19	20.17	0.368
VFA(mg/l)	145.9^{d}	147.8^{c}	156.4^{b}	165.3^{a}	0.498

AA= Acetic Acid, Butyric Acid, PA= Proponoic Acid, NH3= Ammonia, VFA= Volatile Fatty Acid

CONCLUSION

This Experiment could be concluded that rams fed 10% (T3) *Vernonia amygdalina* had outstanding growth performance followed by 15% *Vernonia amygdalina* graded levels. Bitter Leaf *Vernonia amygdalina* graded levels do not negatively affect nutrient digestibility. However, considerable changes occur in VFA and rumen microbes' concentration from 0 to 15% *Vernonia amgydalina.*

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COMPARATIVE ANALYSIS OF THREE GROWTH MODELS IN INDIGENOUS NORMAL FEATHERED CHICKENS OF NIGERIA

*[1] Lamido, M., [2]Alade N. K. and [2]Mukaddas J.

[1]Department of Animal Science, Federal University Dutsin-Ma, Katsina State.

[2]Department of Animal Science, University of Maiduguri, Borno State.

*Corresponding author: +2348036127209, lamidogdm@gmail.com

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ABSTRACT

This study was carried out to compare three growth models using body weights of 123 progenies generated from unselected random bred parents. The experiment which lasted for 24 weeks was carried out at the Poultry production unit (PPU) of the Ministry of Animal and Fisheries Resources, Potiskum, Yobe state. The data were analysed using Statistix (Version 9.0). Coefficient of determination (R^2) values for Gompertz, Logistic and Richard models were 0.61, 0.73 and 0.44 respectively. The Logistic model had the highest R^2 value (0.73) and Richard had the least (0.44). In contrast, Richard had the highest MSE (Mean Square Error) and AIC (Akaike's Information Criterion) while, Logistic had the least. Richard had the poorest fit (high MSE, AIC and lower R^2) while Logistic model and Gompertz best described growth in that order (lower MSE, AIC and high R^2). Consequently, based on the goodness of fit criteria; R^2, MSE and AIC values, the logistic function best described the growth pattern in indigenous normal feathered chickens of Nigeria.

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INTRODUCTION

Growth of animals is often measured by change in weight with time and historically the S-shaped or sigmoid curve has been used to mathematically describe this phenomenon. Growth functions are the most adequate means for describing the growth pattern of body weight or body parts, because they summarize the information into a few parameters that may be interpreted biologically (Goliomytis *et al*., 2003). Mignon-Grasteau *et al*. (1999) reported that growth curve parameters describe the age-body weight relationship in chickens, and these traits are heritable. Nonlinear models have been used broadly to describe variations in body weight with age, so the genetic potential of the chicken can be assessed (Adenaike *et al*., 2017).

Modelling of growth function is of paramount importance as it provides means of assessing growth patterns over time, and it generate equations that can be used to predict the expected weight of a group of animals at a specific period (Yakupoglu and Atil 2001; Segul and Kiraz, 2005). Various models that are used for describing growth in animals have different characteristics and limitations. Hence, an appropriate model that best describe a particular growth pattern should be carefully selected. There are several growth models such as Broady, Gompertz, Logistic, Morgan Mercer Flodine, Richards, Von Bertanlaffy and Weibull that have been used to describe animal growth (Bridges *et al*., 2000). Most of these mathematical functions are either three or four parameter non-linear exponential equations, with an inflection point coinciding with the time of maximum growth rate and are asymptotic to the mature size of the animal being described. A useful growth function should describe the data well and contain biological and physically meaningful parameters (France *et al*., 1996).

The report of Aliyu (2012) considered Logistic as the best model that described growth pattern of indigenous chickens due to closeness to the mean values and lowest error of prediction compared to Gompertz, Richard and Monomolecular function, though all the models had high R^2 values. Similarly, Adenaike *et al*. (2017) compared Gompertz, Broady, Logistic, Von Bertanlaffy and Richard function in the three genetic groups (Marshall, Naked Neck, and Normal Feathered chickens) and established that logistic model gave the best fit in terms of closeness of average matured weight and it standard error. Rhido *et al*. (2021) focused on comparison of Gompertz and Logistic function in heavy ecotype chickens and observed that all the models had similar R^2 values are high in both sexes (0.99 and 0.99 respectively), but suggested that Gompertz model was accurate for body weight prediction in normal feathered chickens due its low standard error. Generally, there is dearth of information on growth models that describe growth pattern of indigenous normal feathered chickens with respect to sex, season and

year factor. This study was carried to establish model(s) that best fit the growth of indigenous normal feathered chickens in semi-arid zone of Nigeria.

MATERIALS AND METHODS

Experimental Site

The study was carried out at the Poultry Production Unit (PPU) in Potiskum Local Government Area, of Yobe State. Potiskum is located between latitudes 11^0 03' and 11^0 30' N, longitudes 11^0 50' and 11^0 51' E at an altitude of 427 m above sea level (Bunmi *et al*., 2016). It falls within the wet and dry Sudano-Sahelian Savannah belt of Nigeria, and it is characterized by fluctuating climatic and seasonal variations. Furthermore, the area has a short period (4-5 months) of rainfall, usually between June to October having an average rainfall of 700 mm/annum with a long dry season of about 7-8 months (NIMET, 2014). The ambient temperature is as low as 20^0C during the dry cold season especially in January being the coldest month and as high as 44^0C during the dry hot period. The hottest month of the year is April. Relative humidity is 45% in August which usually lowers to about 5% in December and January; day length varies from 11 to 12 hours.

Experimental Birds and Management

A total of 60 matured and healthy indigenous normal feathered chickens comprising of 50 females and 10 males of breeding age were used as parent stock to generate progenies for the experiment. The birds were purchased from households in Potiskum, Yobe State. Prior to the arrival of the birds, pens were thoroughly cleaned, disinfected, and properly littered with wood shavings. The drinkers and feeders were also washed and cleaned. Each batch of chickens bought were quarantined for two weeks and fed layers mash containing 18% CP and 2650 ME/kg. After quarantine, the foundation population was divided in to ten (10) breeding groups; each group containing six (6) birds of five hens and one cock. They were randomly assigned into deep litter floor pens at 1:5 mating ratio. Laying boxes were provided for each pen for natural incubation. Feed and water were provided *ad libitum*. Eggs laid from each mating group of sire and dams were identified. Chicks hatched from each mating group were properly identified (wing tagged) and brooded artificially. Commercial diets were fed (chick mash 0-8 weeks, grower crumble 9-19 weeks and layer pellets at 20 weeks on ward) containing 20, 16 and 18% CP with 2780, 2600 and 2650 ME/kg, respectively. All routine husbandry management practices were adhered strictly and maintained through-out the study period. The birds were vaccinated against the major poultry diseases prevalent in the area.

The weighing time in birds was performed every four weeks until 24 weeks of age using a sensitive weighing balance. Nonlinear growth models of Gompertz, Logistic and Richard were fit to estimate the age-body weight relationship using Statistix 9.0 package. Goodness fit of each model were determined by the following criteria; Coefficient of Determination (R^2), Akaike's Information Criterion (AIC), Mean Square Error (MSE) and Standard Error (SE). The mathematical expression of the model parameters are as follows;

(i) Gompertz; Y= a*Exp (-Exp (b-c*X))
(ii) Logistic; Y = a/ (1 + Exp (b-c*X))
(iii) Richards; Y = a/ (1+ Exp (b-c*X)) ^ (1/d)

Where:

Y = body weight at a particular age, X= age in weeks, a=asymptotic weight, b=scale parameter related to initial weight, c=intrinsic growth rate and d=shape parameter

RESULTS AND DISCUSSION

Table 1 shows parameter estimates of growth curve models as affected by sex, season and year of indigenous normal feathered chickens. The overall means for the growth model parameters were 1449.49, 1197.81 and 1445.73 for "a" parameter of Gompertz, Logistic and Richards, respectively. The corresponding values for "b" and "k" were 1.35, 2.83, -3.34 and 0.09, 0.19, 0.10 while additional "d" parameter for Richard averaged 0.009. The mean coefficients of determination (R^2) were 0.61, 0.73, and 0.44 for Gompertz, Logistic and Richard function, respectively. These values are close to those reported by Adenaike *et al*. (2017) for Marshall broiler and Naked neck chickens. Raji *et al*. (2014) reported that the differences were observed in asymptotic weight are directly related to genotype and environment. Based on the coefficient of determination (R^2) values, Logistic model (R^2=73%) had the best fit for growth curve of indigenous normal feathered chickens followed by Gompertz (R^2=61%) and the least was Richard (R^2=44%). Rhido *et al*. (2021) recorded the same high R^2 value of 0.99 value for both Gompertz and Logistic functions in Nigerian indigenous normal feathered chickens. In related study, Mata-Estrada *et al*. (2019) reported similar high R^2 for males and females in Gompertz (0.9412, 0.9374), Logistic (0.9311, 0.9305) and Richards (0.9415, 0.9382) in Mexican native chickens; an indication that prediction efficiency of models was not affected by sex. Similarly, Aggrey (2002) hardly discovered differences in the efficiency of R^2 for Richard, Gompertz and Logistic function because of their higher R^2 values

recorded as 0.98, 0.97 and 0.96, respectively, in Athens-Canadian chickens.

The analysis of the growth curve revealed that, generally, males had significantly (P<0.05) higher matured weights than females. Dry cold had the highest asymptotic weight (1627.02) among the three seasons (with least recorded for wet season), while year one had the higher (1558.50) value compared with year two (928.02). The trend of the seasonal and year effects for matured weight parameter ("a") was similar to the observations made for effect of season and year on "b" and "k" parameters for the three models, though dry cold had the highest in Richard model. Males and females however had similar (P>0.05) "b" and "k" values in the three models. Aggrey (2002) also reported "a" parameter in males and females (2505.8; 1978.7), (2483.8; 1898.8), (2192.7; 1693.6) for Richards, Gompertz and Logistic function, respectively, in native Canadian chickens. In another study, Mata- Estrada *et al.* (2019) also reported higher "a" value in males than females for Gompertz (2683.1; 1839.1), Richard (2875.1; 2012.8), Von-Bertanlaffy (3011.3; 2011.6) and logistic function (2356.9; 1652.3) in Mexican native chickens. Similar observation was also made by Rhido *et al*. (2021). Seasonal and year effects on "a" parameter correspond with observation of Aliyu (2012), though the pattern of his observation differed among the models. In his report highest "a" value (3497.80) was recorded during dry cold season for monomolecular model and lowest (1190.40) in wet season for Logistic function.

Insignificant (P>0.05) sex effect on "b" values was observed in all the models, though season and year differences were observed. Dry cold had the highest values among the three models, and the least was recorded in Richard with negative values. Year one had the best value in all three models compared to year two. This is similar to the reports of Aliyu (2012) who observed significant (P<0.05) effects of season and year on "b" parameter.

Table 1: Least Square Means of Growth Curve Parameters of Gompertz, Logistic and Richard in Indigenous Normal Feathered Chickens as Affected by Sex, Season and Year

		Gompertz				Logistic				Richard				
		a	**b**	**k**	**R^2**	**a**	**b**	**k**	**R^2**	**a**	**b**	**k**	**d**	**R^2**
	OM	1449.49±16.79	1.35±0.0043	0.099±0.002	0.61	1197.81±17.83	2.83±0.005	0.19±0.002	0.73	1445.73±16.91	-3.34±0.026	0.10±0.002	0.009±0.0002	0.44
Sex	M	1464.03±20.72^{a}	1.35±0.0057^{a}	0.10±0.003 ^{a}		1212.26±22.33^{a}	2.83±0.0065^{a}	0.20±0.002^{a}		1460.65±20.85^{a}	-3.36±0.036^{a}	0.10±0.003^{a}	0.009±0.0003^{a}	
	F	1424.63±28.47^{b}	1.35±0.0066^{a}	0.099±0.003 ^{a}		1173.09±29.59^{b}	2.82±0.0075^{a}	0.19±0.002^{a}		1420.19±28.68^{b}	-3.32±0.04^{a}	0.10±0.003^{a}	0.009±0.0003^{a}	
Ss	W	1227.26±10.28^{c}	1.31±0.0010^{c}	0.091±0.001^{c}		970.66±8.20^{c}	2.79±0.0020^{c}	0.18±0.001^{c}		1221.56±10.21^{c}	-3.21±0.007^{a}	0.092±0.009^{b}	0.011±0.0001^{a}	
	DC	1627.02±16.34^{a}	1.41±0.0054^{a}	0.12±0.005^{a}		1420.80±15.47^{a}	2.89±0.010^{a}	0.22±0.002^{a}		1626.14±15.73^{a}	-3.60±0.06^{b}	0.012±0.005^{a}	0.008±0.001^{b}	
	DH	1480.04±14.86^{b}	1.32±0.0022^{b}	0.094±0.002^{b}		1191.26±12.07^{b}	2.80±0.0040^{b}	0.19±0.001^{b}		1475.31±15.19^{b}	-3.22±0.005^{a}	0.095±0.002^{b}	0.011±0.0001^{b}	
Yr	1	1558.50±13.51^{a}	1.37±0.0060^{a}	0.10±0.003^{a}		1311.10±15.72^{a}	2.85±0.0070^{a}	0.20±0.002^{a}		1555.79±13.55^{a}	-3.41±0.004^{a}	0.110±0.003^{a}	0.091±0.0003^{a}	
	2	1241.86±11.98^{b}	1.31±0.0010^{b}	0.09±0.001^{b}		982.01±9.34^{a}	2.79±0.0024^{b}	0.18±0.001^{b}		1236.08±11.90^{b}	-3.21±0.007^{b}	0.092±0.001^{b}	0.011±0.0001^{b}	
MSE		8594.90				8583.80				8643.00				
AIC		1111.20				1110.30				1111.60				

a = Asymptotic Weight, b = Integration constant, k = Relative growth rate and d = Shape parameters, R^2 = Coefficient of determination, W = Wet, DC = Dry cold, DH = Dry hot, OM = Overall mean, F = female, M = Male, Ss = Season, YR = Year 1: 2018, 2: 2019, MSE=Mean squared error, AICs=Akaike's information criterion.$^{a, b, c}$ Means with different superscripts with sub-columns differed significantly (P<0.05)

Table 2 shows actual and predicted body weights of indigenous normal feathered chicken at different ages using Gompertz, Logistic and Richard function and their prediction errors. With the lowest errors of prediction at all ages, Logistic had the best prediction followed by Gompertz model because of their positive residual values. Richard had the poorest prediction weight due to its association with large errors compared with the other models. However, with the lowest residual values recorded for Gompertz by Segul and Kiraz (2005) and Iyiola *et al*. (2017) both concluded that Gompertz was the best for predicting body weight in normal feathered chickens. The same pattern of efficiency for three models had also been reported by Aliyu (2012) for the three models. In this study, logistic function best described growth pattern in indigenous normal feathered chickens in terms of higher R^2, and relatively lowest residual values. Richard was the poorest model.

Table 2: Actual and Predicted Weights of Indigenous Normal Feathered Chickens at different ages

Age (Weeks)	Actual (BW)	Gompertz Computed	Residual	Logistic Computed	Residual	Richard Computed	Residual
4	90.20	98.28	-8.08	134.21	-44.01	1412.18	-1321.98
8	291.56	221.71	69.85	254.52	37.04	1423.07	-1138.51
12	506.81	391.12	115.69	438.24	68.57	1430.46	-923.65
16	687.22	581.17	106.05	661.56	25.66	1435.46	-748.24
20	866.78	766.12	100.66	868.56	-1.78	1438.83	-572.05
24	1060.99	929.00	131.99	1017.43	43.56	1441.10	-380.11

CONCLUSION

This study showed that based on the criteria used for comparing these models in indigenous normal feathered chickens, it could be established that the Logistic model gave the best fit for the description of growth pattern in indigenous normal feathered chickens, although Gompertz function was equally good in growth description pattern in these chickens. Richard model had the poorest fit.

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INFLUENCE OF ENVIRONMENTAL ENRICHMENT AND OUTDOOR ACCESS ON PERFORMANCE, CARCASS AND BLOOD PROFILE OF NOILER BIRDS

Jibia, Z.S., Garba, M.G., Aruwayo, A., & Gaddafi, S.
Department of Animal Science, Federal University Dutsin-Ma, Katsina State, Nigeria
*corresponding author: zsaminu336@gmail.com: GSM: +234(0)8034666471

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ABSTRACT

A total of 250-day-old Noiler chicks was procured from Chi hatchery, Ibadan. The birds were brooded in an indoor floor pen. At the end of the brooding period, four treatment group were made, consisting of fifty-five (55) birds per treatment. Each treatment was replicated into 5 with 11 birds per replicate, in a completely randomized design (CRD). Treatment one: deep litter (DL), trepatment two: Deep litter and environmental enrichment (DL+EE), treatment three: Deep litter and outdoor access (DL+OD) and treatment four: deep litter, outdoor access and environmental enrichment (DL+OD+EE). Data collected were analysed using analysis of variance (ANOVA) of statistical analysis system (SAS) and treatment means were separated using Duncan Multiple Range Test. The growth performance result revealed that birds raised in DL+OD+EE group had significantly ($P<0.05$) outstanding growth performance. Carcass characteristics profile showed that birds in DL+OD+EE followed by DL+OD had significantly ($p<0.05$) better carcass and visceral profile. The haematological profile showed that birds in DL+OD+EE group had significantly ($P<0.05$) higher haemoglobin concentration while DL group have significantly ($P<0.05$) higher monocytes and lymphocytes. With the exception ($P<0.05$) of albumin and aminotransferase all other serum biochemical profile were not significant ($P>0.05$) differences. It could be concluded that: Birds raised on DL+OD+EE had the best growth performance and carcass characteristics. Enrichment and outdoor access enhances haemoglobin concentration, reduces monocytes and lymphocytes thereby regulating the serum biochemical profile of Noiler birds.

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INTRODUCTION

Poultry welfare problems has however, been identified as one of the major barriers to enable maximum performance and productivity, hence these will eventually have deleterious effect in the final product and reduce the profit earning by the poultry farmers (Jibia *et al.,* 2023). Animal welfare concerns the state of an animal relative to the environment in which it lives. In recent times,
animal welfare as a term, has arisen in society to express ethical concerns about the quality of life experienced by animals, particularly animals that are used in production agriculture. The term is therefore not one that necessarily expresses a scientific concept, nevertheless, because scientific methods are used to identify, interpret and implement societal concerns about animal quality of life issues, animal welfare has become established as a scientific field (Duncan, 2004).

Thus, animal welfare has now become measurable characteristics of an animal at a particular time or during a period (Grandin, 2015). Still animal welfare remains a complex and emotional topic which is difficult to define and assess. For example, the housing, handling, loading, transporting and unloading of animals can have very substantial effects on their welfare and meat quality, which may be given different interpretations by different stakeholders.

The scientific assessment of animal welfare involves measurements that capture different viewpoints on what constitute a good quality of life for animals. Development of scientific disciplines relevant to animal welfare has a long history and has been summed to include animal husbandry, animal science, veterinary medicine and behavioural science, which contribute to the understanding of welfare problems of animals (Grandin, 2015). Environmental enrichment and outdoor access by poultry have been a subject of study by researchers. Environmental enrichment describes the provision of physical and social opportunities to promote chickens behaviour that is important, valuable and specific to them. It encourages and allows chickens to do things that matter to them, resulting in positive experiences based on their individual interests, which underpins good animal welfare. Jacobs et al. (2023) reported that providing environmental enrichments that increases environmental complexity can benefit poultry welfare. Outdoor access to provide access to a covered veranda or an outdoor area where a wider range of elements, such

as natural weather conditions (including sunlight), vegetation, different flooring materials, and insects, in addition to more space may stimulate active spacies-specific behaviour. It has proven to be of immense benefit on the welfare and productivity of poultry. This study will therefore explore the effect of environmental enrichment and outdoor access on performance and welfare of dual purpose chickens.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at Poultry Unit of Professor Lawal Abdul Saulawa Livestock Teaching and Research Farm, Department of Animal Science, Federal University Dutsin-Ma, Katsina State, Nigeria. Dutsin-Ma LGA lies on latitude 12°26'N and longitude 07°29'E while the farm site lies between latitude 12°27'18' North and 7°29'29' East and 605 meters above sea level with an average rainfall of 700mm within the Sudan Savannah zone Rainfall is between May and September with a peak in August. The mean annual temperature ranges from 29°C – 31°C. The highest air temperature normally occurs in April/May and the lowest in December through February (Gaddafi *et al.,* 2019).

Experimental design and treatments

The experimental birds were laid in a completely randomized design (CRD). The following treatment:
Treatment one – Deep litter without outdoor access (DL)
Treatment two – Deep litter and environmental enrichment (DL+EE)
Treatment three – Deep litter and outdoor access (DL+OD)
Treatment four – Deep litter, outdoor access and environmental enrichment (DP+OD+EE)

Experimental birds and their Management

A total of 250-day-old Noiler chicks was procured from reputable hatchery, Ibadan. The birds were brooded in an indoor floor pen. At the end of the brooding period, fifty-five (55) birds were assigned to each of the treatments above. Each treatment was having 5 replicates of 11 birds each. The deep litter (DL) group were reared indoors on concrete floors without access to outdoors while the other groups were in indoor pens that was open onto separate yards, which were surrounded by net fencing. The outdoor portion was 2 x 20m^2. The birds were fed on commercial diets throughout the study.

Data collection

Growth Performance

Feed intake

A given quantity of feed was measured and fed to the experimental birds on a weekly basis. Weekly feed intake was measured. Daily feed intake and total feed intake were determined. Daily feed intake was calculated by subtracting the leftover of the feed from the daily feed intake

Live weight gain

The experimental birds were weighed before allotting them treatments to get the initial weight.. They were then be weighed weekly early in the morning before being offered feed and water using a weighing balance throughout the experimental period. Total weight gain and daily weight was calculated.
Body weight gain = final body weight – initial body weight.
Average daily weight gain = total weight gain / no of days of experiment

Feed conversion ratio

Feed conversion ratio (FCR) was derived mathematically as the ratio of feed consumed to weight gain as shown in the following equation:

$$\text{Feed conversion ratio} = \frac{\text{Feed intake (g)}}{\text{Body weight gain (g)}}$$

Carcass Characteristics

At end of this study five (5) birds from each treatment were randomly selected and slaughtered by cervical dislocation through the severing of Jugular vein (Halal method), the carcass was singed, eviscerated and cut into various parts. Each body parts were weighed using digital weighing scale and recorded accordingly.

Haematological and Serum Biochemical Parameters Determination

Blood was collected at the point of lay (19 weeks post trail) by using sterile syringe and needle using jugular venepuncture of five Noiler Pullets per treatment after overnight fasting and was put into well labelled blood collection bottles, which contained ethylene diamine tetraacetic acid (EDTA). The blood samples was put in an ice pack and transported to the haematology laboratory for determination of haematological parameters which includes are packed cell volume (PCV) haemoglobin content, white blood cells, red blood cells, neutrophils, lymphocytes, eosinophil, monocytes and basophils were determined by the procedure outlined by Decie and Lewis (2001) while the mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH) and mean corpuscular Volume (MCV) will computed using appropriate formulae (Olaniyi *et al.,* 2012).
MCV, MCH and MCHC will be calculated as follows:

$$\text{Mean corpuscular volume (MCV)} = \frac{Packed\ cell\ volume}{Red\ blood\ cell} x10$$

$$\text{Mean corpuscular haemoglobin (MCH)} = \frac{Haemoglobin}{Red\ blood\ cell} x\ 10$$

$$\text{Mean corpuscular haemoglobin concentration (MCHC)} = \frac{Haemoglobin}{Packed\ cell\ volume} x100$$

Serum biochemical determination

Blood and serum samples was collected at the point of lay of Noiler pullets (19 weeks) by using sterile syringe and needle using jugular venepuncture of five overnight fasted Noiler Pullet from each treatment. 5 ml of blood was collected into labelled sterile sample bottles without anticoagulant and was used for the serum biochemical analysis. The sample was centrifuged at 3000 rpm for 15 minutes. Separated serums were stored frozen at -20ºC in sample bottles without anticoagulant until the time of analysis. The serum biochemical indices to be determined were serum albumin, globulin, total protein, alkaline phosphate (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST).

RESULT AND DISCUSSION

Influence of Environmental Enrichment and Outdoor Access on Growth Performance Dual Purpose Chickens

Table 1 present growth performance of dual-purpose chickens raised on deep litter, environmental enrichment and outdoor access. The result showed no significant (P>0.05) differences of initial weight this signifies body weight balance and homogenous allocation of birds into different treatment groups. The result revealed that there were significant (P<0.05) differences in the final weight where birds in deep litter + outdoor + environmental enrichment group (DL+OD+EE) had significantly higher final weight (2.476kg) followed by deep litter (DL) with 2.300kg, deep litter + outdoor (DL+OD) with 2.300kg while deep litter + environmental enrichment (DL+EE) had the lowest final weight of 2.117kg in this study. The increases in final weight in birds raised on DL+OD+EE could be linked to the increase in welfare and outdoor accessibility compared to deep litter group. This could be supported by findings of Jones *et al.* (2020) who states that environmental enrichment, such as providing perches, litter materials and foraging opportunities, enhance the growth performance of poultry.

Environmental enrichment and outdoor accessibility in this study greatly and significantly (P<0.05) influences the weight gain of dual-purpose birds in this study. DL+OD+EE had the highest weight gain of 1.663kg followed by birds in DL+OD (1.493kg), DL (1.483kg) while lower weight gain (1.310kg) were recorded in birds raised on DL+EE. This collaborates with the findings of Jones *et al.* (2020) that broilers reared in enriched environments with access to perches and pecking objects showed a 5 - 10% improvement in weight gain compared to those in barren environment.

The result follows a similar trend (P<0.05) on average daily weight gain (ADWG) in which DL+OD+EE had the highest ADWG values of 21.56g/day followed by 20.30, 20.13 and 17.58g/day for DL, DL+OD and DL+EE respectively.

The result revealed that there were no significant (P>0.05) differences of total feed intake in this study. however, DL group have demonstrated higher numerical values in feed intake which could be likely attributed to enclosure nature of the group since they spend time mostly in feed and water intake while other groups have accessibility to either outdoor or enrichment thus will prevent birds to concentrate and consumed more feed. Feed conversion ratio is an important attribute in measuring animal performance and revealed significant (P<0.05) differences in this study. Birds raised on DL+OD+EE had the best FCR values of 2.699 followed by birds in DL+OD while birds in DL+EE had poor FCR with highest value in this study (3.435). this study validates the findings of Ribers *et al.* (2017) who found that broilers with access to enrichment devices (e.g hanging, toys, pecking objects) had a 3 -5% improvement in FCR compared to control group.

Table 1: Influence of environmental enrichment and outdoor access on growth performance dual purpose chickens

Parameters	DL	DL+EE	DL+OD	DL+OD+EE	SEM	LOS
IW (kg/bird)	0.817	0.820	0.807	0.813	0.043	NS
FW (kg/bird)	2.300^{b}	2.117^{c}	2.300^{b}	2.476^{a}	0.052	*
WG (kg)	1.483^{a}	1.310^{b}	1.493^{a}	1.663^{a}	0.037	*
ADWG (g)	20.30^{a}	17.58^{b}	20.13^{ab}	21.56^{a}	0.487	*
TFI (kg/bird)	4.625	4.500	4.490	4.490	0.059	NS
FCR	3.118^{ab}	3.435^{a}	3.007^{ab}	2.699^{b}	0.123	*

DL = Deep litter, DL+ EE = Deep litter and environmental enrichment, DL+OD = Deep litter and outdoor, DL+OD+EE = Deep litter, outdoor and environmental enrichment, IW = Initial weight, FW = Final weight, WG = Weight gain, ADWG = Average daily weight gain, TFI = Total feed intake, FCR = Feed conversion ratio, SEM = Standard error mean, LOS = Level of significance

Influence of Environmental Enrichment and Outdoor Access on Carcass Characteristics of Dual-Purpose Chickens

The carcass characteristics response of dual-purpose chickens raised using environmental enrichment and outdoor access were presented in table 2 below. The result showed no significant (P>0.05) differences in the live body weight irrespective of environmental enrichment or outdoor accessibility compared to control group. Dressing weight is an important attribute of carcass quality characteristics that revealed the actual carcass weight after bleeding loss and feather removal. Carcass weight showed no significant (P>0.05) differences however, slight numerical variation exist between treatment groups were T4 (Deeplitter + outdoor + environmental enrichment) had slightly highest (2.333kg) carcass weight followed by DL and DL+OD with similar carcass weight of 2.217kg each while lower carcass weight was recorded in DL+EE (Deeplitter + environmental enrichment group) with 2.000kg.

Back weight showed significant (P<0.05) differences were birds raised in DL+OD+EE had the highest back weight (486.7g) followed by DL (463.3g), DL+EE (380.70g) and DL+OD (307.3g) with a lowest back weight. Chest weight is an important carcass attributes and considered as a prime cut in poultry. Considerable and significant (P<0.05) differences were recorded in this study in which 593.0g was highest chest weight obtained in DL+OD+EE, while 441.0g, 437.1g and 381.7g are the chest weight for DL+OD, DL and DL+EE respectively. The result further revealed significant (P<0.05) differences in thigh weight.

Significantly (P<0.05) higher thigh weights were recorded in DL+OD+EE (320.3g) followed by DL+OD (247.0g), DL (226.3g) and DL+EE (211.0g). The higher thigh weight observed in this study could be linked with the availability foraging materials (insects, grasses and inorganic substances from soil) during outdoor access that provides additional protein, vitamins and minerals which will eventually promote development and growth of muscular tissue. Zhan *et al.* (2006) reported that higher levels of amino acids and vitamins optimizes thigh and breast meat yield. Therefore, the slaughter yield chest, thigh and back observed in DL+OD+EE group could be attributed to a possible best synergistic interactive effect of experimental diet and foraging materials obtained by birds during outdoor access. This support the findings of Jibia *et al* (2022); Obinne and Mnereola (2010) that slaughter yield could be influenced by nutrition especially dietary protein and energy that may be obtained from foraging. Similarly, this study further supports the findings of Jibia *et al.* (2022) that the increases in dressing weight could be linked to the increase in welfare and foraging accessibility of birds which enables birds to picks variety of materials from soil, insect, grasses and other edible materials in one way might contain proportion of vitamins and minerals that play vital role in nutrient utilization and ultimately growth performance.

There were no significant (P<0.05) differences in drumstick, wing, neck and head weight of dual-purpose chicken in this study. however, leg weight of birds raised in deep litter + outdoor + environmental enrichment (DL+OD+EE) was statistically (P<0.05) higher with 81.67g followed by DL+OD (69.00g) while DL and DL+EE had similar numerical values of leg weight (59.33g) in the current study.

Table 2: Influence of Environmental Enrichment and Outdoor Access on Carcass Characteristics of Dual-Purpose Chickens

Parameters	DL	DL+EE	DL+OD	DL+OD+EE	SEM	LOS
Live Weight (Kg)	2.300	2.100	2.300	2.467	0.179	NS
Carcass Weight (Kg)	2.217	2.000	2.217	2.333	0.180	NS
Back (g)	463.300^{a}	380.700^{ab}	307.300^{b}	486.700^{a}	61.400	*
Chest (g)	437.100^{b}	381.700^{c}	441.000^{b}	593.000^{a}	37.100	*
Thigh (g)	226.300^{bc}	211.000^{c}	247.000^{b}	320.300^{a}	12.630	*
Drumstick (g)	212.000	190.300	219.300	242.300	22.210	NS
Wing (g)	171.700	158.300	172.700	195.000	14.920	NS
Neck (g)	116.000	102.700	107.300	142.300	24.050	NS
Head (g)	51.000	47.670	54.330	55.330	3.140	NS
Leg (g)	59.330^{a}	59.330^{a}	69.000^{a}	81.6700^{a}	2.309	*

DL = Deep litter, DL+ EE = Deep litter and environmental enrichment, DL+OD = Deep litter and outdoor, DL+OD+EE = Deep litter, outdoor and environmental enrichment, SEM = Standard error mean, LOS = Level of significance

Influence of Environmental Enrichment and Outdoor Access on Visceral organ weight of Dual-Purpose Chickens

The result on the influence of environmental enrichment and outdoor access on visceral organ weight of dual-purpose chicken were presented in

Table 3. There was no significant (P>0.05) differences in liver tissue weight were recorded in this study. The liver weight values in this study collaborates that of Manal *et al.* (2004) who reported that there were no hyperthrophy in the birds raised in a similar study.

The result shows that there were significant (P<0.05) differences in heart, lungs, intestine, crop and proventriculus weight. Intestine is the major organ for nutrient digestion and absorption by squeezing the feed particles through peristalsis movement and rhythmity and digesta will be observed through the intestinal villi. The result revealed significant (P<0.05) differences in intestinal weight.

Gizzard is an important digestive organ that play a mechanical role of feed breaking down to a smaller particle size with the aid of stones, grits and muscular tissue. No significant (P>0.05) differences were recorded in gizzard weight. Bile and gallbladder were not significantly (P>0.05) difference in this study.

Table 3: Influence of Environmental Enrichment and Outdoor Access on Visceral organ weight of Dual-Purpose Chickens

Parameters	DL	DL+EE	DL+OD	DL+OD+EE	SEM	LOS
Liver (g)	44.33	40.00	50.33	51.67	4.93	NS
Heart (g)	7.333^{b}	9.333^{a}	9.333^{a}	9.333^{a}	0.745	*
Lung (g)	8.333^{ab}	7.333^{b}	8.000^{ab}	9.333^{a}	0.589	*
Intestine (g)	105.3^{ab}	96.0^{b}	121.7^{a}	116.0^{ab}	10.12	*
Crop (g)	10.67^{b}	17.67^{a}	17.67^{a}	17.33^{a}	0.471	*
Gizzard (g)	58.33	60.33	66.33	64.00	3.87	NS
Proventricolus (g)	11.67^{bc}	9.00^{c}	15.67^{a}	13.67^{ab}	1.291	*
Bile (g)	3.000	2.333	2.333	3.067	0.337	NS
Gallbladder (g)	2.067	1.733	2.833	2.100	0.497	NS

DL = Deep litter, DL+ EE = Deep litter and environmental enrichment, DL+OD = Deep litter and outdoor, DL+OD+EE = Deep litter, outdoor and environmental enrichment, SEM = Standard error mean, LOS = Level of significance

Influence of environmental enrichment and outdoor access on haematological profile of dual-purpose chickens

Analysis of haematological profile of the experimental animals is very important; since it is related to health status and are of diagnostic importance in clinical evaluation of the state of health. It also serves as indicator of physiological, pathological and nutritional status of an animal (Okoruwa and Ihimioya, 2014).

The haematological profile of dual-purpose chickens subjected to environmental enrichment and outdoor access is presented in table 4. Despite numerical variations across the treatment groups, the result showed that there were no significant (P>0.05) differences in red blood cell (RBC), packed cell volume (PCV), Mean corpuscular volume (MCV), Mean corpuscular

RBC level and haemoglobin are used to determine and classify anaemia (Jain, 1986). High PCV values indicate either an increase in the number of circulating RBC or reduction in circulating plasma volume (Kopp and Hetesa, 2000) it also provides additional information nutritional status of animal (Adejumo, 2004). The result revealed that there were significant (P<0.05) differences in haemoglobin (Hb) where DL+OD+EE had the highest Hb values (12.36g/dl) followed by DL+OD (12.26g/dl) while birds reared in deep litter had the lowest Hb value (11.35g/dl). Hb has the physiological function of transporting oxygen to tissue of the animal for oxidation of ingested food so as to release energy for the other body functions as well as transport carbon dioxide out of the body of animals (Soetan *et al.,* 2013). The significantly (P<0.05) higher Hb observed in a group that have outdoor accessibility may be as a result good oxygen inhalation from the surrounding environment. This implies that increased Hb level with outdoor accessibility in this study would enhance perfusion rate in the animal tissue and adequate removal of carbon dioxide with improve animal health and production. Studies have reported that broilers with outdoor access had higher hemoglobin levels compared to those kept indoors, suggesting enhanced oxygen carrying capacity (Urtecho-Novelo *et al.,* 2021).

The major function of white blood cells (WBCs) and other differential counts is to defend the body by phagocytosis against invasion by foreign organisms and to produce, transport and distribute antibodies in immune response (Etim *et al.,* 2014). Animals with high WBC and leucocytes counts are capable of generating high volume of antibodies during phagocytosis and have high degree of resistance to disease (Soeten, *et al.,* 2013) and enhance adaptability to local environment (Kabir *et al.,* 2011; Isaac *et al.,* 2013). The result showed that there were no significant (P>0.05) differences in WBC. Despite non-significant (P>0.05) differences birds raised in

DL demonstrated high level of WBC which may be attributed to the management system (intensive-deep litter) which makes the birds face challenges from microbial load in the litter compared to other groups that have minimal contamination level with litter materials due to perches or outdoor accessibility.

The differential count has a specific role in the immune response to different pathological conditions. It helps to evaluate body`s immune response to infections, inflammations, allergies, bone marrow disorders and monitoring treatment response (AACC, 2023). The result showed that there were significant ($P<0.05$) differences in monocytes and lymphocytes. Birds in DL had significantly ($P<0.05$) higher monocytes and lymphocytes 3.843% and 58.09% respectively, while DL+OD+EE have demonstrated low monocytes and lymphocytes values of 2.067% and 52.63% respectively.

The result showed that there were no significant ($P>0.05$) differences in heterophils, eosinophils and basophil in this study.

Table 4: Influence of environmental enrichment and outdoor access on haematological profile of dual-purpose chickens

Parameters	DL	DL+EE	DL+OD	DL+OD+EE	SEM	LOS
RBC ($x10^2$/l)	2.267	2.197	2.254	2.467	0.115	NS
PCV (%)	31.11	32.43	31.89	34.02	1.394	NS
Hb (g/dl)	11.35^{b}	12.09^{ab}	12.26^{a}	12.36^{a}	0.367	*
MCV (fl)	133.8	132.9	133.6	145.5	7.81	NS
MCHC (g/dl)	49.64	48.28	51.53	52.47	4.80	NS
MCH (pg)	66.03	65.96	64.87	66.07	2.016	NS
WBC ($x10^9$/l)	65.49	61.65	62.17	61.91	6.08	NS
Monocytes	3.843	2.233^{b}	3.093^{ab}	2.067^{b}	0.624	*
Lymphocytes (%)	58.09^{a}	53.93^{ab}	57.51^{ab}	52.63^{b}	2.104	*
Heterophils (%)	35.67	40.92	37.69	42.47	3.11	NS
Eosinophils (%)	1.887	1.527	1.293	1.170	0.778	NS
Basophils (%)	0.300	0.400	0.600	0.667	0.542	NS

DL = Deep litter, DL+ EE = Deep litter and environmental enrichment, DL+OD = Deep litter and outdoor, DL+OD+EE = Deep litter, outdoor and environmental enrichment, SEM = Standard error mean, LOS = Level of significance, RBC = Red blood cell, PCV = Packed cell volume, Hb = Haemoglobin, MCV = Mean cell volume,
MCHC = Mean corpuscular haemoglobin concentration, MCH = Mean corpuscular haemoglobin WBC = White blood cell

Influence of Environmental Enrichment and Outdoor Access on Serum Biochemistry of Dual-Purpose Chickens

The serum biochemical profile of Noiler birds raised on different environmental enrichment and outdoor access were presented in table 5 below. The result revealed that were no significant ($P>0.05$) differences in total protein. The total protein obtained in this study are slightly higher than total protein ranges of Noiler birds reported by Egna *et al.* (2014) who reported that Noiler birds had TP ranges 3.5 – 5.5 g/dl. Total protein reflect nutritional status and liver function of the birds while low total protein (hypoproteinemia) may indicate malnutrition and liver dysfunction.

Albumin is a major protein synthesized in the liver. It play a critical role in maintaining osmotic pressure and transporting hormones, fatty acids and drugs. The result in this study indicates that there were significant ($P<0.05$) differences in albumin. DL+OD+EE had the higher plasma albumin (3.497g/dl) followed DL+OD (3.190g/dl) while low albumin values were recorded in DL (2.817g/dl). Globulin are involved in immune response and are produced by liver and immune cells. The globulin result in this study showed non-significant ($P>0.05$) differences.

Alkaline phosphatase in this study are fall within the alkaline phosphatase of Noiler birds reported by Oke *et al.* (2016) and Adeyemo and Longe (2008) who reported that Noiler bird had alp ranges from 50 – 200u/l. alkaline phosphatase is associated with bone metabolism and liver functions. Elevated levels may indicates bone growth or liver damage. Therefore the alp values in this study are within the acceptable levels of healthy birds.

Alanine aminotransferase and aspartate aminotransferase are liver function enzymes. Alt and AST elevated levels may indicate hepatocellular damage. The result showed that DL+OD group had significantly ($p<0.05$) higher AST. The AST values obtained in this study are similar to the AST values reported by Adeyemo and Longe (2008) and Egna *et al*. (2014) of Noiler birds (50 – 150u/l).

The result revealed that housing enrichment and outdoor access in this study had no significant ($p>0.05$) effect on plasma electrolytes (sodium,

potassium, chloride). Electrolytes are essential for maintaining fluid balance and nerve functions.

CONCLUSION

It could be concluded that: Birds raised on DL+OD+EE had the best growth performance and carcass characteristics. Enrichment and outdoor access enhances haemoglobin concentration, reduces monocytes and lymphocytes thereby regulation of serum biochemical profile of Noiler birds.

RECOMMENDATION

It could be recommended that farmers should improve poultry housing with enrichment and outdoor accessibility for best performance and normal blood profile.

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EFFECT OF HYDROPONIC RICE FODDER SUPPLEMENTED DIETS ON GROWTH PERFORMANCE, NUTRIENT DIGESTIBILITY AND RUMEN ECOLOGY OF RED SOKOTO BUCKS

Garba, M.G., Nura I., Gaddafi, S. and Yusuf, A.

Department of Animal Science, Federal University Dutsin-Ma, Katsina State, Nigeria.

Correspondent author Phone: +2347068701315 Email: idrisnura064@gmail.com

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Hydroponic, rice, fodder, performance, bucks

Abstract

This study assessed the effect of hydroponic rice fodder supplemented diets on growth performance, nutrient digestibility and rumen ecology of Red Sokoto bucks. A total number of sixteen (16) Red Sokoto bucks of average of 10kg were randomly allocated into four treatments comprising four (4) replicates in a Completely Randomized Design (CRD). The Animals were given basal diets with hydroponic fodder supplement at 0g, 250,500g, and 750g per kg diets for T1, T2, T3 and T4 respectively. The feeding trial lasted for 84days after which two bucks were randomly selected from each treatment and allocated to metabolic cage for faecal and urine sample collection. Animal was allowed to acclimatize with the cage for seven days followed by feeding trial where faecal sample was collected daily and weigh. The urine sample was collected in a jarcan containing 10% concentrated sulphuric acid to prevent bacterial microbial activities and urine ammonia and nitrogen escape. Rumen fluid were collected using stomach tube for volatile fatty acids and rumen microbes' determination. Data obtained were subjected to analysis of variance (ANOVA) and the treatment means were separated using Duncan multiple range test. The growth performance result revealed comparable weight gain across the treatments. The result further revealed significant ($P<0.05$) differences in nutrient digestibility. There were significant ($p<0.05$) differences in all rumen ecological parameters. It could be concluded that Supplementation of hydroponic rice fodder in the diets of goats is of immense benefits. It is therefore recommended hydroponic rice fodder can be to goats from 250g to 750g improved performance.

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INTRODUCTION

Feeds and animal nutrition presents a major sector in providing food security. However, there is a large gap between feed supply and demand (Akkenapally and Lekkala, 2021). This gap can be attributed basically to climatic changes, urbanization and increase in meat demand. Nowadays, especially after the covid-19 pandemic, there is a crucial problem in supplying fresh green feed to remote and urban regions. The main problem of feed scarcity emanates from land scarcity; actually, rapid urbanization is the major cause behind the decrease in land meant for grazing and fodder cultivation. With Water, labor shortage and elevated cost of fertilizers the farmer leans to cultivate commercial food crops over green fodder (Shit, *2019*). Fodder production cannot easily be increased due mainly to ever increasing human pressure on land for production of cereal grains, oil seeds and pulses.

To meet the increasing demand for green fodder, one of the alternatives is hydroponic fodder production to supplement the meager pasture resources (Bakshi *et al*., 2017). Hydroponic fodder is a type of feed produced by germinating seeds without using soil. Hydroponic fodder is an exciting and unique way of growing young, tender grass grown from cereal grain. The major limitations of the conventional method of fodder cultivations are overcome by the hydroponics technology. Less land is required as the vertical growing process allows the production of large volume of hydroponics fodder on a fraction of the area required by conventional cultivation and thus there is high yield in small area with increase in stocking capacity (Garba *et al.,* 2023). Under hydroponics technology, about 600 kg

hydroponic fodder can be produced daily in seven days only in 50 sq. m. area. It is estimated that to produce the same amount of fodder, about 1 ha land is required. The water requirement in hydroponics technology is very less as water can be applied and reapplied continuously. To produce one kg of fresh hydroponics fodder (7-day) about 1.5 litre (if water is reused) to 3 (if water is not reused) liters of water is required (Naik *et al.,* 2013) against about 30 liters of water per kg of fresh green fodder grown in laterite soil under conventional practices. Only one person is sufficient to work in the hydroponics system to produce 600 kg hydroponic fodder daily. The study investigated the effect of feeding hydroponic rice fodder on performance, nutrient digestibility and rumen ecology of Red Sokoto bucks.

MATERIALS AND METHOD

Experimental site:

The experiment was conducted at Professor Abdu Lawal Saulawa Livestock Teaching and Research Farm, Department of Animal Science, Federal University Dutsin-Ma, Katsina State. The Farm is situated within the latitude 12°27'18' North and 7°29'29' East and 605 meters above sea level with an annual average rainfall of 700mm and situated in the Northern Sudan Savannah zone (Gaddafi, 2019).

Preparation of hydroponics fodder

The rice seeds were procured from reputable source in Dutsin-Ma. 500g of the seeds were soaked for 24 hours in 2 liters of water after which they were sieved and spread in a hydroponic aluminum tray and covered with foiling paper to incubate for 48 hours. After that, the foiling paper was removed, and the tray was taken to the hydroponic chamber. The fodder was harvested after seven (7) days.

Sourcing of Experimental Animal

A total number of sixteen (16) Red Sokoto bucks were sourced from Dutsin-Ma. They were quarantined for two (2) weeks during which they were given prophylactic treatment with Oxytetracycline (intramuscularly at 1 ml per 10 kg body weight. They were treated with levamisole and Ivermectin against internal and external parasites. They fed with groundnut haulm, cotton seed cake, rice milling, salt and bone meal throughout the quarantine period. Water was offered them *ad libitum*.

Experimental animals and design

The experimental animals of average weight of 20kg and within the same age of six months were randomly allocated into four treatments comprising four (4) replicates in a Completely Randomized Design (CRD). The animals were given basal diets with hydroponic fodder supplement at 0g, 250,500g, and 750g per kg diets for T1, T2, T3 and T4 respectively.

Data Collection

Growth Performance:

Growth performance of Red Sokoto bucks fed with hydroponic fodder supplemented diets were evaluated. The initial weight of the bucks was taken on the date of commencement of the experiment while the final weight was measured at 84th days of the feeding trial. The parameters are determined as follows:

Weight gain (kg) = Final Weight-Initial Weight

Feed Intake= Feed given to the animal-left over (Ort)

$$\text{Feed conversion ratio} = \frac{\text{Feed intake}}{\text{Weight gain}}$$

Nutrient Digestibility

Two bucks were randomly selected from each treatment and allocated into metabolic cages for faecal and urine sample collection. They were allowed to acclimatize with the cage for fourteen (14) days followed by seven (7) days period of faecal sample collection. The faecal samples were bulked, weighed and representative sample taken for proximate composition and crude fibre analysis by AOAC (2005) and Van Soest (1987).

Rumen ecology

The rumen liquor was collected using stomach tube and vacuum pump. The tube was inserted into rumen and pump to obtained rumen fluid. The fluid was put in a sample bottle and taken to laboratory for rumen VFA determination. The sample was filtered with four-layer cheese cloth and subsamples was divided into two portions. The 1st portion for total volatile fatty acid (VFA3000) and the proportions of acetate, propionate and butyrate. The samples were centrifuged at x g for 10 min; they were allowed to settle and decanted. The decant were titrated with 0.1M of sodium hydroxide (4/1000gml H2O) solution each with 2-3 drops

of phenophtaline (1/100gml ethanol) as the indicator. Determination of the various fractions using the following formula:

i. Acetate = (Titre value x 0.1 x 0.06 x 100)/5
ii. Propionate = (Titre value x 0.1 x 0.04 x 100)/5
iii. Butyrate = (Titre value x 0.1 x 0.006 x 1000)/5
iv. Total volatile fatty acids (Titre value x 0.1 x 0.09 x 100)/5

The second portion of the rumen filtrate were used for microbial count and identification. 2ml of rumen liquor was subjected to microbial count were proteolytic bacteria, amylolytic bacteria, fungi Oozoorespores protozoa and total colliform bacteria counts would be analyzed. Protozoa count were obtained by direct observation using a microscope at 10 x magnification. Colony-forming units/ml (CFU/ml) of both bacterial and fungi was observed with the pour plate technique using nutrient algae (NA) and Potato dextrose agar (PDA) respectively. The plates were then incubated for 24 hours at 37ºC. All colonies appearing at the end of the incubation period was be counted using a digital illuminated colony counter. Colonies grown on nutrient agar plates was suspected to be either gram-positive or gram-negative; thus, all colonies found on each plate was used for gram staining. Colonies grown on the PDA was further incubated for three days after the first 24 hours to check for morphology and isolation of fungi. Physical characteristics of rumen liquor such as temperature, pH, colour and odour.

Data analysis

All data obtained in this study was subjected to analysis of variance (ANOVA) using the General Linear Model of SAS (2001). The means were separated using Duncan multiple range test (DMRT).

RESULT AND DISCUSSION

Effect of Hydroponic Rice Fodder on Growth Performance of Red Sokoto Bucks

Table 1 shows the effect of feeding graded levels diets supplemented with hydroponic fodder on the performance of Red Sokoto goats. There was no significant difference ($P>0.05$) in the initial and final body weight of the experimental animals. Weight gain were not significantly ($P>0.05$) influenced by the inclusion of hydroponic fodder in the diets of the animals. The total feed intake by the animals differed significantly ($P<0.05$) across the treatments with ranges of 25.21kg to 38.42kg. The feed conversion ratio showed significant difference ($P<0.05$) between T4 and other treatments. T1, T2 and T3 were not significantly different from each other. This shows that hydroponic rice fodder supplementations had a profound effect in improving live weight of Red Sokoto bucks. The findings of this study shows that feeding hydroponic to the experimental animals enhanced feed intake and weight gain. This is in accordance with the reports from several research that body weight gain in various livestock species, including goats are enhanced by hydroponics (Naik and Singh 2013; Rachel Jemimah *et al.* 2015; Shit (2019); Arif *et al.* 2023)

Table 1: Effect of hydroponic rice fodd`1qer on growth performance of red Sokoto bucks

PARAMETERS	T1	T2	T3	T4	SEM	LOS
IW(kg)	10.03^{a}	10.30^{a}	10.28^{a}	10.75^{a}	0.487	NS
FW	$11..07^{a}$	11.20^{a}	11.53^{a}	11.93^{a}	0.444	NS
WG(kg)	1.050^{a}	0.900^{a}	1.250^{a}	1.175^{a}	0.299	NS
ADWG(kg)	0.041^{a}	0.021^{ab}	0.020^{ab}	0.009^{b}	0.009	*
TFI(kg)	25.21^{b}	31.94^{ab}	31.59^{ab}	38.42^{a}	3.56	*
ADFI(g)	600.2^{b}	757.9^{ab}	773.1^{ab}	914.8^{a}	84.6	*
FCR	2.265^{b}	2.857^{b}	2.737^{ab}	3.235^{a}	0.325	*

IW = initial weight, FW = final weight, WG = weight gain, ADWG = average daily weight gain, TFI = total feed intake, ADFI = average daily feed intake, FCR = feed conversion ration

Effect of Hydroponic Rice Fodder Supplemented Diets on Nutrient Digestibility of Red Sokoto Bucks

The results of the effect of hydroponic rice fodder supplemented diets on nutrient digestibility of Red Sokoto bucks is presented in Table 2. The results clearly indicated that dry matter, ash, crude fiber, crude protein, ether extract and nitrogen free extract were all significantly (P<0.05) across the treatments. Increase in dry matter digestibility tend to increase growth rate and muscling. Hadded and Husein (2004) reported that improved DMD correlates with higher average daily gain in ram. From this study, T3 had the highest (P<0.05) dry matter and ash content. T1 had the highest value of crude fiber (4.55%) and ether extract (0.95%). Significantly higher (P<0.05) digestible crude protein ((9.91%) was recorded in T4. NFE (80.50%) was also significantly higher (P<0.05) in T4. The result of the research portrays that feeding hydroponic fodder to animals possess the potential of improving nutrient digestibility. Hydroponic maize fodder supplementation has been shown to improve nutrient digestibility, productive performance, and profitability in Tellicherry buck kids (Ebenezer *et al.* 2021; Jemimah *et al*. 2023).

Table 2: Effect of Hydroponic Rice Fodder Supplemented Diets on Nutrient Digestibility of Red Sokoto Bucks

Treatment	T1	T2	T3	T4	SEM	LOS
DM	89.55^{d}	90.47^{b}	91.12^{a}	90.37^{c}	0.009	*
Ash	5.275^{b}	5.285^{b}	6.175^{a}	4.875^{c}	0.007	*
Crude fiber	4.545^{a}	4.390^{c}	4.500^{c}	3.875^{d}	0.005	*
Crude protein	9.745^{b}	8.915^{c}	8.775^{d}	9.905^{a}	0.007	*
Ether extract	0.935^{a}	0.880^{b}	0.775^{d}	0.830^{c}	0.008	*
NFE	79.57^{c}	80.49 ^{a}	79.75^{b}	80.50^{a}	0.006	*

DM = Dry Matter, CP = Crude Protein, N = Nitrogen free extract

Effect of Hydroponic Rice Fodder on Rumen Ecology of Red Sokoto Bucks

The result of the effect of hydroponic rice fodder supplemented diets on rumen ecology of Red Sokoto bucks is presented in Table 3. The result showed that there were significant (P<0.05) differences in rumen fluid pH with T1 having significantly (P<0.0) highest values of 7.50 while T3 had significantly lowest (6.85). Rumen pH of 6 to 7 favours prediposes rumen microbes to actively performing microbial digestion and volatile gases production. The result further showed that aceatic acids were significantly (P<0.05) higher in T1 followed by T2 while lower in T3. Acetate (C_2) is the dominant in high-fibre diets (60-70% of VFAs); precursor for fat synthesis and ketogenesis. In some ruminant species like rams high acetate is critical for fat deposition and sperm production (Brito *et al.,* 2007). Both butyric acid and propanoic acids were significantly (P<0.05) different in this study. The result revealed that total volatile fatty acids were significantly (P<0.05) higher in T2 (16.44 nmol/L) while lower in T4 with 14.86 nmol/L.

Rumen microorganisms play a crucial role in modulating the rumen ecosystem through microbial fermentation, digestion, producing volatile gases, synthesis of some vitamin, microbial protein formulation and others. The result revealed that there were significant (P<0.05) difference in which T2 had the highest bacterial count ($25.30x10^5$/cfu). Rumen bacteria such as *fibrobacter succinogenes* and *ruminococcus albus* play important role of fiber digestion by producing cellulase and hemicellulases enzymes to degrade plant cell walls (Bera-Maillet, 2005). Significantly (P<0.05) higher fungi population were observed in Red Sokoto bucks fed diet T3 with $14.41x10^3$/cfu while significantly (P<0.05) higher protozoa were recorded in T1 ($9.250x10^3$/cfu). The rumen fungi obtained in this study clearly indicates that it plays important role fiber digestion. Rumen fungi are crucial microorganisms in the rumen ecosystem that contributed to fibre degradation by hyphal penetration via plant tissue invading

with the aid of rhizoids. Also, it synergized with bacteria to ferment sugars to volatile fatty acids (acetate, propionate) and enzymatic hydrolysis to releases cellulases and hemicellulases (Wang *et al.,* 2019). Ammonia were found significantly (P<0.05) higher in T1 followed by T4, T3 and T2. The values for ammonia in all the treatments was within the normal range of 16.5mg/l to 37.9mg/dl.

Table 3: Effect of Hydroponic Rice Fodder on Rumen Ecology of Red Sokoto Bucks

Treatment	T1	T2	T3	T4	SEM	LOS
Ph	7.500^{a}	7.345^{b}	6.845^{d}	7.295^{c}	0.006	*
AA (nmol/l)	28.39^{a}	27.21^{b}	24.80^{d}	25.55^{c}	0.007	*
BA (nmol/l)	6.295^{b}	7.415^{a}	4.945^{d}	5.590^{c}	0.006	*
PA (nmol/l)	11.59^{b}	13.72^{a}	10.84^{c}	9.95^{d}	0.006	*
Bacteria ($x10^{5}$/cfu)	22.70^{c}	25.30^{a}	24.24^{b}	21.91^{d}	0.006	*
Fungi($x10^{3}$/cfu)	12.27^{c}	13.52^{b}	14.41^{a}	11.86^{d}	0.007	*
Protozoa ($x10^{3}$/cfu)	9.250^{a}	8.435^{b}	7.875^{c}	7.585^{d}	0.006	*
NH3 (mg/l)	32.22^{a}	30.05^{d}	30.15^{c}	31.10^{b}	0.003	*
VFA (nmol/l)	15.64^{c}	16.44^{a}	16.12^{b}	14.86^{d}	0.005	*

CONCLUSION

It could be concluded that supplementation of hydroponic rice fodder greatly influenced growth performance and nutrient digestibility. For best rumen ecosystem T3 and T2 had the best pH, rumen microbial population and total volatile fatty acids. It is therefore recommended hydroponic rice fodder should be given to animals from 250g to 750g for improvement of growth performance, nutrient digestibility and overall health performance.

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EFFECT OF MACA (*Lepidium meyenii*) POWDER SUPPLEMENTATION ON SERUM BIOCHEMISTRY OF YANKASA RAMS DURING HOT SEASON

Gaddafi, S. Yahaya, M.A., and Garba, M.G.,
Department of Animal Science, Federal University Dutsin-Ma, Katsina State, Nigeria
*Correspondent Author Phone Number: +2347067212353; Email: sanigaddafi4@gmail.com

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Biochemistry

ABSTRACT

This study assessed the effect maca (*Lepium meyenii*) powder supplementation on serum biochemistry of yankasa rams raised during hot season. A total of 20 pubertal Yankasa rams were divided into four treatment groups of 0, 5, 10, 15g/ Kg powdered maca per kg diet with five (5) rams each per treatment in a Completely Randomized Design (CRD). At the end of experiment blood samples were collected and analyzed for liver function test, electrolytes and lipid. Data obtained were analyzed using analysis of variance of statistical analysis system were treatment means were separated using Duncan Multiple Range Test (DMRT). Blood samples were collected in a litheium heparin sample bottles and send to laboratory for serum biochemistry analysis. The result revealed that ALT and AST were significantly ($P<0.05$) difference. With the exception of potassium all other plasma electrolytes were not significantly ($P>0.05$) differences. Maca supplement has shown significant effect on plasma cholesterol and HDLP. It could be concluded that maca supplementation from 5–15g/kg diet remarkably enhances liver function tests with a marked hepatoprotective activities. Supplementation of maca across the treatment shown no adverse effect in plasma electrolytes. It is therefore, recommended that maca supplementation up to 15g/kg in diet is safer and farmers and livestock nutritionist can use it in livestock as natural feed additives and blood metabolites enhancers without deleterious effect.

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INTRODUCTION

Climate change and alteration of weather condition refers to a change in climate which is attributed directly or indirectly to human activities and natural variability that alters the composition of the global atmosphere over a long period of time (IPCC, 2007). The variations in climate parameters affect different sectors of the economy, such as agriculture, livestock production, heath, water, energy, e.t.c. According to Intergovernmental Panel on Climate Change, Africa is one of the most vulnerable continents to climate change and climate variability (IPCC, 2007). In mammals, global warming and excessive heat stress causes significant increases in body temperature above the physiological homoeothermic point (hyperthermia) with consequent organic suffering (heat stress) that leads to impaired physiological and reproductive activities (Raffaela, 2019).

Blood is constituted by cells and the plasma, which is the fluid portion. It functions to transport nutrients, regulates bio-functions, protect the entire animal body as well as exercise homeostatic control (Nasyrova *et al.,* 2006). The usefulness of blood in assessing the quality of foods and feed additives were long been underscored by various researchers. Blood is therefore, a fastest and readily available means of evaluating chemical and nutritional health status of animals in feeding trail (Aderemi, 2004). Presence of metabolites and other constituents of stress could be investigated through blood examination thus could be occasioned by nutrition, environment

or disease agent. In livestock production, maintaining optimal serum biochemical parameters is crucial for ensuring animal health, reproductive efficiency, and economic viability.

Maca is a vegetable root native to Peru. Its scientific name is *Lepidium meyenii* and also known in Hausa language as "*Sauyar Maca*" or "*Albasar tamoji*" while Yaroba Language it known as ' *'Isu baka*'' (Gaddafi *et al.,* 2023). In rodent, scientific studies have been shown that maca improves sperm production and testosterone levels without significantly altering serum biochemistry (Ganzales *et al.,* 2002). However, extrapolating these findings to ruminant animals like rams may not be appropriate due to differences in metabolism and digestive physiology. Similarly sharma *et al.* (2018) studies suggest that existing studies of maca in ruminant animal were limited and focused mostly on its aphrodisiac effects rather than systemic biochemical impact. Therefore, this study aims to fill this knowledge gap by assessing the effect of maca supplementation on serum biochemistry in Yankasa rams, this will provides valuable insights for livestock nutritionists and farmers seeking safer and natural reproductive enhancers.

MATERIALS AND METHOD

Experimental site

This experiment was carried out at Small Ruminant unit of Livestock Teaching and Research Farm, Department of Animal Science, Federal University Dutsin-Ma, Katsina State. The site lies in the sudano-sahelian savanna between latitude 12º27`18`N and 7º29`29`E and 605 meters above sea level with an annual average rainfall of 700mm.

Experimental Feed Preparation

All the feed materials that were used in the experimental diets' preparation was purchased from selling and processing centers in Dutsin-Ma. Maize and cotton seed cake was ground and packed in sacks for experimental diets compounding. Whereas groundnut hay was chopped before mixing, other feed ingredients such as wheat offal, maize bran, bone meal, and table salt were purchased from the different centers in Dutsin-Ma town.

Diet was formulated to meet the dietary requirement for breeder rams and pregnancy goats according to dietary recommendation of NRC, (2000) for tropical rams.

Experimental design: this experiment consists of 20 pubertal Yankasa rams which was divided into four treatment groups of 0, 5, 10, 15g/ Kg powdered maca with five (5) rams each per treatment in a completely randomized design (CRD).

Preparation of Maca Powder

Fresh maca was procured from herbal vendor in Dutsin-Ma Market, the maca was washed by tap water, and the fibrous roots was separated from the top. the roots was sliced to 2-cm-thick pieces and sun dried 72 hours at Animal Science Laboratory, Department of Animal Science, Federal University Dutsin-Ma to the moisture content of 6-9%. The maca slices was ground into powders, sieved through 2-mm wire-mesh, and stored at room temperature before use.

Data collection and analysis

Serum biochemical determination

Blood and serum samples was collected at the end of experiment (12 weeks post trail) by using sterile syringe and needle using jugular venipuncture of three (3) overnight four fasted rams from each treatment. A quantity of 5 ml of blood were collected into labelled sterile sample bottles without anticoagulant and were used for the serum biochemical analysis. The sample was centrifuged at 3000 rpm for 15 minutes. Separated serums was stored frozen at -20ºC in sample bottles without anticoagulant until the time of analysis. The serum biochemical indices to be determined were serum Albumin, globulin, total protein, alkaline phosphate (ALP), Alanine aminotransferase (ALT), Aspartate aminotransferase (AST). The data obtained was subjected to analysis of variance (ANOVA) using the general linear model of statistical analysis system (SAS) were treatment means were separated using Duncan Multiple Range Test (DMRT)

RESULT AND DISCUSSION

Effect of Maca Supplements on Liver function test of Yankasa rams

It is very essential to evaluate the liver function since liver play a central role in metabolism, detoxification and protein synthesis. This helps in diagnosing diseases, metabolic disorders,

impact of environmental stressors and monitoring nutritional status and dietary adequacy of Yankasa rams during this experiment. The table below represent liver function test of Yankasa rams supplemented maca-diet. The result showed that there were no significant (P>0.05) differences in plasma protein were total protein, albumin and globulin were not statistically different. Thus, T4 had the higher numerical values of total protein and globulin. The result revealed that there were significant (P<0.05) differences in alanine aminotransferase (ALT); higher ALT values were recorded in T3 (6.25µ/l) followed by T4 (5.38µ/l), T1 (5.01µ/l) while T2 exhibit lower ALT values (4.77µ/l). The ALT values obtained in this study collaborates with the ALT values of Yankasa rams of 4.50 – 6.50 µ/l) reported by Garba and Adeola, (2022). Aruwayo *et al.* (2011) reported that the level of serum glutamic oxaloacetic transaminase (SGOT) otherwise known as alanine aminotransferase is useful for the diagnosis of cases of myocardial infections, hepatocellular disease, skeletal muscle, disorders, trauma or diseases affecting skeletal muscle and various haemolytic conditions.

No significant (P>0.05) changes in alkaline phosphatase (ALP) were observed in this study. ALP values obtained in this study fall within the ALP values reported by Garba and Adeola, (2022) and Saleh and Sanusi (2019) of healthy Yankasa rams. Elevated ALP values occur in biliary obstruction or bone metabolism disorder (Kaneko *et al.,* 2008).

The result was however, showed significant (P<0.05) changes in aspartate aminotransferase. There were marked decreasing AST levels with increasing level of maca in this study; were T1 had the highest AST (14.89 µ/l) values followed by T2 (12.49 µ/l), T3 (12.26 µ/l) and T4 (9.87 µ/l). AST is the liver enzymes used to assess hepatic function. Therefore, the AST values obtained in this study signifies that maca supplementation does not adversely affect liver function and may even have hepatoprotective effects because Kaneko *et al.* (2008) states that elevated levels of AST marker indicate liver damage or disease.

No significant (P>0.05) differences were observed in total bilirubin and conjugate bilirubin. The non-elevated increases of bilirubin observed in this study suggested that Yankasa rams fed maca-diet have no severe haemolysis and liver dysfunction since Kaneko *et al.,* (2008) suggest liver dysfunction and haemolysis as a result of high levels of bilirubin.

Table 1: Effect of Maca Supplements on Liver function test of Yankasa rams

Parameters	T1	T2	T3	T4	SEM	LOS
TP (g/dl)	6.35	6.91	6.34	6.87	0.69	NS
Albumin (g/dl)	4.27	4.39	4.65	4.08	0.32	NS
Globulin (g/dl)	2.09	2.53	1.69	2.81	0.57	NS
ALT (µ/l)	5.01^{b}	4.77^{a}	6.25^{a}	5.38^{a}	0.50	*
ALP (µ/l)	15.82	17.09	17.68	17.21	1.60	NS
AST (µ/l)	14.89^{a}	12.49^{ab}	12.26^{ab}	9.87^{b}	1.85	*
Total bilirubin	1.42	0.99	1.39	0.86	0.34	NS
Conj. Bilirubin	0.36	0.27	0.44	0.31	0.21	NS

TP = Total protein, ALT = Alanine aminotransferase, ALP = Alkaline phosphatase, AST = Aspartate aminotransferase

Effect of Maca supplements on Kidney function test Yankasa rams

The result on the effect of maca on kidney function test (electrolytes) were presented in table below. The kidney function test is very essential to get insight on how the animal kidney regulate fluid balance, electrolyte, and waste excretion.

The result showed that blood urine nitrogen (BUN) and creatinine were not significant (P>0.05) differences. The values obtained for BUN and creatinine were fall within the values reported by Garba and Adeola (2022) for Yankasa rams. This indicates normal kidney functions since elevated levels of BUN and creatinine indicates impaired kidney function (Radostits *et al.*, 2007). With the exception of

potassium (K^+) ($P<0.05$) the plasma electrolytes were not significantly ($P<0.05$) differences in this study. The group supplemented maca have demonstrated moderate K^+ levels. Very low K^+ or high imbalances can signal renal or metabolic disorders (Radostits *et al.,* 2007).

Table 2: Effect of Maca supplements on Kidney function test Yankasa rams

Parameters	T1	T2	T3	T4	SEM	LOS
BUN (nmol/L)	11.32	11.91	11.87	12.09	0.77	NS
Creatinine (µmol/L)	113.0	118.20	110.50	113.70	5.32	NS
Na (nmol/L)	126.5	130.70	126.40	134.40	3.75	NS
K^+ (nmol/L)	2.73^b	3.21^{ab}	3.58^a	3.28^{ab}	0.28	*
Chloride (nmol/L)	1.72	1.80	2.19	2.15	0.29	NS
P (nmol/L)	1.25	1.53	1.32	1.36	0.40	NS
HCO_3 (nmol/L)	25.89	25.76	25.89	25.86	1.162	NS

BUN = Blood urea nitrogen, Na = Sodium, K^+ = Potassium, P = Phosphorous, HCO_3 = Biocarbonate, SEM = Standard error mean, LOS = Level of significance

Effect of Maca Supplement on Lipid Profile Yankasa rams

Evaluation of lipid profile is very essential for assessing metabolism for energy production and cellular function. The table below present the result on the effect of maca supplementation on lipid profile of Yankasa rams. The result revealed significant ($P<0.05$) difference in total cholesterol were T1 had higher cholesterol level ($62.52mg/d^{-1}$) while T4 had the lowest value 4.8.43 mg/d^{-1}. These findings support the study carried out in poultry fed maca which have been reported to have lower cholesterol and triglyceride levels which may be linked to maca`s bioactive compounds. Herdt (2000) revealed that high levels of cholesterol indicate metabolic syndrome or dietary imbalances.

In 2024, Mahdy studies using maca in rams showed that triglyceride and cholesterol were decreased by maca treatments (Mahdy *et al.,* 2024). This also collaborates with findings of Wan *et al.* (2018) concordant to our present results, Olgun *et al.* (2022) who reported that supplementation of 0, 0.5, 1.0, 1.5, 2.0 and 2.5g/kg diet could appear to reduce cholesterol and triglyceride. The result showed that there were no significant ($P<0.05$) differences in triglycerides and low-density lipoprotein. This studies suggest thatat maca can be used as natural feed additives in reducing the chance of atherosclerosis and coronary artery diseases risk since elated level of LDL contributes to plaque buildup in arteries which in turn causes coronary artery disease, stroke and peripheral artery disease. The high-density lipoprotein showed significant ($P<0.05$) differences. It is very important to note that increases maca supplementation levels tend to elevate HDLP in this study. This further proved that maca has hepatoprotective properties. Because elevated HDLP levels helps to remove excess cholesterol from arteries and transports it to the liver for excretion. It also reduces endothelial damage and plaque instability as opined by Rader and Hovingh (2014).

Table 3: Effect of Maca Supplement on Lipid Profile Yankasa rams

Parameters	T1	T2	T3	T4	SEM	LOS
Cholesterol (mg/d^1)	62.52^a	63.43^a	59.38^a	48.43^b	3.57	*
Triglyceride (mgd^1)	18.74	18.28	15.52	17.89	1.32	NS
LDLP (mg/d^1)	12.57	15.33	10.91	10.00	4.55	NS
HDLP (mg/d^1)	56.65^b	59.38^a	62.52^a	62.52^a	3.89	*

LDLP = low density lipoprotein, HDLP = High density lipoprotein, SEM = Standard error mean, LOS = Level of significant

CONCLUSION

The result from this study could be concluded that maca supplementation from 5 – 15g/kg diet remarkably enhances liver function tests with a marked hepatoprotective activities. Supplementation of maca across the treatment shown no adverse effect in plasma electrolytes. Maca supplementation at 10 and 15g/kg have greatly demonstrated decrease in plasma concentration of cholesterol and high density lipoprotein. It is therefore, recommended that maca supplementation up to 15g/kg in diet is safer and farmers and livestock nutritionist can used it in livestock as natural feed additives and blood metabolites enhancers without deleterious effect.

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OCCURRENCE AND RISK FACTORS OF TUBERCULOSIS IN CAMELS FROM THREE NORTH-WESTERN STATES OF NIGERIA

Salisu, U.S.[1*], Kudi, A.C.[2], Danbirni, S.[2], Mamman, P.H.[3], Saidu, S.N.A.[2], Garba, M.G.[2], Sanusi, A.Z.[2], Yusuf, A.[2] and Ishaq, A.[4]

[1]Department of Animal Science, Federal University Dutsin-Ma

[2]Department Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria

[3]Department Veterinary Microbiology, Ahmadu Bello University, Zaria, Nigeria

[3]Department of Animal Science, Federal University of Agriculture, Zuru, Kebbi State, Nigeria

*Corresponding author: usalisu@fudutsinma.edu.ng

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ABSTRACT

The study determined the occurrence as well as risk factors of Mycobacterial infections in camels in three northwestern states. Three hundred and eighty-four blood samples were collected from camel herds, and another 384 from camels presented for slaughter at abattoirs in three States of Kano, Katsina and Jigawa to obtain sera which were used to determine the presence of antibodies to tuberculosis using a lateral flow assay test. Three hundred and eighty four camels were sampled at slaughter at the central abattoirs in the three sates for tuberculous lesions. The results revealed a total occurrence rate of 8.98% for the presence of antibodies to TB in sera and a total occurrence rate of 5.98% based on occurrence of tuberculous lesions in camels in the study area. There was no significant difference ($p \leq 0.05$) in occurrence across study States via lateral flow or occurrence of lesions though Katsina State recorded a numerically higher occurrence of 11.26% and 11.46% than Kano (8.97%; 3.49%) or Jigawa (7.03%, 6.78%) respectively. Occurrence by sex and age was not statistically significant ($\rho \leq 0.05$) as no difference was observed between bulls and cows or adults and young camels. However, a significant difference ($\rho=0.01$) was observed in the occurrence of TB by body condition score, with the highest occurrence in camels with poor body condition score. It was thus recommended that there is need for improved surveillance, monitoring and quarantine services especially at Border States to control trans-border movement of diseases such as tuberculosis into the country and also an urgent need for increased awareness amongst camel stakeholders of the dangers of zoonotic infections from consumption of untreated camel milk and products also bearing in mind the close proximity between camels and their owners/herders. It was also recommended that the National policy on tuberculosis control in humans should be reviewed to include animals, camels inclusive.

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INTRODUCTION

Tuberculosis in animals is a zoonotic disease that is caused by members of the *Mycobacterium tuberculosis* complex, including *Mycobacterium tuberculosis*, *M. africanum*, *M. microti*, *M. bovis*, *M. caprae*, *M. canettii* and *M. pinnipedii* (Brites and Gagneux, 2017).

Infected animals progressively develop specific granulomatous lesions or tubercles in lung tissue, lymph nodes and other organs (Vohra and Dhaliwal, 2024). The incubation period ranges from months to years, but acute stages of the disease can develop during infection, when lesions progress rapidly (Vohra and Dhaliwal, 2024).

The disease is zoonotic and is spread by inhalation of aerosols or the ingestion of unpasteurized milk (Ravi *et al.,* 2018). The disease is rare or eradicated in developed countries via eradication programmes, however, reservoirs in wildlife can make complete eradication difficult (Pokam *et al.,* 2019). However, tuberculosis in animals is still a problem in less developed countries leading to severe economic losses due to livestock deaths, chronic disease and trade restrictions (Mohammed and Hamid, 2016). Cattle are the primary hosts for *M. bovis* (Ejo *et al*., 2021) and Bovine TB is usually maintained in cattle populations, but other domesticated and wild mammals can also be infected (Faye, 2020). A few animal species serve as reservoirs or maintenance hosts (CFSPH, 2019). Most species are considered to be spillover hosts. The brush–tailed Opossums (and possibly ferrets) in New Zealand, Badgers in the United Kingdom and Ireland, Bison and Elk in Canada, and Kudu and African Buffalo in Southern Africa all serve as maintenance hosts (CFSPH, 2019). Sheep, goats, horses, pigs, dogs, cats, ferrets, camels, llamas along with many species of wild ruminants including deer and elk; elephants, rhinoceroses, foxes, coyotes, mink, primates, opossums, otters, seals, sea l ions, hares, raccoons, bears, warthogs, large cats (including lions, tigers, leopards, cheetahs and lynx) and several species of rodents are considered as spill over hosts for the disease (CFSPH, 2019). Most mammals may be susceptible (CFSPH, 2019).

In dromedary camels, *Mycobacterium bovis, M. tuberculosis*, *M. bovis*, *M. caprae* and *M. microti* have been isolated from tissue lesions and bulked camel milk and atypical mycobacteria such as *M. kansasii*, *M. aquae*, *M. fortuitum* and *M. smegmatis* (Elmossalami *et al.*, 2010; Zubair *et al.*, 2004; Wernery and Kinne, 2012; Kinne *et al.*, 2006; Pate *et al.*, 2006; Gumi *et al.*, 2012; Zerom *et al.*, 2012; Mamo *et al*., 2011).

Camelids are members of the biological family *Camelidae*, and are classified in the suborder *Tylopoda* (pad-footed animals). They are also in the order Artiodactyla (even-toed ungulates) (Adamu and Ajogi, 1995). The one humped camel (*Camelus dromedarius*) is an important livestock species in Northern Nigeria. Camels are traditionally used for transport and haulage. However, their role in supplementing animal proteins for humans in terms of meat and milk is presently attracting the attention of scientists in this part of the world (Salihu *et al.,* 2009).

Tuberculosis in Camels has been found in Egypt, the United Arab Emirates, Pakistan, Kazakhstan, Nigeria and Ethiopia to mention a few. *Mycobacterium bovis*, *M. tuberculosis* and Non - Tuberculous Mycobacteria (NTBC) such as *M. kansasii*, *M. aquae*, *M. fortuitum* and *M. smegmatis* have all been isolated as causative agents of camel TB (Jibril *et al*., 2016).

The dromedary camel (*Camelus dromedarius*) is a multipurpose livestock species that is uniquely adapted to different types of harsh environments making it especially important in sub Saharan Africa. They can be used for meat, milk, wool and hide production and transportation and as a source of entertainment and competition (Fesseha and Desta, 2020).

The current world camel population is assumed to be more than 35 million (Faye, 2020). This is a notable increase from the Food and Agricultural Organization statistics (FAOSTAT 2001) figures of about 19 million camels in the world, of which 15 million are found in Africa and 4 million in Asia. Approximately two thirds of the world's camel population is in the arid areas of Africa notably Ethiopia, Sudan, Somalia, Djibouti, Niger, Kenya and Nigeria (Faye, 2020). Of the camels in Africa, Nigeria was estimated to have over 380,000 found in Kebbi, Sokoto, Zamfara, Katsina, Kano, Jigawa, Yobe and Borno states where they are used for transportation, haulage and as a source of meat, milk and hides (Faye, 2020).

The camel is one of the domesticated animals that serve as a spillover host for members of the tuberculosis complex (Duguma, 2022). Camels serve as important sources of milk, meat, draught power and transportation for the pastoralists (Faye, 2020). Zoonotic infections are closely associated with camel pastoralists because of their close contacts with their camels (Kaltungo, 2016) and their

habit of consuming raw camel milk which they regard as being medicinal (Duguma, 2022).

The dromedary camel (*Camelus dromedarius*) is extremely important for the livelihood of pastoral communities (Mamo *et al.,* 2011) and in these communities, camel milk is consumed raw. This habit combined with close physical contact between camel herdsmen and owners and their camels gives rise to a potential public health concern for transmission of zoonotic diseases such as tuberculosis (TB) from animals to the pastoralist (Mamo *et al.,* 2011).

Camels are also bred predominantly in rural settings and are commonly in contact with small ruminant and cattle which could serve as source of infections especially those infected with *Mycobacterium species* (Salisu, 2016). Camel trade is also carried out at livestock markets such as Maigatari and Maiadua livestock markets in the study area which are amongst the largest in West Africa, and camels come into contact with small ruminants, cattle and even equine species at these markets and infection could be spread at these places.

In many arid and semi-arid regions, camels play a critical role in bridging food security and sustaining pastoral livelihoods. Camels are slaughtered for their meat, and their milk is processed into various dairy products such as cheese (Abubakar *et al*., 2021) (locally called cikwi).

Camels are also not routinely screened against Tuberculosis as in other animals such as cattle. There is little information available as to the prevalence of this disease in camels in northern Nigeria. The camel is an important source of animal protein in Northern Nigeria. Camel meat is accepted and consumed and is slowly replacing beef and mutton in the diet of many families because it is cheap and tastes good. The relatively cheap cost of camel meat makes it an ideal source of affordable meat (Salisu, 2016). This poses risks to consumers, particularly regarding food safety and zoonotic diseases. In areas with inadequate veterinary care and poor meat inspection systems, camel meat can harbor pathogens like *Mycobacterium* and other zoonotic infections.

The populace in Northern Nigeria believes that camel milk and urine, when consumed, can cure for various diseases including HIV/AIDS, epilepsy and various cancers (Salisu, 2016). The camel is also one of the animals used as sacrificial animals during the Eid festivities in Northern Nigeria.

The habit of people in the study area of consumption of unpasteurized milk and in some cases even the urine of camels puts the populace at great risk of zoonotic disease should such substances contain the pathogens. Also, the close contact between camels and their owners/herdsmen puts these individuals at high risk of contracting tuberculosis from infected camels should the camels be infected with mycobacteria. This, coupled with the belief of the local populace that the milk and urine have therapeutic effects in the cure of certain diseases and the public health implications of tuberculosis makes it imperative to have a clear picture of the status of camel tuberculosis in the study area. Therefore, investigation of camel TB and identification of its causative agents in the study area is important to control the disease and reduce its risk of zoonosis to the pastoralists and camel handlers. The present study was designed to investigate the status of TB in camels and identify the causative agent(s) in the study area using molecular tools.

MATERIALS AND METHODS

The study was conducted in 3 States viz: Katsina, Kano and Jigawa States (Figure 1). Katsina State covers an area of 24,971 square kilometers (Wikipedia, 2021). It is located between Latitude 11°08'N and 13°22'N and Longitude 6°52'E and 9°20'E. It is located at an elevation of 605 meters above sea level (Wikipedia, 2021). Katsina State is one of the seven States that form Nigeria's North-West geopolitical zone. It is bordered by Jigawa and Kano States to the East, Kaduna State to the South and Zamfara State to the West. It shares an international border with the Republic of Niger to the North (Wikipedia, 2021). The vegetation in Katsina provides suitable grazing grounds for camels (Ghude *et al*., 2024). Temperatures during the dry season can be very high, frequently exceeding

40°C (104°F) between March and May (WeatherSpark, 2024). Katsina receives moderate rainfall during the wet season, with annual precipitation generally ranging from 600 mm to 800 mm (Abubakar *et al*., 2024). The recent estimate of camel population in Katsina State is approximately 52,000. This estimate is based on data from the Nigerian Agricultural Quarantine Service and other sources related to livestock statistics in Nigeria (NAQS, 2024).

Kano State is a State located in Northern Nigeria. it was created on May 27, 1967 from part of the Northern Region. It is located between Latitude 12°00'N and Longitude 8°31'E and borders Katsina State to the northwest, Jigawa State to the northeast, Bauchi State to the southeast and Kaduna State to the southwest. Kano State has a tropical savanna climate, marked by a significant variation between wet and dry seasons. Temperatures during the dry season can be extremely high, often exceeding 40°C (104°F), especially from March to May (Abaje *et al*., 2014). Temperatures during the wet season are slightly cooler but can still be warm, with average temperatures ranging from 25°C to 35°C (77°F to 95°F). Kano is a major hub for camel trade in Nigeria. As of the latest available data, the camel population in Kano State, Nigeria, is estimated to be around 95,000. This estimate is derived from various livestock statistics and agricultural reports (NAQS, 2024).

Jigawa State is one of the thirty-six States that constitute Federal Republic of Nigeria. It is situated in the northwestern part of the country between Latitude 11.00°N and 13.00°N and Longitude 8.00°E to 10.15°E. The State shares a border with Kano and Katsina States to the west, Bauchi State to the East and Yobe State to the Northeast. To the North, Jigawa shares an international border with Zinder Region in The Republic of Niger. The State has a total land area of approximately 22,410 square kilometers. Jigawa State has a tropical savanna climate, characterized by distinct wet and dry seasons. Temperatures can be extremely high during the dry season (October - May), often surpassing 40°C (104°F) from March to May. During the wet season (June - September), temperatures are slightly cooler, ranging between 25°C and 35°C (77°F to 95°F). Jigawa's markets, such as the Maigatari market plays a crucial role in the trade of camels and camel products thereby contributing greatly to the local economy (Jigawa State Government, 2024). The population of camels in Jigawa State, Nigeria, is significant due to the State's favourable environment for camel rearing. However, specific and recent population figures can be challenging to find in general publications. While specific figures for Jigawa State are not readily available, it's important to consider that Jigawa is one of the States in Nigeria where camel rearing is significant due to its Sahelian climate, which is conducive to camel husbandry (NAQS, 2024).

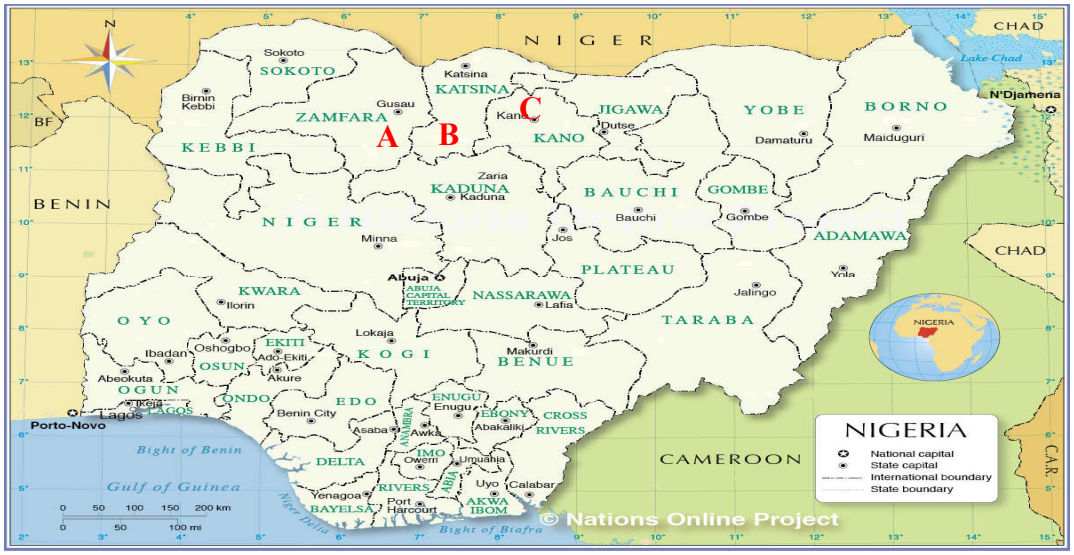

Figure 1: Map of Nigeria showing Sampling States (Source: Ntionsonline.org, 2021)

Figure 2: Map of sample States (Source: Nationsonline.org, 2021)

Study Design

A cross-sectional study using a purposive sampling method was carried out in camel herds. Systematic random sampling was carried out at abattoirs where every third camel intended for slaughter was examined. Lateral flow assay-based kit (rapid assay kit) was used to determine the presence or absence of antibodies in serum obtained from camels in herds and abattoirs.

Camel herds were selected based on the cooperation of the herd owners. Camels from herds in Katsina, Kano and Jigawa States were sampled. Camels brought for slaughter to the central abattoir in the study States were sampled. Age, sex, body condition and origin of each camel were recorded prior to blood collection/slaughter.

Age estimation was carried out using rostral dentition as described by Bello *et al.* (2013). The method involves the eruption and wear of the deciduous and permanent incisors to determine the age of the camels. All camels sampled were distributed into two age groups, with camels aged ≤6 years considered young and camels aged ≥7 years considered adults**.** Body condition scoring (BCS) was carried out according to Faye *et al*. (2001) who used the visibility/prominence of the Hump, spinous and transverse processes of vertebra, hollow of flank, ischial and coxial tuberosity, rib and recto genital area with very visible/prominent being poor BCS, Slightly visible being fair BCS and not visible/prominent being good BCS.

Ethical Clearance

Ethical clearance for the study was sought from the Ethics and Research committee of the Federal Teaching Hospital Katsina with approval number FTHKTHREC REG 24/06/22C/210.

Sample Size Determination

The sample size was calculated using the formula described by Thrusfield, (2007).

$$n = \frac{z^2pq}{d^2}$$

Where:

n – Minimum sample size

z – Appropriate value for the standard normal deviation set at 95% confidence interval (1.96)

p – Prevalence 50% (expected prevalence)

q – Complementary probability (1-p)

d- Level of significance/desired absolute precision 5%

Therefore, $N = \frac{1.96^2 \text{ x (prevalence x 1-prevalence)}}{(0.05)^2}$

$$= \frac{1.96^2 \text{ x } (0.5 \text{ x } 1 - 0.5)}{(0.05)^2}$$

N = 384.16

The minimum sample size of 384 camels to be sampled at the abattoirs and another 384 in camel herds was thus determined giving a total of 768 camels to be sampled.

Blood sample collection

Camels were physically restrained properly on sternal recumbency using ropes around the feet to prevent the camel from rising. Blood samples were collected via jugular venipuncture. Ten (10) milliliters of blood was collected from each camel using a 20ml syringe and 18G needle from the jugular vein. The blood was then gently transferred into anticoagulant - free sample bottles and labeled appropriately based on location, age and sex of the camel and also recorded in a hard cover log book. The labeled bottles were

kept in a slanting position in a cooler on ice packs and taken to the laboratory where they were centrifuged at 1000g for 5 minutes to allow for proper separation of serum from the clotted blood. The serum was then decanted, using sterile pasture pipettes, into a 5 ml plastic serum tube which were appropriately labeled. All the extracted serum samples were then stored in the freezer at – 20ºC until use.

Lateral flow assay

Collected and stored serum was subjected to testing using a lateral flow assay-based kit (rapid assay kit) for tuberculosis diagnosis that employs immuno-chromatographic detection of antibodies in serum, plasma, or whole blood (Ranjan *et al.,* 2018).

The assay relies on chromatographic detection of MPT64, a protein that is produced by *M. tuberculosis* complex during its metabolism in cultures (Kinne *et al.,* 2012). The assay has the advantage of being inexpensive and easy to use. They are easily stored at room temperature and allow for results from positive samples within 15 minutes.

The thawed sera samples were analyzed according to the manufacturer's instructions. For each test serum, 20 µl of thawed serum was placed into the sample window of the test kit. This was followed by the addition of 4 drops of the diluents after which the kit was left on the laboratory bench for 20 minutes at room temperature. The test results were read after 20 minutes by visual inspection.

Interpretation of results;

a) Negative = when staining was observed only on the control line (single straight line).
b) Positive = when staining was observed on both the test and control lines (two lines)

Data Analyses

Data generated are presented in tables, charts and plates. Data was analyzed using SPSS version 25.0. Prevalence and isolation rate of *Mycobacterium species* was calculated using the formula

$$\frac{\text{Total Positive}}{\text{Total sampled}} \times 100$$

Bivariate as well as multivariate analyses were carried out.

For the Bivariate analyses Chi square test was used to test for association between categorical variables. *P* values ≤ 0.05 were considered significant.

RESULTS

Occurrence of *Mycobacterial* Infections in Camels in Study Area based on SD Bioline® TB Ag Lateral Flow Assay

The results revealed a total occurrence of 8.98% for the study from lateral flow assays using SD Bioline® test kits (Table 1). Katsina State recorded the highest total prevalence of 11.25% amongst the 3 States sampled, while Jigawa State recorded the lowest prevalence of 7.03% (Table 1).

Table 1: Occurrence of *Mycobacterial* Infections in Camels in Katsina, Kano and Jigawa States Based on SD Bioline® TB Ag Lateral Flow Assay

State	No of Camels Tested	Positive	Occurrence rate (%)	χ^2	ρ value
Katsina	222	25	11.26	**2.602**	**0.272**
Kano	290	26	8.97		
Jigawa	256	18	7.03		
Total	**768**	**69**	**8.98**		

Occurrence of *Mycobacterial* Infections based on sex of camels in the study area using SD Bioline® TB Ag lateral flow assay

A total of four hundred and fifty-two (452) male camels and three hundred and sixteen (316) female camels were sampled across the three States. Of these 31 males (6.42%) were positive while 38 (12.65%) of females were positive (Table 2). In all States sampled, female camels recorded higher occurrence (Katsina: 15.22%; Kano: 11.11%; Jigawa: 12.36%) than males (Katsina: 8.46%; Kano: 7.10%; Jigawa: 4.19%) (Table 3).

Table 2: Occurrence of *Mycobacterial* Infections Based on Sex of Camels in Katsina, Kano and Jigawa States

Sex	No of Camels Tested	Positive	Occurrence rate (%)	χ^2	ρ value
Male	418	31	6.42	**2.758**	**0.097**
Female	350	38	12.65		
Total	**768**	**69**	**8.98**		

Table 3: Occurrence of *Mycobacterial* Infections based on sex and location of camels in Katsina, Kano and Jigawa States

State		No of Camels Tested	Positive	Occurrence rate (%)	χ^2	ρ value
Katsina	Male	130	11	8.46	**2.758**	**0.097**
	Female	92	14	15.22		
	Total	222	25	11.26		
Kano	Male	155	11	7.10		
	Female	135	15	11.11		
	Total	290	26	8.97		
Jigawa	Male	107	7	4.19		
	Female	89	11	12.36		
	Total	256	18	7.03		
Total		**768**	**69**	**8.98**		

Occurrence of *Mycobacterial* Infections based on age of camels in the study area

Of 768 camels sampled, two hundred and eighty-six (286) were young (below the age of six) while four hundred and eighty-two (482) were adults (seven years and above). Of this 22 (7.69%) were positive amongst young while, 47 (9.75%) were positive amongst the adult camels (Table 4). In all States sampled, adults recorded higher occurrence (Katsina: 12.06%; Jigawa: 8.61%) than young camels (Katsina: 9.88%; Jigawa: 4.76%) except Kano where young camels had higher occurrence rate (9.00%) than adults (8.95%) (Table 5).

Table 4: Occurrence of *Mycobacterial* Infections Based on Age of Camels in Katsina, Kano and Jigawa States

Age range	No of Camels Tested	Positive	Occurrence rate (%)	χ^2	ρ value
≤6 years (Young)	286	22	7.69	**0.930**	**0.335**
≥7 years (Adults)	482	47	9.75		
Total	**768**	**69**	**8.98**		

Table 5: Occurrence of *Mycobacterial* Infections Based on age and Location of Camels in Katsina, Kano and Jigawa States

State		No of Camels Tested	Positive	Occurrence rate (%)	χ^2	ρ value
Katsina	Young	81	8	9.88	**0.930**	**0.335**
	Adult	141	17	12.06		
	Total	222	25	11.26		
Kano	Young	100	9	9.00		
	Adult	190	17	8.95		
	Total	290	26	8.97		
Jigawa	Young	105	5	4.76		
	Adult	151	13	8.61		

	Total	256	18	7.03
Total		**768**	**69**	**8.98**

Occurrence of *Mycobacterial* Infections based on body score condition of camels in the study area

Three body score conditions were considered: Good, Fair and Poor. Of the 768 camels sampled, two hundred and ninety-one (291) had good body condition score, three hundred and three (303) had fair while one hundred and seventy-four (174) had poor body condition score (Table 6). Of these 15 (5.11%) of those with good body condition score were positive for antibodies against tuberculosis, 22 (7.28%) amongst those with fair body condition score were positive while 32 (18.50%) amongst those with poor body condition score were positive (Table 6). In all States sampled, camels with poor BCS recorded a higher occurrence (Katsina: 24.44%; Kano: 21.15%; Jigawa: 13.16%) than camels with good and fair BCS (Table 7).

Table 6: Occurrence of *Mycobacterial* Infections Based on Body Condition Score of Camels in Katsina, Kano and Jigawa States

Body condition score	No of Camels Tested	Positive	Occurrence rate (%)	χ^2	ρ value
Good	291	15	5.11	**25.148**	**0.01**
Fair	303	22	7.28		
Poor	174	32	18.50		
Total	**768**	**69**	**8.98**		

Table 7: Occurrence of *Mycobacterial* Infections Based on body condition score and Location of Camels in Katsina, Kano and Jigawa States

State		No of Camels Tested	Positive	Prevalence (%)	χ^2	ρ value
Katsina	Good	75	6	8.00	**25.148**	**0.01**
	Fair	102	8	7.84		
	Poor	45	11	24.44		
	Total	222	25	11.26		
Kano	Good	122	6	4.92		
	Fair	116	9	7.76		
	Poor	52	11	21.15		
	Total	290	26	8.97		
Jigawa	Good	96	3	3.12		
	Fair	84	5	5.95		
	Poor	76	10	13.16		
	Total	256	18	7.03		
Total		**768**	**69**	**8.98**		

DISCUSSION

A total of seven hundred and sixty-eight (768) serum samples were collected from camels in the study area across the States of Kano, Katsina and Jigawa with half being collected from camel herds while the other half were from camels slaughtered at central abattoirs in the capital cities of the States sampled. The samples collected from each State were not even but varied according to the presence/availability of camel herds and the total number of camels slaughtered per day at the central abattoirs. As a result two hundred and twenty two (222) samples were collected from Katsina State with one hundred (100) being from camel herds and one hundred and twenty two (122) from Katsina Central abattoir, two hundred and ninety (290) serum

samples were collected from camels in Kano State with seventy three (73) from camel herds and two hundred and seventeen (217) collected at Kano Central abattoir while two hundred and fifty six (256) samples were collected from camels in Jigawa State with forty five (45) from camels slaughtered at the central abattoir in Dutse and two hundred and eleven (211) camels were sampled from camel herds in various locations in Jigawa State. This distribution indicated that Jigawa State had the least number of camels being slaughtered at the abattoir per day while Kano State had the highest number of camels slaughtered in a day. The reverse was the case for camel herds as Jigawa State had the largest number of camel herds in the three States sampled while Kano State had the least. These differences led to the variations in the number of camels sampled per location.

The results revealed a total prevalence of 8.98% for the study from lateral flow assays using SD Bioline® test kits. Beyi *et al.* (2014) determined the prevalence of bovine tuberculosis in dromedary camels in Eastern Ethiopia to be 8.3%. However, Ahad *et al.,* 2023 reported an overall prevalence of 13% for camels in Nigeria as a whole.

Katsina State recorded the highest total prevalence (11.26%) of the three sampled States followed by Kano State (8.97%) and while Jigawa State (7.03%) recorded the lowest prevalence. This is not shocking since Jigawa State had least number of slaughtered camels and the highest numbers in herds. Herd owners would naturally sell off animals not doing well and keep the more promising ones for production and reproductive purposes. Abubakar *et al*., 2014 reported a prevalence of 22% in camels slaughtered at Kano abattoir though only based on serological tests while no current reports for Katsina and Jigawa States were found. This paucity of data in these States is worrisome as they are very important camel entry and distribution point into and around Nigeria because of the presence of the Maiadua and Maigatari markets respectively which are arguably the largest animal markets after Potiskum cattle market.

Female camels recorded higher prevalence than males though without significant difference in this study. This is probably due to the fact that female animals are always kept longer in the herds since they reproduce while most male animals are fattened and sold off leaving only a few studs. This long stay in the herds puts females at higher odds of being infected. A study on the prevalence and associated risk factors of camel tuberculosis at Akaki abattoir in Ethopia also reported numerically higher positives without statistical significance in females than males (Jibril *et* al., 2016) and also the findings of Zerom *et al*., 2013. The current study however disagreed with the findings of Ahmad *et al*., 2018 who reported that male dromedaries had 1.7 odds of being tuberculous than the females. It also was not at par with the study of Beyi *et al*., 2013 who also reported a higher prevalence in males.

Adult camels recorded higher prevalence of infection than young camels though no statistical significance was observed in the current study and this could be attributed to the chronic nature of tuberculosis. The prevalence in this study was determined from presence of antibodies in sera and as such the establishment of antibodies following challenge and the retention of memory cells would naturally tend to occur in older animals than young ones. This report was in tandem with the findings of Kasaye *et al*., 2013 who reported higher prevalence in adults than young however with no statistical significance. Jibril *et al*., 2016 however reported no significance in age of camels as risk factor to the occurrence of tuberculosis in camels.

Three body condition scores were considered: Good, Fair and Poor. Of the 768 camels sampled two hundred and ninety-three (293) had good body condition score, three hundred and two (302) had fair while one hundred and seventy three (173) had poor body condition score. Camels with poor body condition score despite being the least in number amongst camels sampled had a significant higher difference compared to these with fair and good body condition scores. This finding could be as a result of tuberculosis being a debilitating and wasting disease. The findings followed expected patterns as those with fair body condition score had the next largest

prevalence while those with good body condition score recorded the least. Kasaye *et al*., 2013 reported a numerically higher prevalence in camels of poor body condition score in Akaki, Ethiopia.

CONCLUSIONS

The study in camels observed a total occurrence of 8.98% antibody detection to Mycobateria species in Katsina, Kano and Jigawa States using SD bioline lateral flow test kit. Katsina State recorded the highest total prevalence of 11.26% followed by Kano State which had a prevalence of 8.97% and the least was Jigawa State recording 7.03%. No statistical significance was observed in the prevalence across the three States.

There was no statistically significant association for the prevalence based on sex and age of camels though females and adults recorded numerically higher prevalence's. Significant association was however observed for body condition score ($p \leq 0.01$).

RECOMMENDATIONS

I. There is a need for improved monitoring and quarantine services especially at Border States in Northern Nigeria as this is the major passage way for camels into Nigeria and proper monitoring at this point may limit the introduction of diseases into the country.

II. There is an urgent need for measures to increase awareness in camel herding and rearing communities as well as amongst consumers of camel product (camel milk, cikwi etc) as there is a high prevalence of low knowledge and poor practices especially towards tuberculosis in camels.

III. There is a need for review of the National policy on tuberculosis control in humans to include control in animals, camels inclusive, for the effective control of the disease in the country. The control of the disease should be based on a one health approach.

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ISOLATION AND IDENTIFICATION OF MICROBIAL BIOMASS FROM RUMEN FLUID OF YANKASA RAMS FED COWPEA HAY AND GROUNDNUT HAULMS AS SUPPLEMENTS

Dan Abba, Y. U.

Department of Animal Science, Federal University, Dutsin Ma, Katsina, Nigeria.

Corresponding Author: udyusuf@fudutsinma.edu.ng 08069410373

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ABSTRACT

This study was conducted to assess the influence of cowpea hay and groundnut haulms supplementation on the rumen characteristics of Yankasa rams. The study involved the use of Sixteen (16) Yankasa rams of equal weight randomly assigned to four treatment groups: Rice straw (Treatment I), groundnut haulms (Treatment II), cowpea hay (Treatment III) and combination of cowpea and groundnut haulms (Treatment IV). The experiment was laid out in a Completely Randomized Design (CRD) with four (4) replications for 84 days. About 15 ml of rumen liquor was drawn individually from all the experimental animals from which pH and microbial biomass were determined according to standard protocols. Data obtained for rumen pH and microbial loads were analyzed using Analysis of Variance with Least Significant Difference used to separate significant means at 5% level. Significant difference ($P \leq 0.05$) was found in the rumen fluid pH and microbial counts among the treatment groups. High microbial counts were recorded among Treatment II while Eight different bacterial species were identified with Treatment II having the highest number of bacterial species . Similar result was recorded for fungal species. Three different fungal species were isolated from the rumen fluids in the present study. These are: *Piramonas communis, Sphaeromonas communis* and *Pilobolus* spp. However, Treatment I had the highest number of protozoan species (4 different species). The findings from this study implies that, supplementation of basal rice straw with cowpea hay and groundnut haulm led to improvement in the composition of microbial biomass that aided digestibility and rumen fermentation within Yankasa rams making nutrients available for absorption and assimilation. Treatment II having the highest number of bacterial species is recommended.

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INTRODUCTION

Rumen is a self-sustained ecosystem where feeds consumed by ruminants are fermented by microbes to volatile fatty acids and other potential sources of energy and protein for the host animals (Perez *et al.,* 2024). The rumen microbes played a crucial role in maintaining gastro-intestinal homeostasis, and the entire animal's wellbeing (Zhu *et al.,* 2025). Manipulation of rumen microbial ecosystem for enhancing feed digestibility and ruminants' health to improve performance are some of the most important goals of animal nutritionists (Muhammad *et al.,* 2016). Anaerobic rumen fermentation of feeds is beneficial for the host animal, the co-existence of animal and its microbial eco-system has resulted in stable and the most favored natural selection of bacteria, protozoan and fungi. There exists different kind of symbiotic relationship among different

group of microorganisms due to the diverse nature of these microbial species and their adaptability and interactions in the rumen (Castillo-Gonzalez *et al.,* 2014). It has been reported that ruminal fungi for instance have enzymes which can hydrolyse the majority of the structural polysaccharides found in plant cell wall (Dehority and Tirabasso, 2001).

However, despite the relative importance of rumen microbial biomass to the welfare of the animals and the farmer, rumen microbial composition is easily hampered by a high seasonal variability of feeds availability with low protein concentration thereby reducing their maintenance and production requirements (Fasae *et al.,* 2025). Feeding supplementation have over the years been developed as alternative feeding strategies with economic benefits for utilizing limited feed supply

in ruminant production systems (Moreira *et al.,* 2021). Leguminous plant products such as cowpea hay and groundnut haulms are abundant in Sudano-sahelian zone of Nigeria and are valued for their high-quality protein forage and favorable amino acid profile (Ahmed and Abdelati, 2009), offering significant nutritional benefits as a protein-rich forage to fill dietary gaps for ruminants and manipulate microbial rumen composition (Fasae *et al.,* 2025).

Rumen manipulation improves performance, feed intake and nutrient digestibility using supplementation of diets. The digestibility of fibre fractions like Neutral detergent fiber (NDF), Acid detergent fiber (ADF), hemicellulose and cellulose are increased by supplementation (Santra and Karim, 2002). Supplementation with crude protein to ruminants improves fiber digestibility because of the population of cellulolytic bacteria is increased (Currier *et al.,* 2004). Stabilization of rumen environment favoring development of cellulolytic microbes (Hegarty *et al.,* 1991) and stimulatory effect of rumen ciliate protozoa on rumen bacteria for cellulolysis (Onodera *et al.,* 1988). More so, the results of effect of supplementation on the animal performance are mainly related to animal feed composition and nature of the feeding supplements. The aim of this study therefore is to isolate and characterize the different microbes present in the rumen fluid of Yankasa rams fed cowpea hay and groundnut haulms as supplements.

MATERIAL AND METHODS

Study Location

The study was carried out at the Small Ruminant Unit of Teaching and Research Farm, Department of Animal Science, Aliko Dangote University of Science and Technology, Wudil, Kano State (Latitude 11º 5´N and longitude 9º 40´E and on an altitude of 415m above sea level). The area has a minimum and maximum temperature of about of 26ºC to 36ºC respectively. The mean annual rainfall in the area is 773.4 mm per annum (Adamu *et al.,* 2014).

Collection and Processing of Experimental Materials

Cowpea hay and groundnut haulms were procured from an animal hay seller at Wudil market, Kano state. The experimental materials were bagged separately in clean sacks and labelled accordingly. The rice straw was procured from a rice Farm at Wudil town, Kano. The rice straw was chopped using a forage chopper to size of 4 cm length and bagged. Other feed ingredients were purchased from the same market. All the experimental feeds were bagged properly and stored at room temperature (27±2 ºC) until required for use.

Experimental Animals

Sixteen (16) growing Yankasa rams of equal weight (20.19 ±2.2kg) were procured from Wudil Market, Kano State and were used for the experiment. The animals were quarantined for two weeks, dewormed against internal and external parasites using Ivomec® Super at 200µg/kg body weight prior to experiment.

Experimental Treatments and Design

The experimental animals were randomly assigned into four groups laid down in a Completely Randomized Design (CRD) with four (4) replications. Animals on treatments I were fed rice straw with water *ad libitum* as control, treatment II were fed groundnut haulms (300g /day and rice straw *ad libitum*) and treatment III 300g/day cowpea hay and rice straw *ad libitum* respectively. Those on treatment IV were fed a combination of groundnut haulms and cowpea hay (150g/day Groundnut haulms +150g/day Cowpea hay)

and rice straw *ad libitum*. Wheat bran and sorghum chaff (mixed in a ratio 2:1) plus 1% salt and 1% bone meal were given at 2% body weight to all the experimental animals as concentrate diet. Experimental feeds were offered to the animals twice a day (8:00 am and at 4:00 pm). All the animals received rice straw as basal diet and water *ad libitum*. After the adaptation period, the experiment lasted for 12 weeks (84) days.

Rumen Fluid Collection

Fifteen (15) ml of rumen liquor was drawn individually from the animals, using rubber stomach tube in the morning prior to feeding the animals and at 4 hours after feeding, middle and last week of the experiment. The rumen liquor was stored in sterile glass bottles and kept in a flask containing ice blocks and transported to Microbiology Laboratory, Kano University of Science and Technology, Wudil, for microbial analysis. The bacterial and fungal colonies were observed and identified based on their colony morphology as described by Pelczar *et al*. (2006).

Rumen fluid pH determination

Rumen fluid pH was measured immediately using a digital pH meter (Model: JENWAY 550).

Bacterial isolation and identification

The microbial analysis was conducted using serial dilution technique following the procedure of Adams and Moss (2007). Sterilization of all glass wares was done by washing with detergent rinsed with water and sterilized using hot air oven at 160 ºC for 1 hour while all the liquid media were sterilized in an autoclave at 121ºC for 15 minutes (Prescott *et al*., 2005). One (1) millilitre each of rumen fluid samples were dissolved in a test tube containing 9 ml of sterile distilled water (10^{-1}) dilution. This was shaken to obtain a good suspension. The suspension was then serially diluted to 6 tubes (10^{-6}). From the sixth tube, 1 mi of the suspension containing rumen liquor was inoculated on Nutrients Agar and spread using pour plate technique and incubated at 32 ºC for 24 hours. Colonies formed were counted using colony count metre as described by Prescott *et al*. (2005).

A sterile wire loop of the correct size was dipped into the enrichment culture and inoculated into a small area of a fresh nutrient agar and spread by using a sterile wire loop by streaking and incubated for 24 hours. The pure isolates of each of the colony obtained was transferred into a sterile slant bottles containing fresh nutrient agar and refrigerated at 4ºC for further use (Prescott *et al*., 2005).

Gram staining: Gram staining was carried out according to Prescott *et al*. (2005) method. Smear of bacterial isolates were made on clean glass slide using drop of water with sterile wire loop. It was then allowed to air dry and then passed over a flame in order to fix the smear. The smear was covered with gentian violet for 60 seconds and washed. Iodine was then poured to cover the smear, allowed for 60 seconds and then washed. Ethyl alcohol (ethanol) was used to decolourize the smear and washed immediately with the distilled water, then follow by the application of safranin and left for 60 seconds, and later washed with distilled water. Back of the slide was cleaned with cotton and allowed to air dry. The slide was examined under electrical compound microscope using oil immersion x100 resolution objectives of AMSCOPE microscope (Model: N 400M). The various colonies observed in the plates were distinguished on the basis of their cultural characteristics such as colony size, shape and color as described by Fawole and Oso (1995).

Fungal isolation and identification

Fungal isolation was done using serial dilution technique in which one milliliter of each of the samples was added to 9 ml of distilled water to form 10^{-1}. This was advanced to 10^{-4}. The samples from the last test tube were inoculated on Potato Dextrose Agar (PDA) at 28ºC for 7 days. The total fungal counts were carried out on the samples using Pour plate technique. The plates were subsequently incubated at 32ºC for 72 hours. At the end of incubation, developed colonies were counted in colony forming units per unit milliliter. Discrete colonies were sub-cultured to obtained pure culture which were used subsequently for microscopic identification. Chloramphenicol (30 mg/l) was added to prevent bacterial growth. The distinct colonies formed in the pure culture plates were observed using morphological and cultural characteristics as described by Dashwood *et al.* (1992).

Protozoan isolation and identification

The protozoan counts were used to calculate the protozoal generic distribution and generation time of protozoa according to the following formula:

Generation time in hours = total protozoal counts in fermenter/flow of protozoa in effluent per hour (Sylvester *et al*., 2004). The microorganisms were isolated and identified by conventional method with grams staining for bacterial, fungal and protozoan species.

Statistical Analysis

The data collected were subjected to Analysis of Variance (ANOVA) using SAS (2008) version 9.1; where there is significant difference, the means were separated using Least Significant Difference (LSD) at 5% level of probability.

RESULTS

The results for rumen fluid pH by Yankasa rams fed cowpea and groundnut haulms as supplement to basal rice straw is shown in Table 1. The results showed significant ($P < 0.05$) differences between sampling times. The treatment II recorded a higher acidic rumen fluid pH 4 hours post-feeding than the other treatments, while control (I) had the least acidic value. Whereas the lowest fungal count was found in treatment II and IV before feeding and treatment I and IV after feeding.

Table 1. Rumen pH of Yankasa rams fed cowpea and groundnut haulms as supplement

Sampling Time (Hours)	Treatments				SEM
	I	II	III	IV	
0	6.74	6.67	6.67	6.63	0.06
4	6.29^{a}	6.01^{b}	6.17^{ab}	6.08^{ab}	0.12

^{ab}Means with the same superscript within the same row are not significantly ($p < 0.05$) different, SEM = Standard Error of Mean I= Control Rice straw II= Groundnut Haulms III= Cowpea Hay IV= Cowpea Hay + Groundnut Hay

Influence of Cowpea and Groundnut Haulms Supplementation on Microbial Biomass

The results for the bacterial counts in the rumen fluid of Yankasa rams fed cowpea hay and groundnut haulms as supplements to basal rice straw were presented in Table 2. The results revealed significant variation ($P \leq 0.05$) among the treatments in terms of microbial loads. The result showed that, before morning feeding and at 4 hours after feeding, bacterial counts were recorded higher in treatment II (5.83×10^{6} cfu/ml and 5.87×10^{6} cfu/ml respectively). However, the results for fungal count revealed no significant difference in the fungal count at morning hours before feeding but statistically different ($P \leq 0.05$) after 4 hours of feeding. Similarly, treatment II had higher fungal count (4.26×10^{5}cfu/ml) than all other treatments, followed by treatment III.

Table 2. Rumen microbial counts as influenced by Cowpea and Groundnut haulms supplementation

Parameters	Sampling Time (Hours)	TREATMENTS				SEM
		I	II	III	IV	
Bacterial count x10^{6}(Cfu/ml)	0	5.17^{c}	5.83^{a}	5.46^{b}	5.57^{b}	1.32
	4	5.21^{c}	5.87^{a}	5.59^{b}	5.66^{b}	0.09
Fungal count x10^{5} (Cfu/ml)	0	3.65	3.41	3.75	3.36	1.21
	4	3.31^{c}	4.26^{a}	3.98^{b}	3.26^{c}	0.78

^{abc}Means with the same superscript within the same row are not significantly ($P \leq 0.05$) different, SEM = Standard Error of Mean I= Rice straw, II= Groundnut Haulms, III= Cowpea Hay, IV= Cowpea Hay + Groundnut Haulm

The bacterial species identified in rumen fluids of Yankasa rams fed experimental diets are presented in Table 3. The results indicated the presence of 8 different bacterial species represented by seven (7) were recorded as follows: *Butyrivibrio fibrisolvens, Bacteriodes ruminocola*, *Escherichia coli, Entrococcus spp. Pseudmonas aeruginosa, Fibrobacter succinogenes, Ruminococcus albus and Ruminococcus flavefaciens* with Treatment II

having the highest number of bacterial species (five).

Table 3. Bacterial species isolated from the Rumen Fluids of Yankasa Rams Fed different supplementations

S/N	TREATMENTS			
	I	II	III	IV
1	*Entrococcus* spp.	*Ruminococcus albus*	*Ruminococcus flavefaciens*	*Bacteriodes succinogenes*
2	*Pseudmonas aeruginosa*	*Ruminococcus flavefaciens*	*Butyrivibrio fibrisolvens*	*Ruminococcus albus*
3	*Bacteriodes ruminocola*	*Bacteriodes succinogenes*	*Escherichia coli*	*Escherichia coli*
4		*Butyrivibrio fibrisolvens*		
5		*Escherichia coli*		

Three different fungal species (Table 4) were recorded in the rumen of Yankasa rams fed different feed supplements as follows: *Piramonas communis, Sphaeromonas communis* and *Pilobolus* spp., with treatment II having the highest number of fungal species.

Table 4. Fungal species isolated from the Rumen Fluids of Yankasa Rams fed different supplementations

S/N	TREATMENTS			
	I	II	III	IV
1	*Sphaeromonas communis*	*Sphaeromonas communis*	*Piramonas communis*	-
2	-	*Pilobolus* spp.	-	-

Furthermore, Table 5 revealed the presence of protozoan species in the rumen f Yankasa rams fed different supplements. The result indicated that Treatment I had the highest number of prozoan species (3 species).

Table 5. Protozoan species isolated from the Rumen Fluids of Yankasa Rams Fed different supplementations

S/N	TREATMENT			
	I	II	III	IV
1	*Epidinium caudatum*	*Isotricha intestinalis*	*Entodinium dubardi*	*Eremoplastron rostratum*
2	*Eremoplastron rostratum*	*Epidinium caudatum*		*Entodinium nanum*
3	*Eudiplodinium maggi*			

DISCUSSION

Yankasa rams are grazing animals with the ability to utilize forage sources for maintenance, growth, reproduction and production as such they possess the rumen, which serves as a fermentation chamber composed of high diversity of microorganisms with the ability for degrading fiber or starch rich feed and other types of non-fibrous carbohydrates as reported by Macêdo *et al.* (2022). Bacteria, fungi and protozoans are the three large group of microorganisms inhabiting the rumen environment. As the rumen environment is complex and always dynamic, depending on the existing environmental conditions. The dynamism in the nature and amount of these microbes may occur due to the ability of the microorganisms to compete for available resources for their own development. When diets with high proportion of grain are supplied to animals, the rumen equilibrium is compromised, since the pH of the environment may change from alkaline to acid, then affecting the development of ruminal microorganisms and, consequently, the use of feed as stressed by

Chen *et al.* (2011). The present study reported that, the rumen fluid pH in the treatment groups fed cowpea hay and groundnut haulms supplemented diets were more acidic than those only fed rice straw. This means that, Cowpea hay and Groundnut haulms supplementation provides conducive atmosphere for microbes by modifying the rumen fluid pH as reported by Dan Abba *et al.* (2023). The changes in the rumen pH as reported by Mateos *et al.* (2017) may propitiate the development of pathogenic microorganisms such as *Escherichia coli*, which has high growth rates, multiplies rapidly, and suppress the development of other microbial groups. This microorganism has high degree of pathogenicity, as it may sporulate and produce substances that cause animal metabolic disorders, diarrhea, lack of appetite, hemorrhages and other problems; which can even contaminate the milk and meat of exposed animals.

As the rumen fluid pH decreases below 5.0, the populations of rumen fluids microbes such as bacteria, fungi and protozoa increases and vice versa which might probably be detrimental to the animal. Hence, the shift in the rumen pH reported by this study is more or less to the benefit of the animals. Similar finding was reported by Saricicek and Ozel (2010). The rumen pH was reported by Russell and Rychilk (2001) to be between 5.5-7.0 to enable microbes-aid digestion in ruminant animals as stressed by Saricicek and Ozel (2010).

The bacterial species associated with feeding supplementation as reported by this study highlight the significance of such species in rumen fermentation and feed degradation to enhance performance and well-being of the animals as stressed by Oyaeleke and Okusanmi (2008). Additionally, their presence in the rumen indicated the relative importance of cowpea and groundnuts supplements in providing nourishment. Furthermore, a study by Weimer *et al*. (2008) reported *Ruminococcus albus* and *R. flavefaciens* among the most important bacterial flora in the rumen for their role in cellulose digestion and have been reported in higher roughage diets. Similarly, Yusuf *et al*. (2016) reported the presence of eight different bacterial species in the rumen of sheep. The finding also agrees with that of McAllister (2000) who reported increase in bacterial load with increase in the levels of legumes supplementation.

The presence of three species of fungi in the rumen of the experimental animals is in line with the work of Akin and Borneman (1989) who reported that fungal species play significant role in ruminant nutrition by their ability to colonize extensively the lignin-containing plant cell walls of forages. This may probably be due to the fungal efficient enzymes system that can degrade structural elements of the plant cell wall. Similar report on the protozoan species identified by the present study showed that, the three genera: *Entodinium*, *Diplodinium* and *Isotricha* are the most common protozoan species contributing to the cellulose and starch digestion as reported by Saricicek and Ozel (2010). Previous studies by Finlay *et al*. (1994) and Newbold *et al*. (1995) individually reported that, protozoan species harbor methanogens on their cell surfaces thereby facilitate methane emission. The protozoan species reported by the present study conform to the previous findings of Takenaka *et al*. (2004) and Kamra (2005) who individually reported high protozoan species in bovine rumen with increased in fibre contents. In addition, Hernandez-Sanabria *et al.* (2012) posited that, the entire microbial diversity in rumen as reported by the present study is dynamically modified, since microbial groups present in the rumen are in constant competition for substrates. The development of a particular microbial group, which usually occurs at the expense of another group of microorganisms, depends on the conditions of the environment and the available substrates. The multiplication of these microorganisms occurs as function of degradation of food particles found in the environment, which are further fractionated into small sizes until they become monomers that can be used in the fermentative pathway of ruminal microorganisms. Previous study by Chen (2012) reported that, animals fed on diet consisting of high-grain showed subclinical acidosis, ruminal pH below 5.0, as well as reduction in microbial groups fermenting of structural carbohydrates, decrease of microbial diversity. On other hand, animals fed on the diet consisting of high proportion of the bulky,

showed a ruminal pH close to neutrality, from 5.89 to 6.40, and high development of cellulolytic and hemicellulolytic microorganisms.

CONCLUSION

Eight different bacterial and protozoan species were isolated in the cowpea and groundnut haulms supplemented treatments compared to the control with subsequent improvement in the composition of microbial biomass that aided digestibility and rumen fermentation in the supplemented groups. Three fungal species were also isolated and identified. Cowpea hay and groundnut haulms could be supplemented at 300g/day/head for improving fermentation that could enhance digestion and assimilation with subsequent improvement in growth performance of Yankasa rams.

CONFLICT OF INTEREST

The author declares no conflict of interests.

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EFFECT OF FEEDING VARYING LEVELS OF BLACK-BINDWEED (*Falopia convolvulus*) MEAL ON GROWTH PERFORMANCE AND ECONOMIC EFFICIENCY OF GROWING RABBITS

Mohammed, S., Babale, M. D., Millam, J. J., and Kiri, Y. B.
Department of Animal Production, Adamawa State University, Mubi, Nigeria.
Correspondence: jacobjafiya@gmail.com +234806 150 4098

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ABSTRACT
A feeding trial was conducted to evaluate the effect of feeding black-bindweed (*Falopia convolvulus*) meal at varying levels in diets of growing rabbits. Four experimental diets were compounded to form a total mixed ration comprising the test materials and other feedstuffs. The feed comprised the control, 10BBW (10% black-bindweed), 20BBW (20% black-bindweed) and 30BBW (30% black-bindweed). The experimental feeds were pelleted before feeding to ensure efficient feed intake and utilization. The trial lasted for 8 weeks. A total of 20 growing New Zealand White rabbits weighing about 1 kg were used for the study. Five rabbits were randomly allotted to each of the dietary treatments in a completely randomised design, with each rabbit representing a replicate. The rabbits were weighed using a digital scale at the beginning of the study and subsequently weekly. Feed intake and feed conversion ratio (FCR) were also determined. The cost of feeds was determined using cost-benefit analysis. The data obtained were analysed using the SAS application package. The result revealed significant ($P<0.05$) effects for most of the parameters measured. The average daily weight gain, average daily feed intake and FCR values were better ($P<0.05$) in 30BBW (0.02 kg, 0.09 kg, 5.09, respectively) compared to the control. The feed cost/kg gain was lower in 30BBW (₦12,324.89) while the cost saving was higher in the same treatment with ₦3,217.83 compared to the control. It can be concluded from the study that 30% inclusion of BBW in diets of growing rabbits improved feed efficiency and promoted higher cost savings, and it is therefore recommended.

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INTRODUCTION

Rabbit production is an important agricultural activity, particularly in developing countries, as it provides a valuable source of animal protein and contributes to food security and income generation for small-scale farmers (Birolo, 2023). However, one of the major challenges facing rabbit farmers is the consumption rate of rabbits, which can account for up to 70% of the total production costs (Amber *et al.,* 2017). This financial burden can make rabbit production unsustainable for many smallholder farmers, limiting their ability to improve their livelihoods and meet the growing demand for animal-sourced foods (Alu *et al*., 2022). This challenge has prompted researchers to explore alternative, locally available feedstuffs that can serve as cost-effective sources of nutrients in rabbit diets (Amber *et al.,* 2017). One such potential feedstuff is *Falopia convolvulus*, a common weed found in many parts of the world.

Falopia convolvulus, also known as black-bindweed (BBW) or wild buckwheat, is an annual herbaceous plant that belongs to the Polygonaceae family (Costea *et al.,* 2005). Although the weed is abundantly available and cheap, it is considered a harmful weed in many agricultural systems due to its ability to compete with crops for resources and its prolific seed production (Follak and Essl, 2013). The weed can compete with crops for essential resources such as water, space, nutrients, and sunlight, leading to reduced crop yields (Blackshaw, 2008). Another issue associated with this weed is its resistance to herbicides (Uludag *et al.,* 2018). It will require heavy doses of chemicals to reduce its growth, which may affect the soil profile, leading to leeching of soil nutrients in cultivated crop lands, resulting in the greenhouse effect, the authors added. Additionally, BBW can have

allelopathic effects, releasing allelochemicals that inhibit the growth of nearby plants, including crops (Cheng and Cheng, 2015; Wu *et al.,* 2016). However, despite its weedy nature, some studies have suggested that BBW may have potential as a fodder crop or alternative feedstuff for livestock due to its relatively high protein and carbohydrate content (Wilson *et al.,* 2009; Millam *et al.,* 2023) which can be consumed by both sheep and goat (Millam *et al.* 2023). Sharma *et al.* (2013) also demonstrated that the weed is palatable, increases milk production and improves the overall animal performance. Because of these advantages, instead of using heavy chemicals to control the weed, it can be harvested and fed to livestock, which is a more environmentally friendly method of controlling it, thereby reducing the cost of input and labour while driving mutual benefit from it.

Furthermore, despite its potential, there is less research on the utilization of BBW as a regular feedstuff in rabbit diets. Rabbits have unique digestive systems and specific nutritional requirements that differ from other livestock species (de Blas and Wiseman, 2010), necessitating a comprehensive investigation of the suitability and potential impacts of incorporating alternative feedstuffs such as BBW into their diets. Therefore, this study aims to address this knowledge gap and provide valuable insights into the potential of this weed as a cost-effective and locally available feedstuff for rabbit production systems.

MATERIALS AND METHODS

Location of Study Area: The study was conducted at the Rabbit unit of Adamawa State University (ADSU) Teaching and Research Farm, Mubi Local Government Area (LGA). The area lies within the northern Guinea savannah zone of Nigeria. It is geo-located between latitude 10°16.6'6.9" north of the equator and longitude 13°16'1.2" East Greenwich meridian, with 560 meters above sea level. The dry season of the area commences in November and ends in March, while the wet season begins in April and ends in late October. The mean annual rainfall is about 1050 mm. The relative humidity is extremely low (20–30%) between January and March, but reaches a peak of about 80% in August and September. The maximum temperature can reach 40°C, particularly in April, while the minimum temperature is about 12°C between December and January (Meteorological Enclosure, 2024).

Ethical Consideration: All research protocols and use of animals were approved by Adamawa State University, Institutional Animal Care and Ethics Committee, with the approval number ADSUIACEC/2024/017. It certifies that the procedures adhere to the international standards on animal use and practice.

Source of Black-bindweed and Processing: Black-bindweed (BBW) was sourced from local agricultural fields and the surrounding areas of Mubi North LGA. It was harvested along with the leaves and twigs. After which it was thoroughly cleaned, air-dried, and pulverised into a fine powder using a local roller milling machine and kept safe before it was used in compounding the experimental diet as BBW meal.

Source of Rabbits and Management: A total of 20 growing New Zealand White rabbits weighing at least 1 kg were used for the trial. They were purchased from the Rabbit unit, ADSU Teaching and Research Farm. The rabbits were allowed one week of acclimatization to the experimental pen, where they were housed for the experiment. During this period, they were closely monitored for any sign of ill-health. Feed and water were supplied *ad libitum.* Groundnut haulms served as their basal diet during the period. During the experiment, metallic cages were used for housing the rabbits. The cages (made up of wire mesh) were equipped with individual feeders and drinkers. The cages were designed to house one rabbit at a time. Feed and water were supplied using an *ad libitum* feeding regime. The pen housing the cages was well ventilated, illuminated and had a concrete floor system. The trial lasted for 8 weeks.

Treatments and Design: Four diets were compounded to form a total mixed ration comprising the test materials (BBW) and other feedstuffs as presented in Table 1. The diets consisted of the control, which had no BBW meal but cowpea husk, 10BBW (10% black-

bindweed), 20BBW (20% black-bindweed) and 30BBW (30% black-bindweed). Each of the dietary treatments was palletised before it was supplied to the rabbits. This is to ensure efficient feed intake and utilization (McDonald *et al.,* 2010). The feeds were pelleted at the feed mill of the Department of Fisheries and Aquaculture, ADSU, Mubi. The diets were compounded to supply the basic nutritional requirements of the rabbits (MSD Manual, 2025). The study examined the four dietary treatments, which consisted of five rabbits randomly allocated to each of the dietary treatments in a completely randomised design. Each rabbit represents a replicate.

Table 1: Gross composition of the experimental diets

Ingredients (%)	Control	10BBW	20BBW	30BBW
Cowpea husk	30.00	-	-	-
Black-bindweed meal	-	10.00	20.00	30.00
Maize	10.32	15.79	11.25	8.54
Maize offal	25.65	36.94	29.51	22.07
Groundnut cake	12.19	14.22	14.99	15.76
Local brewers' residue	16.09	17.12	18.50	17.88
Fish meal	3.00	3.00	3.00	3.00
Bone meal	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50
Premix	0.25	0.25	0.25	0.25
Lysine	0.50	0.50	0.50	0.50
Methionine	0.50	0.50	0.50	0.50
Laboratory Analysis				
Energy (ME, kcal/kg)	3574.79	3298.79	3247.66	3262.02
Dry matter	94.02	91.00	94.02	94.37
Crude protein	14.54	17.97	21.00	22.72
Crude fibre	5.46	5.71	6.66	6.96
Ether extract	4.96	5.22	7.02	8.92
Ash	6.31	7.31	7.82	8.02
Nitrogen free extract	62.79	58.17	53.57	47.83

10BBW, 20BBW, 30BBW: level of inclusion of black-bindweed meal at 10, 20 and 30% respectively, which represents the treated groups, ME: metabolizable energy

Growth Trial: The rabbits were weighed using a digital scale (Camry®) at the beginning of the study and weekly thereafter. The feed intake was obtained by subtracting the leftover feed measured from the feed offered daily. The feed offered and left over were measured using a digital weighing scale (Scout™ Pro–SPU 202, 7124201019). Furthermore, the feed conversion ratio was computed as feed intake divided by the weight gained at the end of the trial.

Cost-benefit Analysis: A basic cost-benefit analysis was used to evaluate the potential cost-effectiveness of incorporating black-bindweed meal into the diets of rabbits. The analysis considered factors such as the cost of procuring and processing the plant material, the cost of other feed ingredients, labour, transportation, and water, among others. The estimates were made based on the prevailing market prices of feedstuff in the year 2024 (January–February). The cost/kg feed was computed as the unit cost of one kg of the feedstuff for the 100 kg formulated. The total cost of feed, also known as the cost of feeding, was obtained by multiplying the cost/kg feed by the feed intake of each rabbit. Feed cost/kg gain was calculated as the cost of feed divided by the total weight gained of each rabbit. While cost saving was realised as the feed cost/kg gain of the treated groups subtracted from that of the control diet.

Laboratory Analysis: Representative samples of the experimental diets were taken to the

Animal Nutrition Laboratory, Department of Animal Production, ADSU, Mubi, for proximate analysis. The analysis was determined using the procedures described by AOAC (2005). The metabolizable energy for the feed samples was estimated according to the formula of Pauzenga (1985) as cited in Kwari *et al.* (2014).

Statistical Analysis: All data obtained will be analysed using the Generalised Linear Models Procedure (PROC GLM) of SAS (2002). The effect of dietary treatment was tested at 95% confidence interval (P<0.05), and significant differences among the treatment means were established using Dunnett's test. The statistical model used was:

$$Y_{ij} = \mu + L_i + e_i$$

where:

μ = Overall mean,

L_i = Effect of the i^{th} dietary treatment,

e_I = all error terms are assumed to be random, normally distributed, and independent with expectations equal to zero

RESULTS AND DISCUSSION

Effects on Growth Performance

Table 2 shows the growth performance of growing rabbits fed diets containing black-bindweed (BBW) meal. Most of the parameters measured revealed significant (P<0.05) effects, except for initial weight, which was not significant (P>0.05). The total weight gain and average daily weight gain (ADWG) were higher (P<0.05) in the group of rabbits receiving 30BBW (1.21 and 0.02 kg, respectively) compared to the control diet (0.78 and 0.01 kg, respectively). The higher ADWG observed in this study was higher than that of 14.20 g recorded for 25 g/kg of sweet potato leaves fed as a replacement for pelletized concentrate feed (Abonyi *et al.*, 2012). The result might be attributed to high digestibility of protein, which may make amino acids available for protein metabolism that will promote higher weight gain (Mohammed *et al.*, 2020) or was influenced by the nutritive quality of the diet (Table 1).

Table 2: Growth performance in growing rabbits fed diets containing black-bindweed meal

Parameters	Control	10BBW	20BBW	30BBW	SEM
Initial weight (kg)	1.08	1.23	1.30	0.95	0.09^{NS}
Final weight (kg)	1.85^{b}	2.15^{a}	2.14^{a}	2.16^{a}	0.06
Total weight gain (kg)	0.78^{c}	0.93^{b}	0.84^{bc}	1.21^{a}	0.06
ADWG (kg/rabbit/day)	0.01^{b}	0.01^{b}	0.01^{b}	0.02^{a}	0.00
Total feed intake (kg)	4.69^{b}	4.92^{b}	4.82^{b}	5.61^{a}	0.26
ADFI (kg/rabbit/day)	0.07^{c}	0.08^{b}	0.08^{b}	0.09^{a}	0.00
Feed conversion ratio	7.44^{a}	6.25^{ab}	6.12^{ab}	5.09^{b}	0.99

^{abcd}: Means with different superscript on same row are statistically different at 95% confidence interval, 10, 20 and 30BBW: 10, 20, 30% inclusion of black-bindweed meal, ADWG: average daily weight gain, ADFI: average daily feed intake, NS: not significant, SEM: standard error of means

Regarding total feed intake and average daily feed intake (ADFI), it was observed to be higher (P<0.05) in the group of rabbits fed 30BBW (5.61 and 0.09 kg, respectively) compared to the control diet (4.69 and 0.07 kg, respectively). Similarly, the higher ADFI observed was higher than 44.83 g recorded for rabbits fed 25 g/kg sweet potato leaves as a replacement for pelletized concentrate feed (Abonyi *et al.*, 2012). The result might be attributed to the palatability of the diet resulted from the higher levels of soluble carbohydrates (Table 1) or due to higher digestibility of crude fibre which may trigger less retention period for the diet in the gut, consequently leading to more intake of the diet (Millam, 2023). Similarly, higher intakes in the dietary groups with the test material by the rabbits suggest that the inclusion levels of the forages did not affect the acceptability of the diets by the rabbits (Osei *et al.*, 2024). Besides, the authors added, the intake and the survivability of all the rabbits during the experiment suggest that the diets were of good nutritive quality.

Feed conversion ratio (FCR) is the most extensively used parameter to express the efficiency of converting feed to live weight

gain (Osei *et al.*, 2024). The FCR value (5.09) was the least (P<0.05) in the group of rabbits receiving 30BBW compared to the control diet (7.44). The least FCR (5.09) observed in this study was higher than the range of values (2.41–4.95) recorded for rabbits fed sweet potato leaves as a replacement for pelletized concentrate feed (Abonyi *et al.*, 2012). The least result observed in this study might be attributed to the efficient utilization of the diets by the rabbits due to the inclusion of BBW meal.

Effects on Economic Profitability

The economic efficiency of producing growing rabbits fed diets containing varying levels of BBW meal is presented in Table 3. The cost/kg feed observed in this trial was seen to be lower in the control group (₦2,584.93), followed by the group of rabbits receiving 10BBW (₦2,644.79) compared to the other treatments.

Table 3: Economic proficiency of feeding black-bindweed meal in diets of grower rabbits

Parameters	Control	10BBW	20BBW	30BBW
Cost/kg feed (₦)	2584.93	2644.79	2645.13	2658.31
Total feed intake (kg)	4.69	4.92	4.82	5.61
Total cost of feed (₦)	12123.32	13012.36	12749.53	14913.12
Total weight gain (kg)	0.78	0.93	0.84	1.21
Feed cost/kg gain (₦)	15542.72	13991.78	15178.01	12324.89
Cost saving (₦)	-	1550.94	364.71	3217.83

10, 20 and 30BBW: 10, 20, 30% inclusion of black-bindweed meal

This lower cost in 10BBW might be attributed to the cost of conventional feed being cheaper at the time of purchase of ingredients during which the trial was conducted, or because the level of inclusion was less than the others. Although the BBW was obtained at a cheaper rate, the cost of labour and other costs accrued from transportation, among others, might have led to the test material having some high-cost value. It was also observed that the cost of feed increases as the level of inclusion of BBW increases.

The total cost of feed was observed to be lower in the control diet (₦12,123.32) followed by 20BBW (₦12,749.53) compared to the other treatments. The lower total cost of feed in 20BBW might be attributed to the lower feed consumed by the rabbits in the treatment groups. This result was divergent from the findings reported by Adamu *et al.* (2013), who documented a low cost of feed consumed in the treatment group, where less test material was added. Nevertheless, it was consistent with their findings on total feed intake, which recorded lower total feed cost as feed intake reduced.

Lower feed cost/kg gain was observed to be lower in the group of rabbits receiving 30BBW (₦12,324.89) while maintaining a higher cost saving (₦5,414.81) compared to the control diet (₦15,542.72). The observed result on feed cost/kg gain might be attributed to lower feed consumption in the same treatment. A similar observation was made by Ishaya *et al.* (2025), who documented their findings indicating that lower feed cost per kg gain has been consistent with lower cost of feed consumed. Higher cost savings might be due to lower feed cost/kg gain. It was reported previously that higher cost savings can be attained due to lower feed cost/kg gain (Osei *et al.*, 2024). Concerning the economy of gain, diet 30BBW is much better than others. Even though the control diet and 20BBW contributed economically to the cost/kg and total feed consumed, the study suggests that the best biological and economic returns related to this trial were obtained in the 30BBW group.

CONCLUSION AND RECOMMENDATION

From the results of the study, it was agreed that inclusion of 30% BBW in the diets of growing rabbits improved feed efficiency by 2.35 and promoted higher cost saving by ₦3,217.83, and it is therefore recommended.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

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INFLUENCE OF FEVER BARK STEM BARK EXTRACTS ON ESTRUS SYNCHRONIZATION AND REPRODUCTIVE PERFORMANCE OF BUNAJI HEIFERS IN ADAMAWA STATE

Efusiauten, O. N., Bobbo, A. G., and Ardo, M. B.
Department of Animal Science and Range Management, Modibbo Adama University, Yola, Adamawa State Nigeria
Corresponding author's E-mail: obadiahnoah@yahoo.co.uk

Keywords: Crossopteryx febrifuga, Extracts, Heifers, $PGF_2\alpha$, Synchronization

ABSTRACT

This research conducted to assess the efficacy of Crossopteryx febrifuga (fever bark) stem bark extracts on estrus synchronization of Bunaji heifers. Fifteen Bunaji heifers aged between three and four years and two bulls were used to determine the onset of estrus and conception rates. The heifers allotted to five different treatment groups, T_1, T_2, T_3, T_4, and T_5, for ethyl acetate, ethanol, aqueous extracts, $PGF_2\alpha$ and placebo as positive and negative controls respectively. Each treatment was replicated three times. Of the three heifers administered with ethyl acetate, a heifer displayed heat within 24-46hrs, one heifer in 48-72hrs and the remaining heifer greater than 96 hrs. Similarly, animals administered with Ethanol, one showed heat within 24 -48hrs, one in 48-72hrs and one above 96hrs. Furthermore, one heifer came on heat in 48-72hrs and the remaining two greater than 96hrs after the administration of aqueous extracts. Two heifers showed heat in 24-48 hrs, while the remaining in 48-72hrs when administered with $PGF_2\alpha$. All the heifers in control group were negative. The presence of squamous epithelial cells, cornified epithelial cells, and spermatozoa in the heifers administered with the extracts and $PGF_2\alpha$ is a confirmation that the heifers were on heat. The estrus and conception rates were 100,100,100 and 66.67% for Ethyl acetate and Ethanol, $PGF_2\alpha$ and Aqueous extracts respectively. $PGF_2\alpha$, ethyl acetate, and ethanolic extracts were better synchronizing agents compared to the aqueous extract indicating that the extracts contained phytochemicals and hormones of veterinary importance. Ethanol and ethyl acetate extracts recommended as alternative to synthetic synchronizing agents.

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INTRODUCTION

Estrus synchronization involves manipulating the estrous cycle within a herd to express estrus approximately at the same time, or the manipulation of estrus to bring a large percentage of group of females into estrus at a short-predetermined time (Odde, 1990). It is very useful in large herd size where individual animal monitoring is difficult and often subjective or because small intensively managed herds are milked in robotic systems that minimize animal staff interactions (Macmillan, 2010). The term "estrus" refers to the phase of the estrus cycle in which a sexually mature non- pregnant female is receptive to mating. This period commonly often referred to as "heat period". This periodic pattern of sexual receptivity is the result of organized and complex hormonal changes that occurs in the reproductive system of cattle (Xu, 2011). Ovulation occurs at approximately this time, depending on the specie of animal. It is the process of targeting female mammals to come on to heat within a short time from (36 to 96 hours). This is achieved through the use of one or more hormones. It optimizes labour and time and improves the ease of using artificial insemination (AI) **(**Lamb *et al.,* 2010**)**. Furthermore, estrus synchronization is a labour saving breeding management tool effective in artificial insemination (AI) and embryo transfer program. Groups of females benefited in perspective of parturition by decrease labour, decrease calving period; reduce calving season

and more uniform weaning weights. It synchronized by a large group to ovulate at same time, helps in scheduling the parturition time at most favourable season when the new-borns can be reared in suitable environment with ample food for better survivability and at the same time also facilitates short calving season, reduce labour required for AI breeding, marketing of uniform calf crop (same age) and improves management practices (cattle grouped - closer observation, better feeding practice etc.). Estrus synchronization has a number of advantages but still possess few problems in its practical use like low conception rates, expensiveness, skilled labour etc. (Prajapati *et al.,* 2019).

WHO (2023) has recognized the value and imperative need for adopting traditional herbal practices in global health care and recommended all member countries to promote native herbs of their country as well as to initiate steps to conserve and/or cultivate herbal plants, so that genuine raw materials become readily available to large section of the population. Ethno Veterinary Practices (EVPs) have significant contribution in maintenance of animal health and regarded as sustainable veterinary medicine in the new era (Lin *et al*., 2003). The increase in the use of herbal products is due to their cultural acceptability, availability, affordability, efficacy and safety claims. Herbal products are considered today to be the symbol of safety in contrast to the synthetic drugs that are regarded as unsafe to human beings, farm animals and environment. The blind dependence on synthetics is over and people are returning to the natural with hope of safety and security. It is time to promote them globally (Khan, 2016; UNESCO, 1998).

Therapies involving herbal products like extracts derived from *C. febrifuga* have shown promising potential but many of such products remain untested and their use are either poorly monitored or not even monitored at all. Medicinal plants have been utilized for centuries across various cultures for treating both human and animal diseases. The increasing interest in natural product research necessitates systematic studies of traditionally used plants like *Crossopteryx febrifuga* which has been employed in West African ethno veterinary medicine but remains insufficiently investigated scientifically (Ajaiyeoba *et al*., 2006). *Crossopteryx febrifuga* commonly known as “fever bark” is a small tree widely distributed across tropical Africa. It is commonly found in all parts of Nigeria and known as Ayeye among Yorubas in Nigeria (Ojewale, 2014). Hausa people of Northern Nigeria call it Kasfiya, Hashin Awaki or Giyayyata (Halilu *et al*., 2012). Traditional healers have utilized various parts of this plant to treat fever, dysentery, pain and reproductive disorders in livestock (Halilu *et al.,* 2012). It is widely used in the management of malaria, fever and painful inflammatory disorder (Adeola *et al.,* 2011). It is used traditionally for symptomatic relief of dry cough and for treatment of respiratory infections, fever, dysentery and pain. The decoction of the stem bark is used in central Africa as an antipruritic lotion. The infusion of the root bark is used in treatment of fever, malaria, diarrhoea, intestinal worm and opthalmia and for application to wounds (Edeoga *et al.,* 2005). It has been reported that the crude methanolic extract contains biologically active substances with potential values in the treatment of Trypanosomiasis, Malaria, *Staphylococcus aureus* infection (Yusuf *et al.,* 2006; Hostettmann *et al.,* 2000). Salawu *et al.* (2009) have reported that the extract possesses analgesic, antipyretic and anti-inflammatory activities. There are claims by some herbal practitioners that the aqueous roots extract of *C. febrifuga* is effective in the management of Diabetes and diabetic complications (Ojewale *et al.,* 2014).

So far, there is dearth of information and very limited research findings on the use of *C. febrifuga* as synchronizing agents and the management of infertility in cattle in this environment.

MATERIALS AND METHODS

The Study Area

The experiment carried out in Duware, 2km away from Yola south metropolis. Yola South Local Government created in 1996 and has an area of 719km^2. The Local Government bounded to the North by Yola North and Girei, East and South by Fufore and to the West by Demsa Local Government area of Adamawa. It lies at Latitude 9^0 and 14^1 North and Longitude 12^0 and 28^1 East and altitude of about 152 Metres above sea level and it cover an area of

about 54 hectares. The climatic conditions of the area are constant. The temperature of the area is high throughout the year, with the maximum temperature of about 42^0C observed with minimum temperature range of between 26.9^0C and 27.8^0C. The rainfall shows a variable element of tropical climate to which most of the characteristics such as amount, frequency and intensity vary widely with time (season), it usually starts during the month of April to October with an annual range of 1500 – 2000 per annum and this is accompanied by high relative humidity (Alexander, 2015). The relative humidity is very low between January and March about (20-30%) which will starts increasing from April to reach its peak in August and late September, while the cool dry harmattan starts in November to February (Adebayo, 2010). The study area falls within the North Guinea Savannah vegetation zone and has a tropical wet and dry climate. The zone is characterized by high grassland with shrubs and fewer trees. Yola South has a population density of 386, with Yola town, Namtari, Ngurore, Njoboli and Yolde pate as the major settlements (Adebayo *et al*., 2020)

Plant Collection and Identification

The stem bark of *C. febrifuga* plant collected from Sebore farm, Mayobelwa Local Government Area of Adamawa State. The plant identified by the staff of the Department of Forestry and Wildlife of Modibbo Adama University Yola with voucher number 1576 (*Crossopteryx febrifuga*). The stem bark was shade-dried at room temperature for 14 days in a clean environment to avoid contaminations. The sample was grinded into fine powder using pestle and mortar. The powdered plant sample was stored in appropriate container until required for use.

Extraction Methods

Three extraction methods were used and these are: Solvent extraction method using ethanol, solvent extraction method using ethyl acetate and solvent extraction method using aqueous

Solvent Extraction Method Using Ethanol.

Extract of the stem bark was made by maceration method using 95% Ethanol. After vigorous shaking to ensure thorough mixing, it was allowed to settle for 48 hours. The solution was filtered using cheese cloth and allowed to evaporate in an oven at a temperature 50^0 C. A dark green residue obtained after the evaporation process is the ethanol extract.

Solvent Extraction Method Using Ethyl Acetate

Extract of the plant was made by maceration method using ethyl acetate as a solvent. Two hundred (200) grams of shade dried stem bark powder was extracted with ethyl acetate for 72 hours at room temperature. The extract was filtered through cheese cloth and through Whatman filter paper No 1. The filtrate was evaporated to 500ml at room temperature and then in a vacuum concentrator. The dried powder obtained was stored in a sterile glass bottle and used for the research as described by Javarappa *et al*. (2016).

Solvent Extraction Method Using Aqueous

A standard method was used to obtain the aqueous extract by boiling the powder of the stem bark in water at a temperature range of 60-80^0 C for approximately 20-30 minutes and the mixture filtered through Whatman filter paper to obtain the aqueous extract used for the research.

Experimental Animals

Fifteen (15) Bunaji (White Fulani) heifers aged between three and four years and two (2) bulls with average body condition score (BCS) of 6 were used in the study. The animals were managed semi - intensively throughout the study period which lasted for over three (3) months.

Routine Management

The heifers and bulls were treated with Oxytetracycline for promoting and boosting the general health condition of the animals, Multivitamins to enhance or improve the appetite and libido of the animals, Ivermectin for control of both internal and external parasites. The animals were adequately fed with maize bran, cotton seed cake, fresh grasses/shrubs, salt lick and watered ad libitum.

Heat Detection

Heat is a short period of sexual receptivity of open cows and heifers, normally occurring in every 18-24 days. Each synchronized heifer was observed for primary and secondary signs for heat detection. The primary sign is standing still for mounting, while the secondary signs are, mount other heifers, friendly disposition, clear mucus from vagina and swollen vulva. A minimum of 30 minutes three times in a day

was spent watching the heifers for standing heat detection as described by Smith (1994).

Kamar heat mount detector was also used to detect heat. Kamar heat mount detector is a pressure sensitive device with in-built timing mechanism that is activated by standing heat behaviour. When glued onto the tail head of the heifer, pressure from the brisket of a mounting bull turns the detector from white to red in about three seconds (M'Barek, 2003).

Experimental Design

Fifteen (15) bunaji heifers aged between three (3) and four (4) years and two (2) bulls with good body condition score were used in the study. The heifers allotted to five (5) different treatments. Each treatment was replicated three times. Heifers were administered the following - ethanol, ethyl acetate and aqueous extracts, prostaglandin ($PGF_{2\alpha}$) and distilled water (placebo) as positive and negative control for groups 1,2,3,4, and 5 respectively. Kamar heat mount detector was glued onto the tail head of each of the heifers which were ear tagged for heat detection and easy identification respectively. Two bulls were introduced for natural breeding immediately after the administration of the extracts with uniform concentration of 20% in 2mls intramuscularly per heifer, $PGF_{2\alpha}$ – 2mls (standard dose) and placebo (2mls) per heifer through intramuscular injection (IM). Vaginal swabs of each of the heifers with positive signs of estrus as indicated by Kamar heat mount detector were collected in transport media (neutral formalin) and analysed for vaginal cytology in the laboratory as confirmatory test for estrus.

Statistical Analysis

Simple descriptive statistics (percentage) was used to determine the onset of estrus, estrus response rate and conception rate.

RESULTS

Confirmation of Estrus by Vaginal Cytology

The result of vaginal cytology revealed that two of the heifers treated with Ethyl Acetate extract of *C. febrifuga* (stem bark) showed the presence of moderate positive (++) squamous epithelial cells while one heifer showed positive (+) presence of squamous epithelial cells. Two heifers treated with the same extract showed positive (+) presence of cornified epithelial cells while one heifer showed moderate positive (++) presence of spermatozoa and two heifers showed positive (+) presence of spermatozoa.

Three of the heifers treated with Ethanolic extract of *C. febrifuga* (stem bark) showed positive (+) presence of squamous epithelial cells and spermatozoa while one heifer shows positive (+) presence of cornified epithelial cells.

One of the heifers treated with Aqueous extract of *C. febrifuga* (stem bark) showed strong positive (+++) presence of squamous epithelial cells and two heifers showed positive (+) presence of squamous epithelial cells while two heifers treated with the same extract showed moderate positive (++) and one heifer showed positive (+) presence of spermatozoa respectively. The result also revealed that one of the heifers treated with prostaglandin (PGf_2 alpha) showed moderate positive (++) presence of squamous epithelial cells and two heifers treated with same synchronizing agent showed positive (+) presence of squamous epithelial cells while two heifers showed strong positive (+++) presence of spermatozoa and one heifer showed moderate positive (++) presence of spermatozoa.

None of the heifers treated with Placebo (Negative control) showed the presence of all parameters as seen in Table 1.

Onset of Estrus and Estrus Response Rate

There were variations in the onset of heat when the bunaji heifers administered with different plant extracts and $PGf_2\alpha$. Of the three heifers administered with ethyl acetate, a heifer displayed heat within 24-48hrs, one heifer in 48-72hrs and the remaining heifer greater than 96 hrs. Similarly, animals administered with Ethanolic extract, one heifer showed heat between 24 -48hrs, one in 48-72hrs and one above 96hrs. Furthermore, one heifer came on heat in 48-72hrs and the remaining two heifers showed heat greater than 96hrs after the administration of aqueous extracts. Two heifers showed heat in 24-48 hrs, while the remaining in 48-72 hrs when administered with $PGf_{2\alpha}$, All the heifers in control group were negative. The estrus and conception rates were 100,100,100 and 66.67% for Ethyl acetate, Ethanol, $PGf_2\alpha$ and Aqueous extracts respectively.

Table 1: Confirmation of Estrus by Vaginal Cytology

S/N	Test	Features of vaginal cytology	Outcome of vaginal cytology at the time of estrus											
			24 – 48 hours			72 – 96 hours					>96 hours			
			A	B	C		A	B	C			A	B	C
1	T_1	Squamous epithelial cells	++	-	-		-	+		-		-	-	++
		Cornified epithelial cells	+	-	-		-	+		-		-	-	-
		Spermatozoa	++	-	-		-	+		-		-	-	+
		Pus cells	+	-	-		-	-		-		-	-	-
2	T_2	Squamous epithelial cells	+	-	-		-		+	-		-	-	+
		Cornified epithelial cells	-	-	-		-		+	-		-	-	-
		Spermatozoa	+	-	-		-		+	-		-	-	+
3	T_3	Squamous epithelial cells	-	-	-		+		-	-		-	+++	+
		Cornified epithelial cells	-	-	-		-		-	-		-	++	-
		Spermatozoa	-	-	-		++		-	-		-	++	+
4	T_4	Squamous epithelial cells	++	+	-	-			-	+	-		-	-
		Cornified epithelial cells	-	-	-		-		-	-	-		-	-
		Spermatozoa	+++	++	-	-			-	+++	-		-	-
5	T_5	Squamous epithelial cells	-	-	-	-			-	-	-		-	-
		Cornified epithelial cells	-	-	-	-			-	-	-		-	-
		Spermatozoa	-	-	-	-			-	-	-		-	-

Keys

T_1 = Ethyl acetate extract T_2 = Ethanol extract

T_3 = Aqueous extract T_4 = PGf2α (Prostaglandin)

T_5 = Placebo ++ = Moderate positive

+++ = Strong positive - = Nil/Negative

> = Greater than + = Positive

Table 2: Onset of Estrus, Estrus and Conception Rates of Bunaji Heifers Administered with different extracts, $PGf_2\alpha$ and Placebo

			Time of onset of estrus (hrs)					Response rate (%)	
Synchronizing agent	No of heifers	Heifers age (years)	0-24 hrs	24-48hrs	48-72hrs	72-96hrs	>96hrs	Estrus	Conception
Ethyl acetate extract	3	3-4	0	1(33.33)	1(33.33)	0	1(33.33)	3(100)	3(100)
Ethanol extract	3	3-4	0	1(33.33)	1(33.33)	0	1(33.33)	3(100)	3(100)
Aqueous extract	3	3-4	0	0	1(33.33)	0	1(33.33)	2(66.67)	2(66.67)
$PGF_2\alpha$	3	3-4	0	2(66.67)	1(33.33)	0	0	3(100)	3(100)
Control	3	3-4	0	0	0	0	0	0	0

DISCUSSION

The presence of spermatozoa, squamous epithelial cells and cornified epithelial cells as confirmed by vaginal cytology has shown that the heifers treated with the various extracts of *C. febrifuga* and prostaglandin ($PGf_2\alpha$) were at the various stages of estrus. This is in agreement with Suebkhampet and Chaikhun-Marcou (2024); Siregar *et al*. (2016) who observed that there are histological changes in the vaginal mucosa of the cow during oestrus cycle and following exogenous hormone such as estraidiol benzoate and progesterone treatment. The positive (+) presence of pus cells in one of the heifers treated with ethyl acetate extract of *C. febrifuga* could be as result of contaminants during the time the vaginal sample was taken for cytology.

Eight (66.67%) heifers administered with synchronizing agents in this study exhibited signs of estrus within 48-72hrs and this is partly in agreement with Lemaster *et al.* (2001) who reported that 60% of cross bred cows used in their study showed estrus 48-72hrs after $PGF_2\alpha$ injection. All the remaining heifers displayed heat within 14 to 21 days of administration and is in in agreement with Kebede *et al.* (2013) who reported that heat detection period should be extended to 7 to 10 days or more as most of the cows studied came to standing estrus after mass synchronization operation was concluded.

The variation in the onset of estrus exhibited by the animals may be due to the stage of follicular development at the time $PGF_2\alpha$ in T_4 and other test substances in T_1, T_2, and T_3 were administered which after affected the interval from ovulation to standing heat. Another reason for the variation in the onset of estrus could be due to the physiological response of the animal at the time of injection of the test substances (Repasi *et al.,* 2003).

Estrous synchronization will not substitute for lack of nutrition, herd health or poor herd management and it is not effective in non – cycling females (Tom, 2012). The development of methods to control estrous cycles of the cow has occurred in various distinct phases. Regulation of estrous cycle was believed to be associated with control of the corpus luteum whose life span and secretory activity are regulated by trophic and lytic mechanisms (Patterson *et al.,* 2003). Numerous estrous synchronization protocols developed that use a combination of different drugs and products to alter hormonal changes in the female's estrous cycle. Since different reproductive hormones are used in estrous synchronization, developing a basic understanding of several reproductive hormones is helpful for determining which protocol will work best (Ted and William, 2017).

The results also indicated that the heifers responded positively to the stem bark extracts of *Crossopteryx febrifuga* and the plant contained the bioactive compound that has ability to regulate female reproductive cycle by ensuring the regression of corpus luteum (luteolysis), initiating the development of new follicles, guarantee ovulation and reinitiate the releasing of progesterone to maintain the pregnancy as reported by Bobbo *et al.* (2021).

CONCLUSION

The study revealed that extracts of *Crossopteryx febrifuga* (stem bark) are effective in synchronization and conception of our indigenous heifers aged between three (3) and four (4) years. Comparison of the extracts and $PGf_{2\alpha}$ in terms of estrus synchronization and conception rates showed that ethyl acetate, ethanol extracts and $PGf_{2\alpha}$ are better synchronizing agents than the aqueous extract.

RECOMMENDATIONS

Extracts of *C. febrifuga* (stem bark) can serve as alternative to synthetic synchronizing agents like $PGF_2\alpha$ which are scarce, costly and less acceptable to our local livestock farmers. Further studies on the pharmacological activities of *C. febrifuga* should be investigated in animals.

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ASSESSMENT OF EFFECTS OF DEFORESTATION ON FOREST RESOURCES CONSERVATION IN BENUE NORTH-WEST, NIGERIA

[1]*Origbo, B. U., [1]Shomkegh, S.A., [1]Orshio, T. R., and [1]Aondoakaa, M.A.
[1]Department of Social and Environmental Forestry, College of Forestry and Fisheries, Joseph Sarwuan Tarka University Makurdi, Benue State Nigeria.
*Correspondence author: utabeno2006@gmail.com; +2348066366134

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ABSTRACT

Anthropogenic activities are causing Benue State's forests to disappear, and some academics have proposed that urban forest management and community involvement can slow the rate at which forest resources are being destroyed. Therefore, the purpose of this study was to assess the effects of deforestation on forest resources conservation in Benue North-West, Nigeria. 392 respondents were chosen using a stratified random sample technique with multiple stages. Both descriptive and inferential statistics were used in the collection and analysis of the data. The effects of deforestation on the conservation of forest resources in the research area were similarly measured using a Likert scale assessment. The study's findings showed that animal grazing (ANG), farming operations (FMO), charcoal production (CHP), infrastructure development (IFD), population expansion (POP), and forest fire (FOF) were the main causes driving deforestation. With a probability coefficient of 1.9%, the manufacturing of charcoal was determined to be the primary cause of deforestation in the research area. Illegal logging and farming operations came in second and third, with probability coefficients of 1.88% and 1.86%, respectively. According to the study, the main impacts were habitat destruction, biodiversity loss, desert encroachment, rising temperatures, plant and animal extinction, soil degradation, water body loss, pollution, and climate disruption. The main detrimental consequences of deforestation on forest resources were determined to be habitat destruction (WMS=4.2>3.05), followed by soil degradation which exhibited moderate effects (WMS=2.99 < 3.05), whereas pollution was evaluated as having the lowest effect (WMS=2.49 < 2.95). According to the findings, deforestation can harm the diversity of plants and animals, resulting in erosion, flooding, and the loss of important commercial and medicinal trees. To stop the effects of deforestation, it is advised that people use farming practices that promote afforestation and replanting.

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INTRODUCTION

Forests are vast areas of land predominantly defined by densely-tall woody and non-woody vegetation as well as other communities of flora and fauna in symbiotic relationships (Olagunju, 2015). Forest is an intricate system made up of plants and trees that protect biodiversity, providing home to terrestrial, aquatic and improving the quality of life forms on earth According (Popoola, 2014). to the Food and Agriculture (2002), a forest is an area where trees cover ten percent or more of the land. Onyeanusi and Otegbeye (2012) described forests as huge tracts of land covered with densely growing trees and shrubbery. According to Tee (2010), forests serve as stores of a variety of goods and service that human's need on a daily basis to meet their basic needs. Timber and non-timber forest products (NTFPs), often known as non-wood forest products (NWFPs), are the two main categories into which forest products are typically divided. According to Eleanya (2014), forest resources continue to be essential to the survival of homes,

communities, and countries in a variety of ways.

They provide food, fuel wood, wood for furniture and other non-timber forest products for households' consumption. Udo (2013) observed that, forests and forestry contribute to human wellbeing through food security, job creation, and poverty reduction and as well act as phyto-medicinal cures for diseases. They play critical role for environmental beautification, biodiversity conservation, ecotourism and mitigation of climate change and environmental degradation.

Eleanya (2014) and FAO (2005) posited deforestation is a process where vegetation is cut down for economic or social reasons without any simultaneous replanting. Odediran *et al.* (2013) reported that, global deforestation is threatening environmental sustainability and the very high rate of deforestation in Nigeria has detrimental effect. Ogunwale (2015) and Adebayo (2010) opined that, deforestation simply put is the clearing away of forests. It is the process by which an area gets stripped of its natural forest vegetation and resources. This can be caused by systematic felling, indiscriminate logging, or the complete removal of existing vegetation for arable agriculture or industrial uses. It typically causes destabilization of forest ecosystems and the surrounding environment.

As a result, it is clear that much of the State's vegetated land area is currently being used for agricultural purposes (SIGWA, 2001). However, the rate and intensity at which farming operations negatively affect the vegetation may vary, depending on the nature of the modernization of the farming activities and the level of awareness of the farmers (Nyagba, 1995; SIGWA, 2001; Adeola et al., 2004; Therefore, the purpose of this study is to assess the effects of deforestation on the forest resources conservation in Benue, northwest Nigeria.

MATERIALS AND METHODS

Study Area

Benue State is one of the states located within the north central geopolitical zone of Nigeria. Geologically, it falls within the Benue trough from where the State derives its name. It lies between Lat. 6 º 5' and 8 º 5'N and Long.7 º 47' and 10 º E (Ocheri and Ahola, 2014). The State shares boundary with Nassarawa state in the north and Taraba State in the northeast. In the south, it shares boundary with Cross River State, while the southwest boundary is shared with Enugu and Ebonyi States respectively (Halima and Edoja, 2016). To the west, it is bounded by Kogi State, while a short international boundary is shared with the Republic of Cameroon around Kwande LGA (Nyagba, 1995).

The study area is drained principally by River Benue and its tributary, the river Katsina-Ala. Other rivers include Aya, Guma, Konshisha, Logo, Okpokwu, Obi, and Oyongo. The climate of the area is controlled by two major air masses, namely South-West trade wind and North-East trade. Benue State fells within the Koppen's Aw climate Classification which experiences marked wet and dry seasons. Rainfall in Benue State averages seven (7) months in the year with annual total, ranging from 1,200 – 2,000mm from May to October (Nyagba, 1995). Annual rainfall total is generally higher in the Southern parts of the state than the Northern parts and this is clearly reflected in the lusher and denser nature of the vegetation (Ologunorisa and Tersoo, 2006).

Dry season is dominated with dry dust laden harmattan wind originating from Sahara Desert. Temperature in the study area is particularly high in the months of March and April.

The vegetation is characteristically that of the tropical moist and wet forest with a well-defined three-layer structure in much of the region. This vegetation ranged from mangrove and swamp forests in the coastal south to tropical rain forests to the savannah woodland in the northern part of the state (Fon et *al.*, 2014). The parent materials forming soil in Benue State are largely of sedimentary origin. These produce the deep loamy soils, the basis of agricultural production in most parts of the State. The soils are fine-textured with poor internal drainage. A common feature of the soils is the movement of clay within the soil profile.

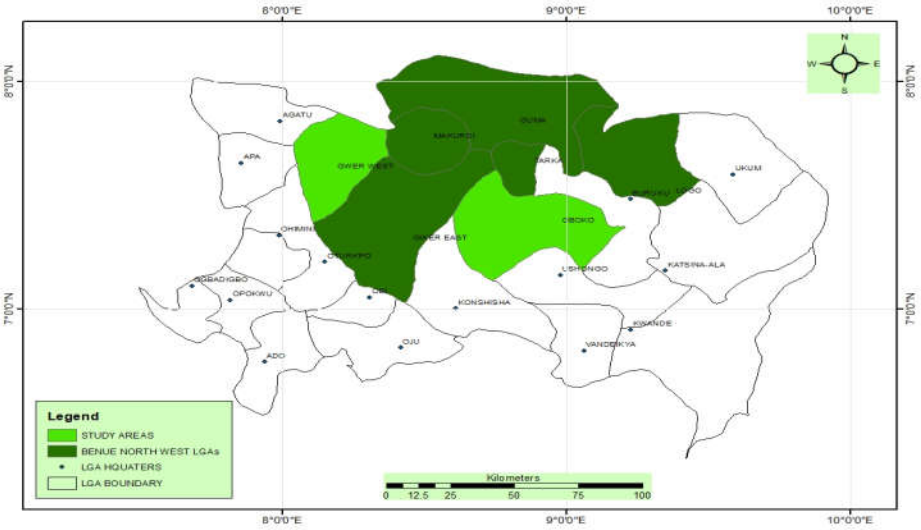

Figure 1: Map of Benue State
Source: Remote Sensing and GIS Laboratory, Geography Department, Federal University of Technology, Minna.

Sampling Techniques

A multi-stage and stratified random sampling technique was adopted in sampling the population for the study to evaluate the effect of deforestation in Benue North West.

Stage 1: Out of seven (7) LGAs in Benue North-West, two (2) were randomly selected at 30% sampling intensity as used by (Dagba *et al.,* 2017).

Stage 2: 5% localities were randomly selected from each of the two LGAs using the 1991 Population figure.

Stage 3: the 1991 population figure of the selected localities was projected to 2019 using 2.8% growth rate. The numerical expression for the 2.8% growth rate is shown below;

$P_t = P_o (I+r)$

Where; P_t = population projection figure for 2019 for any locality

P_o = existing population as at 1991

L = Constant

r = population growth rate (2.8% = 0.0028)

t = number of years population was projected (2019 – 1991 = 28years) (Jennifer. *et al*., 2007; Buba *et al*., 2017).

Stage 4: Taro- Yamene (1967) formula at 5% error degree of tolerance was used for determination of the projected population sample size as shown below;

$$n = \frac{N}{l+N\,(e)^2}$$

Where;

n = projected population sample size

N = Total size of projected population

l = Constant

e = error degree of tolerance 0.005 as used by (Dagba *et al.,* 2017)

The sample size of each locality was determined using the formula.

$$n = \frac{n \times Nh}{N}$$

Where; nh = Locality sample size

n = projected population sample size

Nh = Locality population (projected)

N = Total size of projected population

The entire sample size for the study was 392

Data Collection

Primary and secondary sources were used to gather data for the study. The study's primary data entail using a semi-structured questionnaire, conducting in-person observations of the factors driving deforestation in the study region, and visiting the study area to gather firsthand information on the geography, people, climate, and natural vegetation. The purpose of the semi-structured

questionnaire was to gather data on the human factors that contribute to deforestation and how deforestation affects the preservation of forest resources in the research region. Prior to being given to the respondents, the questionnaire underwent pre-testing and validation. Thus, 392 respondents who were sampled for the study were given the validated questionnaires. The study's secondary data was gathered through a survey of the literature from books, theses, and dissertations.

Data Analysis

The primary data collected were analyzed using appropriate statistical tools as shown below;

Descriptive statistics such as frequency mean and percentages were used to analyze the socioeconomic characteristics of respondents in the study area. Binary Logistic Regression (BLR) Model was used to ascertain the factors influencing deforestation in the study area (Ogunwale 2015). While a five point Likert scale rating format uesd by Emaikwu, (2011) was adopted to measure the effects of deforestation in the study area. The weighting scale was derived from the following values with respect to effects of deforestation; Very High (VH) = 5, High (H) = 4, Moderate (M) = 3, Low (L) = 2, Very Low (VL) =1 (Dagba *et al*., 2017).

RESULTS AND DISCUSSION

Results

Socio-economic characteristics of respondents in Benue North West, Nigeria

Table 1 present the findings on the socioeconomic characteristics of the respondents in Benue North-West, Nigeria. The findings showed that 76.80% of respondents were men and 23.20% of respondents were women. This demonstrated that there were more men than women engaged in deforestation operations. The age distribution of respondents showed that the largest percentage of respondents—35.5%—were between the ages of 31 and 40, Followed with 41 and 50 (26.80%). However, 13.5% of respondents were 50 years of age or older, while 24.2% of respondents were under 30.

On household size, 54.3% had 6 – 10 persons, followed by 30.60% with 11 – 15 persons while 10.5% had 1 – 05 persons. Based on ethnicity, this study identified two major ethnic groups; Tiv (99.70%) and Junkum (0.30%). This implies that, most of the study population within Benue North West, Nigeria was Tiv. This also revealed that, majorities of respondents of the study population do not acquire formal education (36.20%) while 25.80%, 22.20% and 15.80% had first school leaving certificate (FSLC), secondary and tertiary education qualification.

The study found that 71.20% of respondents were married, whereas 11.70%, 10.70%, and 6.40% were widowed, divorced, or single. This suggests that a sizable portion of those surveyed in Benue North West, Nigeria, were family-oriented. Furthermore, 99.2% of respondents identified as Christians, compared to 0.80% who observed traditional religion. Also, this survey revealed that a sizable portion of participants (38.30%) had 21–30 years of farming experience. Next in line are 33.90%, 27.30%, and 0.60% of responders who have been farming for 11–20 years, 30 years or more, and 1–10 years, respectively.

Table 1: Socio-economic characteristics of respondents in Benue North West, Nigeria

Variables	Socio-economic characteristics	Frequency	Percentage (%)
Gender	Male	301	76.80
	Female	91	23.20
	Total	**392**	**100**
Tribe	Tiv	391	99.70
	Junkum	01	0.30
	Total	**392**	**100**
Age	< 30 (Years)	95	24.20
	31 – 40 (Years)	139	35.50
	41 – 50 (Years)	105	26.80
	Above 50 (Years)	20	13.50
	Total	**392**	**100**
Religion	Christianity	389	99.20
	Traditional	03	0.80
	Islam	-	-

	Total	**392**	**100**	
Marital status	Single	46	11.70	
	Married	279	71.20	
	Widow(er)	42	10.70	
	Divorced	25	6.40	
	Total	**392**	**100**	
Academic Qualification	Non Formal	142	36.20	
	Primary.	101	25.80	
	Secondary.	87	22.20	
	Tertiary	62	15.80	
	Total	**392**	**100**	
Household Size	01 – 05	41	10.50	
	06 – 10	213	54.30	6.5
	11 – 15	120	30.60	
	16 – 20	16	04.10	
	Above 20	02	0.50	
	Total	**392**	**100**	
Farming experience	01 - 10 (Years)	02	0.60	
	11 - 20 (Years)	133	33.90	
	21 - 30 (Years)	150	38.30	25.5
	Above 30 (Years)	107	27.30	
	Total	**392**	**100**	

Source; Field Survey, (2020)

Factors influencing deforestation in Benue North West Ecological Zone, Nigeria

Human Factors Influencing Deforestation

Table 2 presents a binary logistic regression estimate of the human factors impacting deforestation in the northwest Nigerian region of Benue. According to the statistical and probability criteria used in the analysis shown below, the results did not differ substantially (P>0.05) from all of the variables that were measured. This accounted for the substantial lack of difference (P>0.05) between charcoal production (CHP), farming activities (FMG), illegal logging operations (IGL), fuel-wood exploitation (FWE), animal grazing (ANG), infrastructure development (IFD), population growth (POP), and fire forest (FRF). This suggests that every variable had a major effect on the fall in forest cover, which in turn caused biodiversity loss.

Table 2: Human factors influencing deforestation in Benue North West Ecological Zone, Nigeria

Variable	B	S.E	Wald	Df	Sig	Exp. (B)	Ranking
Charcoal Production	0.067	0.158	0.178	1	0.67	1.935	1
Farming Activities	0.149	0.170	0.772	1	0.38	1.889	2
Illegal logging	0.222	0.187	1.404	1	0.24	1.861	3
Fuel-wood exploitation	0.184	0.192	0.909	1	0.34	1.901	4
Animal grazing	0.117	0.152	0.597	1	0.44	1.201	5
Infrastructural development	0.019	0.054	0.119	1	0.73	1.019	6
Population Growth	0.008	0.019	0.159	1	0.69	1.008	7
Forest fire	-0.005	0.030	0.025	1	0.87	1.005	8
Constant	1.237	0.592	0.604	1	0.44	1.028	

Significant level = 0.05, Sig. = Significant, B = Binary regression, Exp. (B) = Exponential binary, DF = degree of freedom and S.E = Standard Error

Source: Field Survey, (2020).

Effect of Deforestation on forest resource Conservation in Benue North-West, Nigeria

The distribution of respondents according to how deforestation affects the preservation of forest resources in the research area is shown

in Table 4. The most compelling effect, according to respondents in the study area, was habitat destruction (WMS=4.42>3.05). This was followed by biodiversity loss (WMS=3.87>3.05), desert encroachment (WMS=3.84>3.05), temperature increase (WMS=3.81>3.05), species extinction (WMS=3.34<3.05), soil degradation (WMS=2.99<3.05), loss of water bodies (WMS=2.87<3.05), climatic disruption (WMS=2.69<2.95), and pollution (WMS=2.47<2.95).

Table 4: Effects of deforestation on forest resource conservation in Benue North-West, Nigeria

Test Variable	VH	H	M	L	VL	N	WS	WMS	D
Habitat destruction	259(1295)	73(292)	33(99)	19(38)	08(08)	392	1732	4.42	H
Loss of biodiversity	121(605)	171(684)	46(138)	37(74)	17(17)	392	1518	3.87	H
Desert encroachment	88(4440)	198(792)	61(183)	34(68)	11(11)	392	1494	3.84	H
Increase in temperature	139(695)	142(568)	36(108)	48(96)	27(27)	392	1494	3.81	H
Extinction of flora/fauna	90(450)	118(472)	71(213)	64(128)	49(49)	392	1312	3.34	M
Soil degradation	51(255)	70(280)	141(423)	87(174)	43(43)	392	1175	2.99	M
Loss of water bodies	25(125)	64(256)	168(504)	106(212)	29(29)	392	1126	2.87	M
Pollution	19(90)	51(204)	102(306)	150(300)	71(71)	392	9781	2.49	L
Climatic disruption	51(255)	27(108)	102(306)	175(350)	37(37)	392	1056	2.69	L

NB = values outside the bracket are mean of frequency distribution of respondents while values in the brackets are products of Likert Scale Value., NH = Very High, H = High, M = Moderate, L = Low, VL = Very Low, WS = Weighted Score, MWS = Mean Weighted Score, D = Decision, Number of respondents (N) = 392, Mean score (MS) = 3.0, Upper limit (UL) = 3.05 and Lower limit (LL) = 2.95.

Source: Field Survey, (2020).

DISCUSSION

Socio-economic characteristics of respondents in Benue North West, Nigeria

An analysis of respondents' socioeconomic characteristics showed that there were somewhat more men in the sample than women. The findings of this study on gender categories supported the findings of Wahab et al. (2014) and Igwe (2016), who observed that men are more likely than women to engage in deforestation. The results of the study on ethnic groups showed that the majority of people within the study area were Tiv (99.7%) and indigenous locals, compared to Jukum (0.03%). This was in contrast to Wahab et al. (2014), who identified various ethnic groups within the study on assessment of socio-economic activities and sustainable rural development in Oba hill forest reserve, Osun state, Nigeria.

The largest proportion of respondents in the sampling size were in the age range of 31 to 40 years (35.50%), followed by those in the age range of 41 to 50 years (26.80%), under 30 years (24.20%), and above 50 years (13.59%). The research area's community's increasing trend was demonstrated by the age categories of the respondents. In line with Igwe's (2016) report on deforestation: Impacts on the socio-economic activities of the people of Ekwusigo local government area, Anambra State, Nigeria, the implication of this age group showed a declining productivity stage of respondents due to the increased number of years with respect to deforestation activities.

Furthermore, only 24.20% of the studied population is the youngest, and 13.59% of the study's respondents are too old to be considered productive. This suggested that the young, agile people in the research area were busy and capable of doing any work that would earn them money. These results concur with those of Abiola et al. (2016) and Tsue et al. (2016), who established that individuals in this age group (youth), are primarily engaged in agricultural activities. However, they disagree with those of Aliyu et al. (2014), who identified an age bracket of 40 to 60 years (mostly adults and farmers who engaged in some kind of tree felling).

This result is an indication that, there is tendency of mounting pressure on the available natural resources in the area since most (71.2%) of the respondents were married with a tendency of increasing family size and providing for their basic needs. Result of this study on marital status agreed with report by Wahab *et al*. (2014) and Igwe (2016) who posited that, higher population of married persons are involved in deforestation activities than single, widow(er), divorced etc to in providing for the family needs.

The education level of the respondents within the study area revealed that, 36.20% do not have formal education while 25.80% had only primary education. This means that, majority of the respondents do not have the Universal Basic Education (UBE) qualification which implies that, farming population in the study area. Educational level can have great influence in assimilation of knowledge or compliance to rules, regulations and laws within a given community. The findings in this study is in agreement with Lamino *et al.* (2016) and Omale *et al.* (2019) who stated that, a typical characteristic of rural Nigeria where people are mostly non-formal education holders while Ibrahim *et al.* (2015) reported a negative relationship between education and area of forest lost in Nigeria.

Additionally, this study revealed that the households with the largest populations (54.30% and 30.60%) were those with the largest household sizes (6–10 and 11–15). This indicated that the study area had the potential for rapid population growth and that over time; there would be greater pressure on the use of forested land, which could lead to deforestation activities due to high food consumption, population growth, the need for farmland, and housing development. According to their occupations, a substantial number of respondents had extensive farming skills. This suggested that the research area's farming activities and farmland expansion are probably going to be high, which could have a detrimental effect on the management of forest resources.

Result of this study is in consonant with report by Igwe (2016) on deforestation: Impacts on the socio-economic activities of the people of Ekwusigo local Government Area, Anambra State, Nigeria. Result of this study is also in tandem with the assertion of Abere and Opera (2012) that, from the economic point of view, deforestation has created a negative impact on the average Nigerian.

Factors influencing deforestation in Benue North West Ecological Zone, Nigeria

The results of human factors, which are common in most communities in our forest sector, had a significant influence. Some of the factors that may lead to the loss of forest area include poverty, ignorance, agricultural growth, settlement, and revenue creation. This result confirms the findings of Ogunwale (2015) and Ibrahim et al. (2015), who discovered that deforestation increases in proportion to increases in rural-urban migration, poverty, ignorance, and agricultural growth. Furthermore, according to Mortimor (1989), in the absence of job opportunities, rural dwellers would be forced to sell wood as a feasible source of income, resulting in a drier climate that jeopardizes human survival by negatively impacting the ecological balance of our surroundings

As population increases, there will be an increase in demand for agricultural lands, settlements and food which all impact negatively of forest resources. This agreed with the work by Alao (2003) who opined that, high demand for timber by different end uses for construction purposes, furniture, sawn timbers and wood for energy (charcoal and fuel-wood) in Nigeria.

The result of natural factors influencing deforestation in the study area implies that, natural factor (such as climate/global warming, wildfire, flood, pest and disease) had no any serious effect (significant effect) influencing deforestation in the study area. This could be as a result of rare occurrence of these factors within the study area. The result is in line with the reports that, many uncertainties still exist in regards to the longer term rates of global warming, the unfolding dynamics of weather patterns, feedbacks between climatic and other environmental changes and thresholds (Arnell, 2000; IPCC, 2007; Bonan, 2008; Schuur *et al.,* 2008; Zheng and Yoon, 2009; Colman and Power, 2010; Dallmeyer *et al.,* 2010; Aliyu *et al.,* 2014). The loss of species generally renders ecosystems less resilient to disturbances such as fires, and the impact of insect pests, diseases and invasive alien species. Climate change can affect forests by altering the frequency, intensity, duration and timing of droughts and fires as well as storms and associated landslides (Dale *et al.,* 2001). Results of this study on effects of natural factors of deforestation agrees with the opined report that, the exact consequences of deforestation cannot be foreseen clearly at present, but plant and animal species' phenologies are sensitive to changes in temperature, rainfall and humidity, seasonal cycles and may also react to the increased levels of CO_2 in the atmosphere whereby, some species may gain an advantageous competitive edge over other species (IPCC, 2007; Schuur *et al.,* 2008; Colman and Power, 2010; Ghazoul and Sheil, 2010; Igwe, 2016).

Effect of Deforestation on forest resource Conservation in Benue North-West, Nigeria

Investigations on how deforestation affects the protection of forest resources shows that habitat degradation has the most impact, followed by biodiversity loss, desert encroachment, temperature increases, and extinction of plants and animals. The findings also showed that the fall in forest activities due to deforestation was a major factor in the protection of none biodiversity in Benue North-West Nigeria. These reasons included soil degradation, loss of water bodies, pollution, and climatic disruption. Charkeseliani (1990), Agarwal (1992), and Isese (2019) have observed that deforestation is frequently linked to a number of problems, including forest decline, soil degradation, and a loss of genetic and biological diversity.

A substantial reduction in water body conservation was found in Benue North-West as a result of the effects of deforestation on forest resource conservation. The outcome supports the findings of Pimm and Jenkins' (2010) document, which claims that the pace of extinction is currently more than 100 times higher than its natural rate and is approaching levels that were previously unthinkable.

Conclusion

Based on the result of this findings, majority of the respondents within the Benue North-West, Nigeria were young, agile, married, non-formal-education and have been residing in the area over a period of time. The study also revealed that, lack of awareness and illiteracy amongst members of the community due to the low level of access to forest extension agents and services has limiting effects on community compliance to forest activities thereby leading to environmental challenges due to deforestation activities. The study also revealed that, human and natural induced factors also played a positive role in influencing deforestation activities within the Benue North-West region thereby leading of

loss of valuable forest resources which is not limited to economic and medicinal trees. This study revealed that deforestation has negative effect on both animal and plant diversity which includes loss of valuable forest species, reduced animal's population due to habitat destruction and plant biomass, extinction and reduced species richness and evenness.

Recommendations

This study suggests ways to mitigate the environmental problems associated with deforestation in the study Area as follows;

i. There is a need for a pragmatic approach in the form of policy formulation through proper legislation prohibiting the general public from indiscriminate tree felling, open grazing and forest fire due to lush vegetation by creating ranches and feedlots.
ii. There should be adequate access to forest extension services which could enhance high Level of awareness and compliance with forestry laws in the study area.
iii. Agriculture growth and increased population were also considered as major factors affecting forest cover within the study area; thus, there is the need to sensitize the people dwelling around the forested areas of the importance of agro-forestry and the need to embark on such practices.
iv. Government, NGOs and individual should endeavor to encourage the need of training and retraining of personnel and farmers by organizing regular workshops and seminars for knowledge on the effects of deforestation on environmental challenges.

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DETERMINATION OF DRIVERS OF DEFORESTATION AND FOREST DEGRADATION IN NORTH-WESTERN PART OF BENUE STATE, NIGERIA'

[1*]Mbasaanga, S.S., [1]Aondoakaa, M.A., [1]Origbo, B.U., [1]Sambe, L.N., and [5]Nyiekpoughul, T.
[1]Department of Social and Environmental Forestry, Joseph Sarwuan Tarka University, Makurdi, Nigeria
[5]Department of Geography, Nassarawa State University, Keffi
*Corresponding author: mbasaangasesugh@gmail.com +2347035995515

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ABSTRACT

The study was carried out to determine drivers of deforestation and forest degradation in North-west ecological zone of Benue state, Nigeria. A multistage and sampling techniques were used, data were collected from 391 respondents across selected communities within Buruku and Gwer-East Local Government Areas with 30% sampling intensity. Descriptive statistics was used to describe the socio-economic characteristics of the people, Spearman rank correlation analysis was used to test for significant relationship between socioeconomic variables of the people and level of deforestation, participatory index was used to assess the participation of the people in deforestation and five-point Likert scale format was used to measure the effects of deforestation in the study area. The result showed, 49.9% of the respondents were males while 50.1% were females. Farming was the dominant occupation (95.9%), and a large proportion of respondents (54.2%) were aged above 60 years. Correlation analysis revealed that age and income significantly influenced tree felling, while household size showed a strong negative correlation. Participation in deforestation was notably high, with 100% involvement recorded in Gwer-East (0.69) and Buruku (0.67). Major human factors such as fuelwood extraction, poverty, and land-use change were found to significantly contribute to deforestation. Administrative lapses, including poor forest management and failure to enforce environmental laws, were also identified as major drivers. While natural factors had minimal impact, legislative inconsistencies and lack of enforcement significantly exacerbated forest degradation. Conclusively, the consequences of these activities included diminished forest resources, loss of biodiversity, erosion, and climate change impacts. The findings recommend the urgent need for policy reforms, improved enforcement mechanisms, and community engagement in sustainable forest management practices.

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INTRODUCTION

Background of the study

Trees are the oldest, reliable, extremely useful and widely used raw materials that play a crucial role in oxygen supply and absorption of greenhouse gases (Effects of Deforestation, 2010). Thirty per cent of the earth's land area or about 3.9 billion hectares is covered by forests. It was estimated that the original forest cover was approximately six billion hectares (Bryant *et al*., 1997). According to John (2020), deforestation has caused the loss of 50 to 100 animal and plant species each day. Many of these species are now at the verge of extinction even with their significant importance to humans, especially in the area of medicine (John, 2020). Deforestation is any activity that disrupts the natural ecology of the forest as a result of agricultural, social and economic activities carried out in the name of development (Ibrahim, 2015). It also affects economic activity and threatens the livelihood and cultural integrity of forest-dependent people by reducing the supply of forest products and causes siltation, erosion, desertification, drought and flooding (Annan, 2013). The social and economic impact of deforestation has triggered the transformation of forested lands and represents a great force in global environmental change and drivers of biodiversity loss. Forests are cleared,

degraded and fragmented by timber harvest, conversion to agriculture, road- construction, and human-caused fire. Mankind's activities on the environment in his quest for development have resulted in a continuous and serious degradation of the ecosystem, thus posing a threat to both his present and future living (Ogunwale, 2015). By destroying the forests, we risk our own quality of life, gamble with the stability of climate and local weather, threaten the existence of other species and undermine the valuable services provided by biological diversity (Rhett, 2019).

A degraded forest delivers a reduced supply of goods and services from a given site and maintains only limited biological diversity. It has lost the structure, function, species composition and/or productivity normally associated with the natural forest type expected at that site (ITTO, 2002). The degradation of the forest ecosystem has obvious ecological effects on the immediate environment, but it may also affect distant areas (Adeofun, 1999). Forest degradation involves a change process that negatively affects the characteristics of a forest such that the value and production of its goods and services decline. This change process is caused by disturbance, which may vary in extent, severity, quality, origin and frequency. Disturbance may be natural (e.g. that caused by fire, storm or drought), human-induced (e.g. through harvesting, road construction, shifting cultivation, hunting or grazing) or a combination of the two. Human-induced disturbance may be intentional (direct), such as that caused by logging or grazing, or it may be unintentional (indirect), such as that caused by the spread of an invasive alien species (FAO, 2009). Forests in the tropics are being destroyed at an alarmingly high rate in recent years especially in Nigeria (Eboh *et al.,* 2006; Dagba *et al.,* 2005; Chagbe *et al.,* 2013; FAO, 2011). In Nigeria, the rate of deforestation appears to have accelerated in recent years in spite of policy measures to stem the rate of deforestation it has continued to increase at an alarming rate. For instance, Oseni (1998) and Aruofor, (1999) estimated deforestation rate for the country at approximately 285,000 hectares annually. Ayala, (2010) reported that between 2000 and 2005, Nigeria lost 5.7 percent of its primary forest` as a result of deforestation which continues to increase at a rate of 3.8 percent, which is equivalent to 4,000 hectares per annum. Therefore, this study seeks to determine the socio-economic characteristics of respondents in the study area, assess the socioeconomic factors influencing deforestation, determine the level of participation of the people in deforestation, determine factors influencing deforestation & forest degradation and determine the effects of deforestation in Benue North-West ecological zone Nigeria.

METHODOLOGY

The Study Area

The study was carried out in Benue State, located at longitudes 6°35' E and 10°E and latitudes 6° 30' N and 8° 10' N within the Guinea savanna area of Nigeria with a total land mass of 30,955 km2 (National bureau of statistics, 2012). Benue State is bounding with Nasarawa State to the North; Taraba State to the east and Cross river to the south. Enugu and Kogi State share borders to the east and west, respectively. It has an estimated population of about 4.2 million people according to the 2006 National Population Census, (National population commission, National Population Census; 2006.). The climate of Benue State is tropical with two distinct seasons namely rainy and dry seasons. Rainy season starts in April and ends in October while dry season is from November to March. The annual rainfall varies from 1750 mm in southern part to 1250 in the north. The mean annual temperature fluctuates between 23°C to 30°C Dada O. Secondary School Atlas Second Longman Nig. Ltd. (2006; 2007).

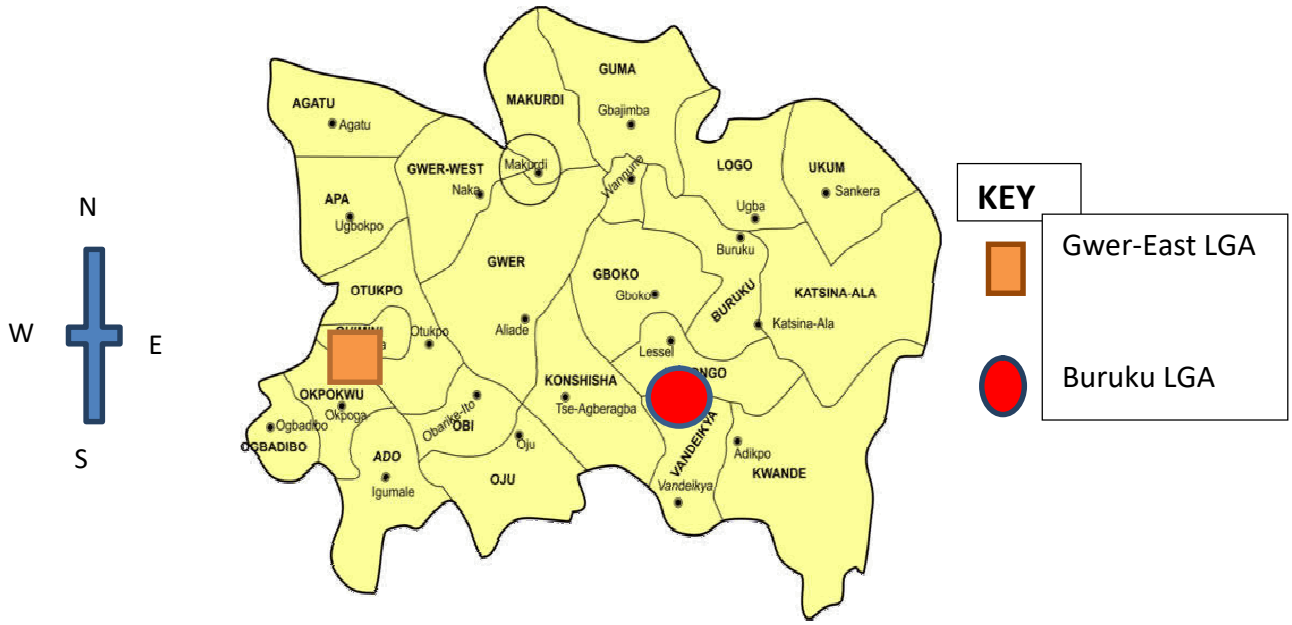

Figure 1: Map of Benue state showing the study areas.
Source: Data: image/jpeg; base64, /9j/4AA. Retrieved on the 10th/06/2020.

Population Sampling and Data Collection

Multistage random sampling with 30% sampling intensity was used to select local governments from the zone. Sample size for the study was determined using Taro Yamen formula as follows:

n= N/ (1+N (e) 2) (Taro, 1967)

Where: n = sample size, N = size of population, 1 = constant, e = error degree of freedom (0.05). Using the population of each of the Local Government Area, the sample size for each of the Local Government was determined using the formula:

$$nh = \frac{n \times Nh}{N}$$

Where: nh = local government sample size, n = population sample size, Nh = local government population, N = total population of the study.

Respondents were drawn across the randomly selected communities to form the source of data and information. Therefore, the sample size for the study was 391 as shown in Table 1.

Table 1: The Study Area and Sample Size

Locations	Sample Areas	Sample size	Percentage
Local Government Area	Buruku	243	62.1
	Gwer-East	148	37.9
	Total	**391**	**100.0**
Council ward	Mbayaka	24	6.1
	Mbaakura	25	6.4
	Shorov	38	9.7
	Mbatyough	17	4.3
	Mbaatirkyaa	31	7.9
	Mbaazagee	35	9.0
	Mbaapem	13	3.3
	Mbaade	60	15.3
	Kyonov	38	9.7
	Mbakyaan	16	4.1
	Ugee	49	12.5
	Shough	45	11.5
	Total	**391**	**100.0**
Community	Anshav	25	6.4
	Gbeleve	24	6.1
	Mbaikya	38	9.7

Mbaakuta	17	4.3
Mbaavar	31	7.9
Mbatseva	35	9.0
Mbaiwar	13	3.3
Mbaakumshi	15	3.8
Mbagbum	45	11.5
Mbamune	38	9.7
Abeda	16	4.1
Mbadinya	8	2.0
Mbagenda	41	10.5
Mbaje	45	11.5
Total	**391**	**100.0**

Data Analyses

Data analysis was carried out based on the objectives of the research. Descriptive statistics such as frequency, mean and percentages were used to analyze data for socio economic characteristics of the people and identify factors affecting degradation of natural resources in the study area. The Spearman Rank correlation analysis was used to test for significant relationship between socioeconomic variables of the people and level of deforestation. The Spearman Rank correlation is expressed as:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

Where: r_s = Spearman Rank Correlation Coefficient, d= the difference between the two ranks of each observation, n= Number of observations, 6= Constant of the formula.

Participatory Index (PI) as adopted by (Alhassan, 2010) was used to assess the participation of the people in deforestation in the study area. The PI is expressed as:

$$PI = \frac{(f_a \times 1) + (f_o \times 0.8) + (f_r \times 0.4) + (f_n \times 0.2)}{N}$$

Where, PI = Participatory index for deforestation, fa = frequency of respondent always participating in deforestation, fo = frequency of respondent often participating in deforestation, fc = frequency of respondent occasionally participating in deforestation, fr = frequency of respondent rarely participating in deforestation, fn = frequency of respondent never participating in deforestation

N = Total number of respondents participating in deforestation in the study area.

A Five-point Likert scale format was used to measure the effect of deforestation and forest degradation in the study area. The weighting scale was derived from the following values with respect to effects of deforestation; Very High effect (VHE) = 5, High Effect (HE) = 4, Moderate Effect (ME) = 3, Low Effect (LE) = 2, Very Low Effect (VLE) = 1.

The Likert rating Mean Score (MS) of effects of deforestation was expressed as:

$$MS = \frac{\sum f}{n}$$

Where: f = Summation of the five-point rating scale and n = Number of points

Therefore, for a five point Likert scale, MS is expressed as:

$$MS = \frac{1+2+3+4+5}{5}$$

$$MS = 3.0$$

The *Likert* Weighted Mean Score (WMS) of effect of deforestation was expressed as:

$$WMS = \frac{\sum_{i=1}^{n} f_i x_i}{N}$$

Where: f = frequency of respondent, x = Likert scale point, N= Total Number of respondents. Using the interval scale of 0.05, the Upper Limit (UL) cut-off is MS+0.05 (3.0+0.05 = 3.05). The Lower Limit (LL) cut-off is MS - 0.05 (3.0-0.05 = 2.95). Based on these two extreme limits any variable with WMS below 2.95 (WMS<2.95) was considered 'Low'. Variable with MWS between 2.95 and 3.05, 'Moderate' any variable MWS greater than 3.05 (MWS>3.05), 'High'.

RESULTS

Socio economic characteristics of respondents in North-West Ecological Zone of Benue State

Based on the result, 49.9% of the respondents were males while 50.1% were females. The result revealed that the ages of the respondents ranged from 31 to 96 years, with majority (54.2%) within the age category of 60 years and above, followed by those with 51 to 60 years (23.5%), while 18.9%

of respondents were within the age bracket of 41 to 50 years as shown in table 2.

The result on the educational level of the respondents showed that 36.8% of the respondents attained secondary school, 34.3% of the respondents attained primary school with 19.4% of the respondents had no formal education while 9.5% attained tertiary level education. The major occupation of the respondents was recorded as farming (95.5%), followed by 1.8% who were civil servants and traders while 0.3% of the respondents were students in the area. On marital status, 53% of the respondents were married, 34.3% were single with 6.1% reported to be divorced and 5.9% of the respondents were widows and widowers. This work reveals that 6.6% has the lowest household size range from 1-5 persons while 27.9% had the highest household size of between 6-10 persons. For period of residence, 30.4% resided for more than 50years while 1% stayed for the shortest time (less than 11years). The income category of respondents ranged from less than ₦21,000 to greater than ₦ 100,000 with 2.9% having income category of less than ₦ 21,000 while 63.2% had income greater than ₦ 100,000.

Table 2: Socio economic characteristics of respondents in the North West Ecological Zone of Benue State, Nigeria

Characteristics	Category	Frequency	Percent
Gender	Male	195	49.9
	Female	196	50.1
Age	31-40	13	3.3
	41-50	74	18.9
	51-60	92	23.5
	>60	212	54.2
Educational level	Non-formal	76	19.4
	Primary	134	34.3
	Secondary	144	36.8
	Tertiary	37	9.5
Major Occupation	Civil servant	7	1.8
	Farming	375	95.9
	Hunting	1	0.3
	Trading	7	1.8
	Student	1	0.3
	Total	391	100.0
Marital Status	Married	210	53.7
	Single	134	34.3
	Divorced	24	6.1
	Widow	9	2.3
	Widower	14	3.6
	Total	391	100.0
Household size category	1-5	26	6.6
	6-10	109	27.9
	11-15	101	25.8
	16-20	78	19.9
	>20	77	19.7
	Total	**391**	**100.0**
Period of residence Category	<11	4	1.0
	11-20	42	10.7
	21-30	82	21.0
	31-40	60	15.3
	41-50	84	21.5
	>50	119	30.4
	Total	391	100.0
Income Category (₦) per annum	<21,000	9	2.3

	21,000-40,000	60	15.3
	41,000-60,000	37	9.5
	61,000-80,000	15	3.8
	81,000-100,000	23	5.9
	>100,000	247	63.2
	Total	391	100.0
Distance to forest (km)	<2	165	42.2
	2-3	169	43.2
	4-5	57	14.6
	Total	**391**	**100.0**

Source: Field survey, 2020

Socio-economic Factors Influencing Deforestation in the North-West Ecological Zone of Benue State

Table 3 shows the result of spearman's correlation test on socio-economic attributes of the respondents and factors influencing tree felling in the study area. Based on the findings, there was a weak correlation between socioeconomic attributes and factors influencing tree felling in the study area. The correlation relationship between tree felling and age category was recorded to be 0.110 (11%) with a significant *p*-value of 0.030; followed by education level of the respondents which had a non-significant (*p*=0.523*)* weak relationship of 0.032 (3.2%). This was followed by years of residence, which had a non-significant (*p*=0.846) weak correlation of 0.010 (10%). Household size and income categories had a significant negative correlation of -0.961 (-96.1%) and -0.125 (-12.5%) respectively, with tree felling in the study area; while distance to forest category had a significant (*p*=0.129) negative relationship of -0.077 (-7.7%) with tree felling.

Table 3: Spearman Rank Correlation Test on Socioeconomic Attributes and Tree felling in the North-West Ecological Zone of Benue State

Spearman's rank test vs attributes	Correlation Coefficient	*P*-values	Decision
Age Category **vs.** Tree felling	0.110	0.030	Sig
Educational level **vs.** Tree felling	0.032	0.523	NS
Household size category **vs.** Tree felling	-0.961	0.057	NS
Period of residence **vs.** Tree felling	0.010	0.846	NS
Income Category **vs.** Tree felling	-0.125	0.013	Sig
Distance to forest Category **vs.** Tree felling	-0.077	0.129	NS

Correlation is significant at the 0.05 level (2-tailed), NS = Not significant, Sig. = Significant.
Source: Field survey, 2020

Table 4: Level of Participation in Felling Trees in the North West Ecological Zone of Benue State

Local Govt. Area	Rate of participation	Frequency	Percent	Participatory index
Buruku	Always	52	21.4	0.6733
	Often	58	23.9	
	Occasionally	80	32.9	
	Rarely	33	13.6	
	Never	20	8.2	
	Total	**243**	**100.0**	
Gwer-East	Always	6	4.1	0.6905
	Often	66	44.6	
	Occasionally	65	43.9	
	Rarely	11	7.4	
	Total	**148**	**100.0**	

Source: Field survey, 2020

Participation of the People in Deforestation in the North West Ecological Zone of Benue State

The findings on participation in tree felling in the area showed that there was high level of participation in deforestation in Buruku LGA with 91.8% and 8.2% claimed they never participated in felling trees while in Gwer-East 100% participated in felling trees for different reasons (as shown in Table 4)

Factors Influencing Deforestation and Forest Degradation in the North West Ecological Zone of Benue State, Nigeria

The factors influencing deforestation and forest degradation in the study area were human, administrative, natural and legislative factors as presented on table 5,6 and 7. Human factors comprised of uncontrolled grazing of livestock, land use for residential purpose, deforestation, poverty, unemployment, illiteracy and fuel wood production (Table 5) and the respondents reported that these factors have a significant (wms>3.00) effect in their lives.

Administrative factors such as improper behavior of rangers or forest guard, poor participation of villagers in forest management, over exploitation and failure to address violations of offenders in court of law were the key factors reported by the respondents in the study area. All the key factors as administrative factors were evaluated and the result showed that, these factors have very serious effects on influencing forest degradation in the study area. (Table 6)

Respondents reported that, natural factors (such as storm, floods, forest pests and disease outbreaks) and legislative factors (such as weak laws and regulations of natural resources, inconsistency of forest laws and non-implementation of existing forest laws and policies) were the key factors influencing deforestation and forest degradation in the area. These factors were evaluated to determine their level of effect in influencing deforestation and forest degradation, and the result showed that, inconsistency of forest laws and non-implementation of existing forest laws and policies (legislative factor) have significant (wms>3.00) serious effects while, storms, floods and forest pests and disease outbreaks (natural factor) had no significant (wms<3.00) effects (low effect) in influencing deforestation and forest degradation in the area (Table 7).

Table 5: Human Factors Influencing Forest Degradation in the North-West Ecological Zone of Benue State

Factors	VLE (1)	LE (2)	ME (3)	SE (4)	VSE (5)	N	WS	WMS	DEC
Uncontrolled grazing of livestock	16	95(190)	135(405)	84(336)	61(305)	391	1252	3.20	Sig.
Land use for residential purpose	14(14)	75(150)	120(360)	96(384)	86(430)	391	1338	3.42	Sig.
Timber smuggling	9(9)	61(122)	122(366)	108(432)	91(455)	391	1384	3.54	Sig.
Early grazing of livestock in forest	5(5)	44(88)	92(276)	118(472)	131(655)	391	1496	3.83	Sig.
Poverty and unemployment	6(6)	40(80)	87(261)	140(560)	118(575)	391	1482	3.79	Sig.
Illiteracy of people around resource	8(8)	49(98)	99(279)	120(480)	115(575)	391	1440	3.68	Sig.
Providing fuel and traditional uses of wood to forest dwellers	5(5)	42(84)	84(252)	113(452)	147(735)	391	1528	3.91	Sig.

VLE=Very Low Effect; LE= Low Effect; ME= Medium Effect; SE=Serious Effect; VSE= Very Serious Effect; Sig. = Significant.
N= total Number of Respondents; WS= weighted Score and WMS= Weighted Mean Score
Source: Field survey (2020).

Table 6: Administrative Factors **Influencing Forest Degradation in the North West Ecological Zone of Benue State**

Factors	**VLE (1)**	**LE (2)**	**ME (3)**	**SE (4)**	**VSE (5)**	**N**	**WS**	**WMS**
Lack of application of research results	0(0)	4(8)	64(192)	154(616)	169(845)	391	1661	4.25 sig.
Improper behavior of rangers	0(0)	1(2)	32(96)	278(1112)	80(400)	391	1610	4.12 sig.
Failure of security officers to perform protective duties	1(1)	5(10)	54(162)	244(976)	87(435)	391	1584	4.05 sig.
Lacking the participation of villagers in forest management	6(6)	49(98)	92(276)	139(556)	105(525)	391	1461	3.74 sig.
Over exploitation	0(0)	0(0)	13(39)	97(388)	281(1405)	391	1832	4.69 sig.
Failure to address violations by offenders in courts	0(0)	1(2)	25(75)	250(1000)	115(575)	391	1651	4.25 sig.

VLE=Very Low Effect; LE= Low Effect; ME= Medium Effect; SE=Serious Effect; VSE= Very Serious Effect; N= total Number of Respondents; WS= weighted Score and WMS= Weighted Mean Score Sig=Significant
Source: Field survey (2020).

Table 7: Natural and Legislative Factors Influencing Forest Degradation in the North West Ecological Zone of Benue State, Nigeria

Factors	VLE (1)	LE (2)	ME (3)	SE (4)	VSE (5)	N	WS	WMS
Storms	278(278)	111(222)	0(0)	0(0)	0(0)	389	500	1.28 NS
Floods	182(182)	163(326)	39(117)	7(28)	0(0)	391	653	1.67 NS
Forest pests and diseases outbreaks	351(351)	40(80)	0(0)	0(0)	0(0)	391	431	1.10 NS
Legislative Factors								
Weak laws and regulations of natural resources	11(11)	67(134)	106(318)	121(484)	86(430)	391	1090	2.79 NS
Inconsistency of forest laws	15(15)	56(112)	113(339)	111(444)	96(480)	391	1390	3.55 Sig.
Non-implementation of existing forest laws and policies	19(19)	60(120)	90(270)	108(432)	113(565)	390	1296	3.31 Sig.

VLE=Very Low Effect; LE= Low Effect; ME= Medium Effect; SE=Serious Effect; VSE= Very Serious Effect; N= total Number of Respondents; WS= weighted Score and WMS= Weighted Mean Score sig=significant; ns=not significant.
Source: Field survey (2020).

Effects of Deforestation and forest degradation in the North West Ecological Zone of Benue State, Nigeria

Based on the result presented in table 8, forest degradation has very severe effects on the environment. Some of these effects identified in the study area were: low availability of forest resources, ineffective provision of forest services, decline in forest jobs and erosion problems. These effects all had significant (wma>3.0) effects on the people and environment. The effects of deforestation on the environment in the study area were assessed and the result of this finding is presented in Table 9. Based on this result, destruction of wildlife habitat, erosion, floods, climate change and desertification encroachment are some of the identified effects of deforestation in the study area. Flooding issues as an effect of deforestation has no significant (wms=1.28) effect on the environment in the northeast ecological zone of Benue state. Also, desertification encroachment has no significant (wms=2.39) effect on the environment; while destruction of wildlife habitat and climate change have significant (wms>4.00) effects.

Table 8: Effects of Forest Degradation on Environment in the North West Ecological Zone of Benue State

Effects	VLE (1)	LE (2)	ME (3)	SE (4)	VSE (5)	N	WS	WMS
Low availability of forest resources	0	0	1(3)	55(220)	335(1675)	391	1898	4.85 Sig
Ineffective provision of forest services	0	0	51(153)	204(960)	136(680)	391	1793	4.59 Sig
Decline in forest job opportunities	9(9)	29(58)	95(285)	120(480)	137(685)	390	1517	3.88 Sig
Erosion problem	2(2)	18(36)	83(249)	122(576)	166(830)	391	1693	4.33 Sig

VLE=Very Low Effect; LE= Low Effect; ME= Medium Effect; SE=Serious Effect; VSE= Very Serious Effect; N= total Number of Respondents; WS= weighted Score and WMS= Weighted Mean Score sig=significant; ns=not significant.

Source: Analyzed result (2020).

Table 9: Effects of Deforestation on the Environment in the North West Ecological Zone of Benue State, Nigeria

Effects	VLE (1)	LE (2)	ME (3)	SE (4)	VSE (5)	N	WS	WMS
Destruction of wildlife habitat	0(0)	2(3)	46(138)	91(364)	252(1260)	391	1765	4.51 Sig.
Erosion issues	167(167)	110(220)	61(183)	41(164)	12(60)	391	794	2.03 NS
Flooding issues	282(282)	109(218)	0(0)	0(0)	0(0)	391	500	1.28 NS
Climate change	1(1)	17(34)	117(531)	133(532)	123(615)	391	1713	4.38 Sig.
Desertification	0(0)	246(492)	138(414)	6(24)	1(5)	391	935	2.39 NS

VLE=Very Low Effect; LE= Low Effect; ME= Medium Effect; SE=Serious Effect; VSE= Very Serious Effect; N= total Number of Respondents; WS= weighted Score and WMS= Weighted Mean Score, Sig=Significant; NS=Not Significant.

Source: Analyzed result (2020).

DISCUSSION

Socio economic characteristics of Respondents in the North West Ecological Zone of Benue State, Nigeria

The number of females randomly sampled for this study was slightly higher than the males, this is line with Aondoakaa *et al.,* (2023), who reported that more females were involved in livelihood activities in the forest reserve than men. It is noticed that women constitute major actors in forest resource utilization not only males. This finding focused on the age bracket from 31 years and above. This age class was believed to be mature and can take social responsibility, and able to understand the environment. About 75% of the respondents were above the age of 50 years. This could have a great impact in participation in tree planting the area. Due to advances in age, majority of the respondents may hardly be actively involved in tree planting. The zeal to safeguard and plant more trees for sustainable forest management won't be their priority due to old age. The educational level of the respondents could influence their perception towards tree planting and climate change mitigation in the area. A greater proportion of respondents knew the adverse effects of bare lands. In a related study, Selby *et al.,* (2003) found that tree planting was considered by all especially to land abandonment leading to natural regeneration by woody plants of low or no value.

Farming was the major occupation of the respondents with fewer of them engaging in hunting, civil service, trading and schooling. These findings reveal that, the respondents in the study area were mostly full time farmers with a source of income from farm produce. Thus, when there was low farm produce in any year, this could lead to more pressure on forest products and deforestation of the available forest estates in the area. When there was any alternative source of income other than farm produce. The result on household size and marital status of the respondents signifies the area was densely populated. This could lead to more pressure on forested lands over a period of time with forest lands converted to farmlands as a result of population growth, high food consumption and housing development. This result is in line with the report of Barana *et al.,* (2020), he reported that over the past century, many scholars maintained thinking that rapid population growth is the major cause of many environmental concerns especially in developing countries. The result on period of residence in the area by the respondents could be a factor that influences deforestation because of over familiarity between the respondents and the forest. The result on income category of the respondents showed that, the respondents generated their income from farm produce and/or other sources such as craft making, timber and fuel wood etc.

The result on descriptive statistics of socio-economic attributes of the respondents implied that, the mean age of the respondents were adults which could be regarded as post service age in developing countries like Nigeria; while the minimum age fell within the youth category. Household size of 14 persons with a minimum of 2 persons per household signified a fast growing household size. This implied that there was a tendency that the communities in the study area will grow at an alarming rate, which means more pressure to the forests and forest resources in the study area. Most of the respondents were indigenes of the area, conversant with the forest and the terrain. This could be one of the reasons why laws, regulations and policies guarding the forest areas were violated and ineffective. The result of the findings showed that deforestation and forest degradation could be influenced by socio-economic attributes of sampled households differently. Different socio-economic factors have aggravated deforestation and forest degradation in the area.

Socioeconomic Factors Influencing Deforestation in the North West Ecological Zone of Benue State

The result of spearman's correlation test on socioeconomic attributes of the respondents influencing tree felling implies that, positive correlation between socioeconomic attributes and tree felling indicated that the attributes move in the same direction with tree felling; thus, increase in age category of the respondents could lead to a significant increase in tree felling. This was followed by income category of the respondents which had a significant negative correlation with tree felling in the area. This signified that, income and tree felling moved in the opposite direction, i.e. a significant increase in income category resulted to a decrease in tree felling. Household size and distance to forest categories had a non-significant negative correlation with tree felling in the area. This result implied that increase in household had no significant decrease in tree felling. So also, increase in distance to a forest in the area could lead to no significant decrease in tree felling. This was in line with the findings of Aklilu *et al.,* (2020), who reported that socio-economic characteristics (sex, family size, and education level) of respondents at Duguna Fango Woreda in Ethiopia were significantly associated with the forest status of the woreda. Since the forest has a direct and indirect role in the community's livelihood, the dependency on forest and forest products for both income generation and home consumption resulted in massive deforestation and forest degradation. Also, Aondoakaa *et al.,* (2023), reported most of the respondents were married with four children and above implying that livelihood activities and utilization of forest resources could be high in the study area in other to support their household needs.

Participation of the People in Deforestation in the North West Ecological Zone of Benue State

The participatory Index (PI) as adopted by (Alhassan, 2010) was used to assess the participation of the people in deforestation in the study area and an index of 0.67 and 0.69 was recorded. The level at which the respondents participated in tree felling was assessed to determine the trend of forest estates and the resources in the study area. The result implied that, more than 75% of the respondents participated (always, often and occasionally) in felling of trees and majority of the respondents collected forest resources from the forests estates without actively participating in tree planting or campaign in the area. This result reveals that in the future, most of the forested areas in the area will become bare lands thereby exposing the soil and microorganisms to erosion, soil and environmental degradation and increase in climate change effects. The role of tree cover cannot be over emphasized because of the numerous importance to man and his environment. The high level of participation in tree felling could be as a result of the respondent's socio-economic attributes such as educational, income and occupational statuses.

Factors Influencing Deforestation and Forest Degradation in the North West Ecological Zone of Benue State, Nigeria

This finding suggested that, uncontrolled grazing of livestock, land use for residential purposes, timber smuggling, poverty, unemployment, illiteracy and fuel wood production were the major influencers of forest degradation in most communities in Benue North-West ecological zone. These key factors were emancipated from anthropogenic activities that took place within and around the forests. When there was low interest on forest protection and tree planting among people, then unhealthy activities to the forest surviving should always be expected; and such activities (anthropogenic) tended to have the most severe effect on the environment. The effect of the administrative factor on the livelihood of the respondents in the study area was assessed to ascertain the level of their effect in influencing forest degradation, their responses were evaluated and the result implied that, administrative factor had serious effect when it comes to influencing forest degradation in the area.

The result on natural and legislative factors influencing forest degradation in the study area indicated that, natural factors (such as storm, floods and forest pests and disease outbreaks) had no serious effect (significant effect) in influencing forest degradation. This could be so as a result of rare occurrences of such problems (i.e. storm, floods and forest pests and disease outbreaks) in such a significant rate. Legislative factors which were common in our forests in most areas had a significant effect. These factors could be as a result of Government priority which is lacking in the forest sector as widely observed and speculated among the respondents in the study area.

The factors responsible for tree felling were poverty, ignorance, settlement, agricultural expansions and income generations. Among all the factors identified by the respondents in the study, agricultural expansion was the most devastated factor responsible for deforestation and environmental degradation. This is so because agricultural expansion recorded the highest percent of respondents (34.9%) from Buruku and Gwer-east (34.3%). This is in line with Nyagba (1995), who reported that since the economy of Benue State is agrarian dependent, more than 70% of the state's population engages in one form of agriculture or the other. Also, Nigeria Environmental Study Team (NEST) in 1991 estimated that over 350,000 ha of vegetative land in the country were lost annually due to farming alone.

Ignorance was not a factor responsible for tree felling in the area. This showed that, all the respondents had knowledge of the effects of tree felling. Income generation was very low in terms of influencing tree felling. Though, income from forest activities makes up about one fifth of total household income for rural households living in or near forests (Manfre and Rubin, 2012). This finding is in time line with of Madulu (2004), who reported that, agriculture is not the only factor that contributes to the dynamics of vegetation change; population pressure, logging, fuel wood gathering/charcoal production, changes in land tenure system, and climate change are among the other factors.

The result on participation in tree felling in the study area implied that majority of the respondents engaged in felling of trees while fewer of the respondents did not participate in felling of trees. Those respondents who participated in tree felling in the study area had different reasons which they perceive more important to them than the implications such activities would cause in future time. This perception could be as a result of low level of education on impacts of forest and environmental degradation; or it could even be as a result of poverty which is ravaging most rural communities due to communal crisis.

This finding is in line with John (2020), who opined that, poverty and urbanization were strong factors leading to deforestation, stating that lack of awareness on the adverse effects of deforestation caused the destruction of over 8.5 million hectares of tropical forests yearly, used for the construction of buildings and new urban areas. The reasons for tree felling in the area were timber harvesting, crop farming, fuel wood production, craft making and carving and charcoal production. Craft making could be on the increase due to the rate of unemployment and poverty. Poor agricultural practices such as slashing and burning of trees in forested areas could contribute to deforestation (Terminski, 2012). About 60% of Nigerians use fuel wood for cooking due to the high cost of kerosene (Akinbami, 2003). According to FAO, developing countries from the tropics suffered most from deforestation between 2000 and 2005. This suggested a relationship between poverty and deforestation (John, 2020). Poverty induced human activities were the major causes of deforestation in Nigeria (Terminski, 2012). Other causes of deforestation in Nigeria include: housing development, clearing of forest for industrialization, farming activities, felling of trees by rural dwellers for fuel wood and charcoal productions with the aim of generating income due to poverty. These activities caused negative impacts on rural and urban livelihoods. Trade in wood products is an obvious source of substantial income for national and local governments, traditional rulers and individuals. This often comes in the form of export earnings, taxes, royalties and personal income for those engaged either directly

or indirectly in the exploitation of these forest products (John, 2020).

Effects of Deforestation in the North West Ecological Zone of Benue State

Forest degradation occurs when the ecosystem functions of the forest are degraded. (Anon., 2010). Environmental problems that are termed degradation collectively, such as desert encroachment, erosion, flooding and drought, all have a strong link with deforestation. High deforestation rate leads to increased temperature, which reduces the rate of rainfall thus leading to increase in desertification. Over a period of time, human health and life becomes adversely affected by high rate of deforestation. Deforestation impacts socially, economically and agriculturally on the overall quality of life of any nation (Sahney *et al.,*2010). Deforestation is considered as a recurring problem in Nigeria; this might be connected with the high poverty level in the midst of abundant natural resources (Fakoya, 2010). Deforestation on lowland plains moves cloud formation and rainfall to higher elevations (Lawton et al, 2001). Deforestation disrupts normal weather patterns creating hotter and drier weather thus increasing drought and desertification, crop failures, melting of the polar ice caps, coastal flooding and displacement of major vegetation regimes. Deforestation affects wind flows, water vapor flows and absorption of solar energy thus clearly influencing local and global climate (Chomitz et al, 2007). Tropical deforestation is responsible for the emission of roughly two billion tonnes of carbondioxide (CO_2) to the atmosphere per year (Houghton, 2005).

The result on the effects of deforestation on the environment in the study area implies that destruction of wildlife and its habitat and climate change has very serious effects on the environment and mankind. This result is in line with the report of John (2020), who reported that, deforestation has caused the loss of 50 to 100 animal and plant species each day. Many of these species are now at the verge of extinction even with their significant importance to humans, especially in the area of medicine (Effects of Deforestation, 2010). Other effects identified were erosion and desertification encroachment which also has insignificant effect (low effect). Flooding had a very low effect on the environment due to deforestation. Deforestation rate in Nigeria is put at 3.5% and 400,000 hectares every year (International Institute of Tropical Agriculture (IITA) (2011). About 400 out of every 1,000 forestlands are deforested every year and only 26 hectares of these are reforested thus leaving 374 hectares deforested (Babalola, 2012).

Illegal logging causes economic sabotage to government and also exposes a nation to an unavoidable scarcity and low quality of forest products (Tunde, 2017). Nigeria could face the possibility of timber and fuel wood scarcity towards the end of the century (John, 2020). It has been predicted that within the next fifty years, unless adequate measures are taken, most humid tropical forestland area in Africa could be transformed into unproductive land and the deterioration of the savannah into desert will be accelerated (Hunter *et al,* 2005; Medugu, 2010).

With extensive deforestation, villagers are compelled to walk long distances to fetch fuel wood and eventually tempted to substitute dried animal dung and crop residues for fuel wood. This tends to have serious consequences for local agricultural production and productivity because the rural communities also rely on this substituted resource for improving soil fertility (John, 2020).

CONCLUSION

According to the study, a mix of socioeconomic, administrative, and legislative causes are primarily responsible for deforestation and forest degradation in Benue State's North-West Ecological Zone. Throughout the research area, there was a high degree of community involvement in deforestation, mostly due to poverty, reliance on farming, fuelwood, and a lack of other sources of income. Forest loss has been made worse by inadequate forest governance, lax enforcement of forest regulations, and low levels of public involvement in forest management. Even though natural occurrences like floods and storms were noted, their impacts were comparatively little in comparison to institutional and human influences. The negative effects of these activities, including dwindling forest resources, biodiversity loss, erosion, and climatic variability, highlight how urgently a multifaceted approach to forest protection is needed. Stronger environmental laws, persistent enforcement, and greater public awareness are required to stop additional deforestation and advance sustainable resource management. Prioritization should also be given to alternative livelihood opportunities and community participation in forest governance. If successfully carried out, these initiatives will help restore ecological balance and guarantee the sustainability of Benue State's Forest resources.

RECOMMENDATIONS

Based on the results from this research, it is recommended that:

1. Further study should be carried out on the strength and weakness of existing policies and regulations guiding the forest estates and its resources for sustainable forest management.
2. There should be skills acquisition program for rural women and youth dwelling in the study area in order to curtail the rate of deforestation

and forest degradation due to poverty and unemployment.

3. Multiple land use systems should be encouraged among the people as a paramount factor for sustainable forest management in the area.

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Effect of Mahogany (*Khaya senegalensis*) Leaf Extract on Growth Performance, Carcass Characteristics and Nutrient Digestibility of Broiler Chickens in Semi-Arid Zone of Nigeria

[1]Yaduma, M., [1]Kwari, I.D., [1]Duwa, H., [2]Balami, S.I. and [1]Kaanti, A.M.

[1]Department of Animal Science, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State.

[2]Department of Animal Science, Borno State University, P.M.B. 1122, Maiduguri, Borno State.

Corresponding author: Balami, S.I. Email: simonbalami92@gmail.com , Tel: 07037870423

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Khaya senegalensis, Broiler Chickens, Performance, Nutrient Digestibility, Carcass

ABSTRACT

A study was conducted using two hundred (200) day old broiler chickens to investigate the effect of Mahogany (Khaya senegalensis) leaf extract on the growth performance, carcass characteristics and nutrient digestibility of broiler chickens in Semi-Arid zone of Nigeria. The broiler chicks of mixed sexes were randomly allotted into five treatment groups of 40 birds each in a completely randomized design (CRD). The treatments were as follows: T1 = 0.00mil/L, T2 = 25mil/L, T3 = 50mil/L, T4 = 75mil/L and T5 = 100mil/L of mahogany leaf extract administered via drinking water on daily basis. Each treatment was replicated four times with 10 chicks per replicate. The following data were collected and analyzed; feed intake, weight gain, feed conversion ratio and weight of cutoff parts. Faecal samples were for digestibility and nutrient digestibility coefficient was calculated. At the end of the experiment, results showed significant (P<0.05) effect of Khaya senegalensis leaf extract on final weight with T1 (0 ml/L) and T4 (75 ml/L) having higher (P<0.05) values (2108.51 g/b and 20.78.44 g/b respectively) while T3 (50 ml/L) had higher (P<0.05) total feed intake that the other treatments. T4 and T5 had similar (P>0.05) feed conversion ratio which was better that the other treatments. Higher (P<0.05) average live weight, slaughter weight and dressed weight were recorded for birds fed 0, 25, 50 and 100ml/L compared with the birds fed 75ml/L KS leaves. In conclusion, Mahogany (Khaya senegalensis) leaf extract could be added up to 75ml/L without adverse effect on productive performance of broiler chickens in semi-arid zone of Nigeria.

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INTRODUCTION

One of Nigeria's fastest-growing industries, the poultry sector has undergone a radical transformation in recent decades, moving from an unscientific farming method to a commercial production system (Angelakis *et al.*, 2013). In addition to being a rich source of protein and having rapid returns on investment, broiler chicken farming provides a source of revenue (Kekocha, 1994). All things considered, the most common livestock operation is still the production of chicken. In the majority of nations, it is a key component of sociocultural and economic advancements as well as gains in food security (Alders, 2005, Dieye *et al.*, 2010). Nonetheless, there are a number of obstacles that the developing country feed industry must overcome. These obstacles include a high feed to gain ratio and rising feed costs due to the high cost of feed ingredients (Abbas, 2013). One way that these obstacles have been addressed is by using feed additives.

The utilization of various contemporary growth-promoting strategies and appropriate disease control methods has been the primary cause of the chicken industry's tremendous rise (Angelakis *et al.*, 2013). Global demand for affordable, high-quality feed is always growing, which highlights how important it is to produce broilers profitably by employing the right growth promoters to maximize nutrient uptake (Huyghebaert *et al.*, 2011).

Several livestock farmers have gone out of business due to the high cost of conventional feedstuff, which has decreased the amount of

animal protein produced overall and its availability for human dietary needs. According to reports, 60–80% of the total cost of raising livestock in developing countries alone is related to feed supplies (Igboeli, 2000; Esonu, 2006). As a result, chicken farmers are increasingly looking for unusual feed ingredients, such as leaf, bark, and seed meals of ethnomedical plants, that may be less costly (Okoli *et al.*, 2001). It has been established that different plant extracts are used in the production of broilers (Essien *et al*., 2007; Nworgu *et al.*, 2007; Galib & Noor, 2010). Since ancient times, phytobiotics have been used as food preservatives, health-promoting ingredients, and to give food flavor and scent. In order to maximize the production potential of poultry birds, where the usage of natural phytogenic medicines is currently gaining popularity as feed additives in poultry rations (Hashemi and Davoodi, 2010; Khan *et al*., 2012).

Animal performance can be improved by medicinal plants, which include the entire plant as well as its leaves, flowers, bark, and extracts. Tree species *Khaya senegalensis* (KS) is a member of the Meliaceae family. It has many medical uses, such as antibacterial and antimalarial properties. In addition, it is well known that KS stem bark has anti-sickling (Fall *et al.*, 1999), antifungal (Abdelgaleil *et al.*, 2004), anthelmintic (Ademola *et al.*, 2004; Ndjonka *et al.*, 2011), anti-cancer (Androulakis *et al.*, 2006; Zhang *et al.*, 2009), antimicrobial (Sule *et al.*, 2008), antihyperglycemic (Kolawole *et al.*, 2012), and antiprotozoal (Ibrahim *et al.*, 2013) qualities in addition to scavenging free radicals. Moreover, the stem bark of KS has been shown to have hepatotoxic (Abubakar *et al*., 2010; Kolawole *et al*., 2011) as well as hepatoprotective (Ali *et al*., 2011) effects on rats (Sule *et al*., 2008). According to Awohouedji *et al*. (2013), KS leaves have 11% crude protein, 43% neutral detergent fibers, and 17% ash on a dry matter basis. As predicted, a number of active substances, including terpenoids, flavonoids, alkaloids, glycosides, steroids, calicedrin, saponins, and tannins, have been extracted from the KS bark and leaves (Makut *et al*., 2008). The bark and leaves of KS have also been found to contain certain limonoids (Nakatani *et al*., 2002; Yuan *et al*., 2013). Despite KS's demonstrated medicinal efficacy, nothing is known about the effects of the plant's leaves. If growth performance of broiler chickens exposed to different leaf extracts are promoted and tracked, Nigeria's poultry industry will have improved beyond its current state. For consumers, the high price and usage of traditional commercial multivitamins to promote growth has already resulted in more negative effects than positive ones.

Feed additives are substances given to chicken diets to boost health, reduce morbidity, and promote productivity (FAC, 1998). Due to their abundance in the natural environment and lack of residual effects, plant-based feed additives, also known as phytogenics, have recently been marketed as growth-promoting feed additives for broiler chickens (Ndelekwute *et al.*, 2015). This is due to the fact that enterocytes in the colon absorb the active elements of phytogenic feed additives, which the body then rapidly metabolizes (Kohlert *et al.*, 2000). Therefore, the study's goal was to ascertain how Mahogany (*Khaya senegalensis*) leaf extract affected the broiler chickens' growth performance, carcass features, and nutritional digestibility.

METHODOLOGY

Experimental Site

The study was conducted at the Livestock Teaching and Research Farm of the Department of Animal Science, University of Maiduguri, Borno State. Maiduguri is located at the Northeastern corner of Nigeria and situated between Latitudes of 11°15’ and 12° North and Longitudes 31° 05’ and 14° East and at an average altitude of 345m above sea level (Raji *et al*., 2010). The area falls within the semi-arid zone of West Africa which is characterized by short rainy season (3 to 4 months per annum) and a long dry season (8 to 9 months) (Aliyu, 2012).

Sourcing and Preparation of *Khaya senegalensis* (KS) Leaf Extract and Dosage

Fresh Mahogany (KS) leaves were collected within Maiduguri and its environs, and washed with clean water to remove any dirt. The leaves were mashed with mortar and pestle. It was then packed into a container. 100g of the mash was weighed into a container and two litres of clean water was added to it. The

extract was filtered to avoid residue and allowed to stand for 24hrs under laboratory condition and 2litres of the solution was served to the animals in each of the treatment. The solution was administered to the birds at graded levels of 0.00 (T_1), 25 mill/L (T_2), 50 mill/L (T_3), 75 mill/L (T_4) and 100 mill/L (T_5) via drinking water on daily basis.

Experimental Birds and Management

A total of two hundred (200) day old Marshal strain broiler chickens from Zartech hatchery were used for the experiment. The broiler chicks of mixed sexes were randomly allotted into five treatment groups of 40 birds each in a completely randomized design (CRD). The treatments were as follows: T1 = 0.00 ml/litre, T2 = 25.00 ml/litre, T3 = 50.00 ml/litre, T4 = 75.00 ml/litre and T5 = 100.00 ml/litre of KS leave extract. Each treatment was replicated four times with 10 chicks per replicate placed in a deep-litter pen of fresh wood shavings measuring 1.50m x 1.50m. All the groups were served water and feed *ad-libitum* with a formulated diet as presented in Table 1.

Data Collection

Feed intake: a set quantity of feed was given each morning, and the amount that was left over was measured the following day. Feed intake was defined as the difference between the feed that was provided and the feed that was left over. The following formula was used to determine the average feed intake.

$$Feed\ Intake\ (FI) = Daily\ feed\ served - Daily\ feed\ left\ over$$

Gain in body weight: This was computed using the body weight information. By deducting the body weight from the current week, the body weight gain was calculated.

$$\text{Body weight gain (g)} = \text{Present week weight (g)} - \text{Previous week weight (g)}$$

Feed Conversion Ratio (FCR): The ratio of feed intake to body weight gain (g) was used to calculate the FCR.

$$FCR = \frac{Average\ Feed\ Intake\ (g)}{Average\ Body\ weight\ Gain\ (g)}$$

Apparent Nutrients Digestibility: The entire collection process was applied. Between 56 and 64 days of age, the chickens' digestibility was assessed. It was carried out in specifically made metabolism cages with feeding and drinking troughs that were automated and separate. From each treatment, three birds per replication were chosen at random and sent to metabolism cages so that the apparent digestibility of the nutrients could be obtained. After allowing the birds to acclimate for three days, after which each chicken was given 160 g of feed. The faecal droppings from each treatment were bulked and used for proximate analysis after their entire droppings were collected for four days and oven dried at 68 ^{O}C. In the Animal Science Laboratory, the approximate composition of the feed and droppings was examined. The following formula was used to calculate the apparent nutrients' digestibility.

$$Digestibility\ Coefficient\ (\%) = \frac{(Nutrient\ in\ Feed\ x\ FI) - (\%\ Nutrient\ in\ Faeces\ x\ FO)\ x\ 100}{\%\ Nutrient\ in\ Feed\ x\ FI}$$

Aduku and Olukosi, 1990)

Data Analysis: All data collected were subjected to analysis of variance (ANOVA) using Statistical Analytical System (SAS) version 9.1 (SAS, 2002). Duncan Multiple Range Test (DMRT) was used to separate treatment means where significant differences exist at 5% level of probability (0.05 level of significance) (Duncan, 1995).

Table 1: Ingredients Composition and Calculated Analysis of Broiler Starter and Finisher Diets (%)

Ingredients	Starter	Finisher
Maize	54.00	58.00
Groundnut cake	20.00	5.00
Soybean meal	10.00	20.00
Wheat offal	7.50	8.50
Fish meal	5.00	4.00
Bone ash	2.00	2.50
Limestone	0.50	0.50
Min-vit premix*	0.40	0.40
Methionine	0.30	0.30
Lysine	0.10	0.10
Salt	0.20	0.20
TOTAL	100.00	100.00
Calculated Analysis (%)		
Crude protein	22.46	20.19
Crude fibre	3.69	3.97
Ash	2.58	3.06
Ether extract	5.11	4.23
Nitrogen free extract	66.16	68.57
Calcium	1.00	1.10
Phosphorus	0.44	0.50
ME (Kcal/kg)	2839.58	2955.18

2.5kg composition of broiler starter premix supplying the following: VitaminA=12000mg,VitaminD_3=300000mg,VitaminE=30000mg,Vitamin$K_3$2000mg,VitaminB_1=2000mg,VitaminB_2=1,600 mg,Niacin=8,000mg,Pantothenic=2,000mg,VitaminB_6=600,VitaminB_{12}=4mg,Folicacid=200mg,BiotinH_2=300mg,Choline+ Chloride=7,0000mg,Cobalt=80mg,Copper=1,200mg,Iodine=400mg,Iron=8000mg,Manganese=1,6000mg,Selenium=80mg, Zinc=1,2000mg. Antioxidant=500m

*composition of broiler finisher premix supplying the following per kg of feed: VitaminA=3,400IU,VitaminD_3=600IU,VitaminE=4,000IU,Vitamin$K_3$600mg,VitaminB_1=640mg,VitaminB_2=1,600mg,Niaci n=8,000mg,Pantothenic=2,000mg,VitaminB_6=600,VitaminB_{12}=4mg,Folicacid=200mg,BiotinH_2=300mg,Choline+Chloride= 7,0000mg,Cobalt=80mg,Copper=1,200mg,Iodine=400mg,Iron=8000mg,Manganese=1,6000mg,Selenium=80mg,Zinc=1,200 0mg and Antioxidant=500m

RESULTS AND DISCUSSION

Growth performance of broiler chickens fed diets containing *Khaya senegalensis* leaf extract

The growth performance of broiler chickens fed diets containing *Khaya senegalensis* leaf extract is presented in Table 2. There was no significant (P>0.05) effect of *Khaya senegalensis* leaf extract on initial weight of the birds which ranged from 547.15 g/b for birds fed 100 ml/L of *Khaya senegalensis leaf* extract to 586.15 g/b for birds fed 0 ml/L of the extract. Significant (P<0.05) effect of *Khaya senegalensis* leaf extract was recorded for final live-weight, total feed intake, daily feed intake, total weight gain, daily weight gain, feed conversion ratio, total water intake and daily water intake. Significantly (P<0.05) higher final live-weight (2108.51 g/b), total weight gain (1522.36 g/b) and daily weight gain (43.50 g/b/d) were recorded for birds fed 0ml/L *Khaya senegalensis* leaf extract which were similar with the birds fed 75ml/L *Khaya senegalensis* leaf extract (2078.44 g/b, 1494.62 g/b and 42.70 g/b/d respectively). There were however lower (P<0.05) final live-weight (1983.37 g/b), total weight gain (1408.22 g/b) and daily weight gain (40.24 g/b/d) obtained for birds fed 25ml/L *Khaya senegalensis* leaf extract compared to 0ml/L but similar with birds fed 50ml/L (1996.42 g/b, 1437.44 g/b and 41.07 g/b/d respectively) and 100ml/L (1986.78 g/b, 1439.63 g/b and 41.13 g/b/d respectively) *Khaya senegalensis* leaf extract. Higher (P<0.05) total feed intake (5088.60 g/b) and daily feed intake (145.39 g/b/d) were recorded for birds fed 0ml/L compared to those fed 25ml, 75ml and 100ml/l. Birds fed 75ml/L had total and daily feed intakes (4678.10 g/b and 133.66 g/b/d

respectively) similar to those of birds fed 25ml/L (4607.20 g/b and 131.63 g/b/d respectively). There were however lower (P<0.05) total feed intake (4483.40 g/b) and daily feed intake (128.10 g/b/d) for the birds fed 100ml/L *Khaya senegalensis* leaf extract compared the other treatments except for birds fed 25ml/L *Khaya senegalensis* leaf extract.

Feed conversion ratio (3.12) was better (P<0.05) for birds fed 75ml/L and 100ml/L *Khaya senegalensis* leaf extract compared to birds fed 0ml/L (3.36), 25ml/L (3.28) and 50ml/L (3.48) *Khaya senegalensis* leaf extract. There was poor feed conversion ratio (3.48) obtained for the birds fed 50ml/L *Khaya senegalensis* leaf extract although similar with birds fed 0ml/L *Khaya senegalensis* leaf extract. Higher (P<0.05) total water intake (14005.00 ml/b) and daily water intake (400.14 ml/b/d) were recorded for birds fed 0ml/L *Khaya senegalensis* leaf extract which was similar with birds fed 75ml/L (13764.70 ml/b and 393.28 ml/b/d), followed by birds fed 50ml/L (13571.50 ml/b and 387.76 ml/b/d) *Khaya senegalensis* leaf extract which was also similar with birds fed 75ml/L. This was followed by birds fed 25ml/L (13333.90 ml/b and 380.97 ml/b/d) *Khaya senegalensis* leaves extract which was also similar with birds fed 50ml/L. There were lower total water intake (13221.40 ml/b) and daily feed intake (377.75 ml/b/d) recorded for birds fed 100ml/L *Khaya senegalensis* leaf extract although, there were also similar with birds fed 25ml/L.

The final body weight of birds fed 0ml/L *Khaya senegalensis* leaf extract was 1.43% higher than that of birds fed 75ml/L *Khaya senegalensis* leaf extract while birds fed 75ml/L *Khaya senegalensis* leaves extract had 4.57% higher weight than the birds fed 25ml/L *Khaya senegalensis* leaf extract which had the least final body weight. Total weight gain of birds fed 0ml/L *Khaya senegalensis* leaf extract was 1.82% higher than that of the birds fed 75ml/L *Khaya senegalensis* leaf extract which has 5.78% higher gain than the birds fed 25ml/L *Khaya senegalensis* leaf extract. Birds fed 75ml/L *Khaya senegalensis* leaf extract had better feed conversion ratio because they consumed the least feed with higher weight gain compared to the control. This implies that *Khaya senegalensis* leaf extract improved the utilization of feeds. In line with this study, feed efficiency was improved in Japanese quail fed neem supplemented ration (Mahmud *et al.*, 2015). The improvement of feed efficiency by the use of mahogany leave extract might be due to the content of polyphenolic compounds which might have increased the activity of digestive enzymes, decreased pathogenic microorganisms and inhibits toxins present in feed (Younan *et al*., 2019). The increased growth performance resulting from improved feed efficiency could be due to antimicrobial and anti-protozoal properties of *Khaya senegalensis* leaf extract, which helped to reduce the microbial load of birds (Wanker *et al*., 2009; Abdel-Wareth *et al*., 2014; Mukta, 2022). The significantly (P<0.05) higher final body weight, total weight gain and daily weight gain recorded for birds fed 0ml/L *Khaya senegalensis* leaf extract which was similar with that of birds fed 75ml/L *Khaya senegalensis* leaf extract might be attributed to the active substances present in the leaf that can improve digestion and metabolism and possess bacterial and immune-stimulant activities (Ghazalah and Ali, 2008). The lower (P<0.05) values obtained for final body weight, total weight gain and daily weight gain for birds fed 25ml/L *Khaya senegalensis* leaf extract which was at similar to those fed 50ml/L and 100ml/L *Khaya senegalensis* leaf extract, respectively were slightly higher than the values reported by Beg *et al*. (2018) who fed neem Leaf (*Azadirachta indica*) meal as an alternative to antibiotic in broiler ration. Also, the final body weight and average daily weight gain values recorded in this study were lower than the values reported by Mukta (2022) who fed mahogany and chalta leaves as supplements.

Table 2: Growth Performance of Broiler Chickens Fed Diets Containing *Khaya senegalensis* Leaf Extract

Parameters	*Khaya senegalensis* leaves extract (ml/L)					SEM
	T1 (0ml/L)	T2 (25ml/L)	T3 (50ml/L)	T4 (75ml/L)	T5 (100ml/L)	
Initial Weight (g/b)	586.15	575.15	558.98	583.83	547.15	20.70^{NS}
Final Weight (g/b)	2108.51^{a}	1983.37^{b}	1996.42^{b}	2078.44^{a}	1986.78^{b}	22.95*
Total Feed Intake (g/b)	5088.60^{a}	4607.20^{bc}	4959.00^{a}	4678.10^{b}	4483.40^{c}	67.33*
Daily Feed Intake (g/b/d)	145.39^{a}	131.63^{bc}	141.69^{a}	133.66^{b}	128.10^{c}	1.92*
Weight Gain (g/b)	1522.36^{a}	1408.22^{b}	1437.44^{b}	1494.62^{a}	1439.63^{b}	21.12*
Daily Weight Gain (g/b/d)	43.50^{a}	40.24^{b}	41.07^{b}	42.70^{a}	41.13^{b}	0.60*
Feed Conversion Ratio	3.36^{bc}	3.28^{b}	3.48^{c}	3.13^{a}	3.12^{a}	0.06*
Total Water Intake (ml/b)	14005.00^{a}	13333.90^{cd}	13571.50^{bc}	13764.70^{ab}	13221.40^{d}	156.02*
Daily Water Intake (ml/b/d)	400.14^{a}	380.97^{cd}	387.76^{bc}	393.28^{ab}	377.75^{d}	4.46*
Mortality (%)	0.50	0.50	2.00	0.00	0.00	

^{abcd}Means with different superscript within row differed significantly (P<0.05), NS = Non significant, SEM = Standard error of mean

Carcass characteristics of broiler chickens fed diets containing Khaya senegalensis leaf extract

The carcass characteristics of broiler chickens fed diets containing *Khaya senegalensis* leaf extract is shown in Table 3. There were significant (P<0.05) effects of *Khaya senegalensis* leaf extract on all carcass characteristics studied. Higher (P<0.05) average live weight, slaughter weight and dressed weight were recorded for birds fed 0, 25, 50 and 100ml/L *Khaya senegalensis* leaf extract compared with the birds fed 75ml/L *Khaya senegalensis* leaf which had the lowest values. Higher (P<0.05) carcass weight (1590.80 g/b) was recorded for birds fed 0ml/L *Khaya senegalensis* leaf extract and lower (P<0.05) carcass weights (1378.30 g/b) were obtained for birds fed 25, 50 and 100 ml/L *Khaya senegalensis* leaf extract. The lowest carcass weight was obtained in birds fed 75ml/L *Khaya senegalensis* leaf extract. Major cuts expressed as percentage of dressed weight revealed that higher (P<0.05) head (3.03%) was obtained for birds fed 25ml/L *Khaya senegalensis* leaf extract which was similar with that of birds fed 75ml/L (2.94%) *Khaya senegalensis* leaf extract, followed by that of birds fed 50ml/L (2.88%) *Khaya senegalensis* leaf extract which was also similar with that of birds fed 75ml/L *Khaya senegalensis* leaf extract. The lowest (P<0.05) head (2.67%) was recorded for birds fed 0ml/L *Khaya senegalensis* leaf extract but similar to the values for birds fed 100ml/L (2.70%) *Khaya senegalensis* leaf extract. Higher (P<0.05) shank were recorded for birds fed 25, 50 and 75ml/L *Khaya senegalensis* leaf extract and lower (P<0.05) shank were obtained for birds fed 0 and 100ml/L *Khaya senegalensis* leaf extract. Thigh (12.58%) was highest (P<0.05) for birds fed 100ml/L *Khaya senegalensis* leaf extract although similar with that of birds fed 50ml/L (12.47%) *Khaya senegalensis* leaf extract, followed by that of birds fed 25ml/L (12.18%) *Khaya senegalensis* leaf extract which was also similar with that of birds fed 50ml/L *Khaya senegalensis* leaf extract, and the lowest (P<0.05) thigh (11.69%) was recorded for birds fed 75ml/L *Khaya senegalensis* leaf extract but also similar with that of birds fed 0ml/L (12.03%) *Khaya senegalensis* leaf extract. Higher (P<0.05) wing (8.29%) was recorded for birds fed 25ml/L *Khaya senegalensis* leaf extract although similar with the birds fed 0ml/L (8.09%) and 50ml/L (8.14%) *Khaya senegalensis* leaf extract. This was followed by that of birds fed 75ml/L (7.99%) *Khaya senegalensis* leaf extract which also is similar with that of birds fed 0ml/L and 50ml/L *Khaya senegalensis* leaf extract. The lowest (P<0.05) wing (7.45%) was obtained for birds fed 100ml/L *Khaya senegalensis* leaf extract. Back (9.91%) was highest (P<0.05) for birds fed 100ml/L *Khaya senegalensis* leaf extract while lower (P<0.05) back (9.03%) were recorded for birds fed 0, 25, 50 and 75ml/L *Khaya senegalensis* leaf extract. Highest (P<0.05) neck (6.78%) was obtained for birds fed 25ml/L *Khaya senegalensis* leaf extract, followed by that of birds fed 50ml/L

(6.40%) *Khaya senegalensis* leaf extract although similar with that of birds fed 0ml/L (6.25%) *Khaya senegalensis* leaf extract and the lowest (P<0.05) neck were recorded for birds fed 75 and 100ml/L *Khaya senegalensis* leaf extract but similar with that of birds fed 0ml/L *Khaya senegalensis* leaf extract. Breast (23.90%) was highest (P<0.05) for birds fed 0 and 75ml/L *Khaya senegalensis* leaf extract, followed by that of birds fed 25ml/L (22.84%) *Khaya senegalensis* leaf extract, and the lowest (P<0.05) breast were recorded for birds fed 50 and 100ml/L *Khaya senegalensis* leaf extract. Highest (P<0.05) drumstick (10.82%) was obtained for birds fed 0ml/L *Khaya senegalensis* leaf extract although similar with that of birds fed 25ml/L (10.57%) and 50ml/L (10.64%) *Khaya senegalensis* leaf extract, while lowest (P<0.05) drumstick were recorded for birds fed 75 and 100ml/L *Khaya senegalensis* leaf extract which were however at par with that of birds fed 25 and 50ml/L *Khaya senegalensis* leaf extract. Chest (7.54%) was highest (P<0.05) for birds fed 100ml/L *Khaya senegalensis* leaf extract although similar with that of birds fed 0ml/L (7.14%) *Khaya senegalensis* leaf extract which is also at par with that of birds fed 50ml/L (6.84%) and 75ml/L (6.85%) *Khaya senegalensis* leaf extract. The lowest (P<0.05) chest (6.43%) was obtained for birds fed 25ml/L *Khaya senegalensis* leaf extract but also similar with that of birds fed 50ml/L and 75ml/L *Khaya senegalensis* leaf extract. The results of internal organs expressed as percentage of live weight revealed that highest (P<0.05) gizzard (2.62%) was recorded for birds fed 50ml/L *Khaya senegalensis* leaf extract which was at par with that of birds fed 0ml/L (2.56%) *Khaya senegalensis* leaf extract, followed by that of birds fed 25ml/L (2.48%) which was similar with that of birds fed 100ml/L (2.45%) and 0ml/L *Khaya senegalensis* leaf extract. The lowest (P<0.05) gizzard (2.40%) was obtained for birds fed 75ml/L *Khaya senegalensis* leaf extract which was also at par with that of birds fed 25ml/L and 100ml/L *Khaya senegalensis* leaf extract. Highest (P<0.05) liver (1.67%) was recorded for birds fed 100ml/L *Khaya senegalensis* leaf extract which was similar with that of birds fed 25ml/L (1.60%) *Khaya senegalensis* leaf extract, followed by that of birds fed 50 and 75ml/L *Khaya senegalensis* leaf extract which were also similar while the lowest (P<0.05) liver (1.45%) was obtained for birds fed 0ml/L *Khaya senegalensis* leaf extract. Heart (0.49%) was highest (P<0.05) for birds fed 25ml/L *Khaya senegalensis* leaf extract while lower (P<0.05) heart was recorded for birds fed 0, 50, 75 and 100ml/L *Khaya senegalensis* leaf extract. For crop, highest (P<0.05) value (0.53%) was recorded for birds fed 100ml/L *Khaya senegalensis* leaf extract but similar with that of birds fed 25ml/L (0.49%) and 50ml/L (0.49%) *Khaya senegalensis* leaf extract, followed by that of birds fed 75ml/L (0.46%) *Khaya senegalensis* leaf extract which is also similar with that of birds fed 25ml/L and 50ml/L *Khaya senegalensis* leaf extract. The lowest (P<0.05) crop (0.42%) was obtained for birds fed 0ml/L *Khaya senegalensis* leaf extract which was also at par with that of birds fed 75ml/L *Khaya senegalensis* leaf extract. Caecum were highest (P<0.05) for birds fed 75 and 100ml/L *Khaya senegalensis* leaf extract, followed by that of birds fed 0ml/L (0.71%) *Khaya senegalensis* leaf extract, while the lowest (P<0.05) caecum (0.57%) were recorded for birds fed 25 and 50ml/L *Khaya senegalensis* leaf extract. Highest (P<0.05) abdominal fat were obtained for birds fed 100ml/L *Khaya senegalensis* leaf extract which was similar with that of birds fed 0ml/L (2.13%) *Khaya senegalensis* leaves extract, followed by that of birds fed 25ml/L (1.96%), while the lowest (P<0.05) abdominal fat were recorded for birds fed 50 and 75ml/L *Khaya senegalensis* leaf extract. Intestinal length (217.00cm) was highest (P<0.05) for birds fed 0 and 100ml/L *Khaya senegalensis* leaf extract which were similar with that of birds fed 50ml/L (210.00%) and 75ml/L (213.75cm) *Khaya senegalensis* leaf extract. The lowest (P<0.05) intestinal length (204.25cm) was recorded for birds fed 25ml/L *Khaya senegalensis* leaf extract which was similar with that of birds fed 50ml/L and 75ml/L *Khaya senegalensis* leaf extract, respectively.

The dressing percentages and major cuts obtained in this study were higher than the values reported by Adamu (2024). The thigh weight reported is lower than the 18.87 – 21.28% reported by Oluyemi and Robert (2000). The breast weight obtained in this research were slightly lower (26.32 to 27.13%) to values reported by Onu *et al.* (2011).

Gizzard weights reported were lower than the values (3.77 - 4.37%) reported by Oladunjoye and Ojebiyi, (2010). The variations observed in this study for all carcass parameters might be attributed to strain of the birds and environmental condition in which the birds were raised.

Table 3: Carcass Characteristics of Broiler Chickens Fed Diets Containing *Khaya senegalensis* Leaf Extract

	Khaya senegalensis leaves extract (ml/L)					
Parameters	T1 (0)	T2 (25)	T3 (50)	T4 (75)	T5 (100)	SEM
Live weight (g/b)	2094.80^{a}	2061.30^{a}	2098.30^{a}	1919.50^{b}	2134.00^{a}	39.67*
Slaughter weight (g/b)	2036.30^{a}	2003.50^{a}	2039.80^{a}	1866.50^{b}	2073.00^{a}	39.79*
Carcass weight (g/b)	1590.80^{a}	1512.50^{b}	1513.30^{b}	1387.30^{c}	1519.50^{b}	33.14*
Dressed weight (g/b)	1976.00^{a}	1937.30^{a}	1961.80^{a}	1797.50^{b}	1993.80^{a}	38.50*
Dressing %	94.34^{a}	93.89^{b}	93.49^{c}	93.63^{bc}	93.43^{c}	0.14*
Major cuts (% dressed weight)						
Head	2.67^{c}	3.03^{a}	2.88^{b}	2.94^{ab}	2.70^{c}	0.06*
Shank	4.05^{b}	4.39^{a}	4.56^{a}	4.37^{a}	4.13^{b}	0.12*
Thigh	12.03^{cd}	12.18^{bc}	12.47^{ab}	11.69^{d}	12.58^{a}	0.19*
Wing	8.09^{ab}	8.29^{a}	8.14^{ab}	7.99^{b}	7.45^{c}	0.10*
Back	9.27^{b}	9.03^{b}	9.16^{b}	9.30^{b}	9.91^{a}	0.22*
Neck	6.25^{bc}	6.78^{a}	6.40^{b}	5.98^{c}	5.99^{c}	0.16*
Breast	23.90^{a}	22.84^{b}	21.74^{c}	23.62^{a}	21.39^{c}	0.31*
Drumstick	10.82^{a}	10.57^{ab}	10.64^{ab}	10.45^{b}	10.37^{b}	0.17*
Chest	7.14^{ab}	6.43^{c}	6.84^{bc}	6.85^{bc}	7.54^{a}	0.24*
Organs (% of live weight)						
Gizzard	2.56^{ab}	2.48^{bc}	2.62^{a}	2.40^{c}	2.45^{bc}	0.06*
Liver	1.45^{c}	1.60^{ab}	1.53^{b}	1.54^{b}	1.67^{a}	0.04*
Heart	0.43^{b}	0.49^{a}	0.45^{b}	0.43^{b}	0.44^{b}	0.01*
Crop	0.42^{c}	0.49^{ab}	0.49^{ab}	0.46^{bc}	0.53^{a}	0.03*
Caecum	0.71^{b}	0.57^{c}	0.59^{c}	0.80^{a}	0.79^{a}	0.02*
Abdominal fat	2.13^{ab}	1.96^{b}	1.42^{c}	1.45^{c}	2.22^{a}	0.11*
Intestinal length (cm)	214.50^{a}	204.25^{b}	210.00^{ab}	213.75^{ab}	217.00^{a}	4.79*

^{abcd}Means with different superscript within row differed significantly (P<0.05), SEM = Standard error of mean

Apparent Nutrient Digestibility by broiler chickens fed diets containing Khaya senegalensis leaf extract

The apparent nutrient digestibility of broiler chickens fed diets containing *Khaya senegalensis* leaf extract is presented in Table 4. There was significant (P<0.05) effect of *Khaya senegalensis* leaf extract on dry matter, crude protein, crude fibre, ether extract and nitrogen free extract digestibility coefficients. Higher (P<0.05) dry matter digestibility (77.36%) was recorded for birds fed 0ml/L *Khaya senegalensis* leaf extract, followed by that of birds fed 75ml/L (76.32%) *Khaya senegalensis* leaf extract; and then followed by birds fed 25ml/L *Khaya senegalensis* leaf extract which was similar with birds fed 50ml/L *Khaya senegalensis* leaf extract. The lowest (P<0.05) dry matter (69.88%) digestibility was obtained from birds fed 100ml/L *Khaya senegalensis* leaf extract. Crude protein, crude fibre and nitrogen free extract digestibilities (79.89, 72.99 and 75.26 %) were higher (P<0.05) for birds fed 0ml/L *Khaya senegalensis* leaf extract, followed by that of birds fed 75ml/L (78.35, 70.06 and 73.01 %) *Khaya senegalensis* leaf extract and then followed by that of birds on 25ml/L *Khaya senegalensis* leaf extract which were similar with that of birds fed 50ml/L *Khaya senegalensis* leaf extract. The lowest (P<0.05) crude protein, crude fibre and nitrogen free extract digestibilities (76.00, 66.51 and 60.32 %) were recorded in birds served 100ml/L *Khaya senegalensis* leaf extract. Higher (P<0.05) ether extract digestibility (80.04%) was recorded in birds fed 0ml/L *Khaya senegalensis* leaf extract, followed by birds fed 75ml/L *Khaya senegalensis* leaf extract, and then followed birds fed 25ml/L *Khaya*

senegalensis leaf extract. The lowest (P<0.05) ether extract (73.05%) digestibility was obtained in birds fed 100ml/L *Khaya senegalensis* leaf extract which was similar with birds fed 50ml/L (73.91%) *Khaya senegalensis* leaf extract.

Dry matter and crude protein digestibilities of birds fed 0ml/L *Khaya senegalensis* leaf extract were 1.38% and 1.93% higher than that of birds fed 75ml/L *Khaya senegalensis* leaf extract which however had 8.44% and 3.00% higher dry matter and crude protein digestibility than birds fed 100ml/L *Khaya senegalensis* leaf extract. Similarly, crude fibre and ether extract digestibilities of birds fed 0ml/L *Khaya senegalensis* leaf extract were 4.01% and 5.07% higher than that of birds fed 75ml/L *Khaya senegalensis* leaf extract which were 2.00% and 6.87% higher than that of birds served 100ml/L *Khaya senegalensis* leaf extract.

The nitrogen free extract digestibility of birds served 0ml/L *Khaya senegalensis* leaf extract was 2.99% higher than birds served 75ml/L *Khaya senegalensis* leaf extract which also had 17.38% higher nitrogen free extract digestibility than the birds fed 100ml/L *Khaya senegalensis* leaf extract. The nutrient digestibilities of the diets were good since the values of the digestibility coefficients were above 60%. The higher nutrient digestibilities obtained may be due to the presence of phytochemicals which have pharmacological effect on the digestive system of the birds by increasing the activity of digestive enzymes, decreased pathogenic microorganisms and inhibits toxins present in the feed (Obikaonu, 2012; Younan *et al*., 2019).

Table 4: Apparent Nutrient Digestibility by Broiler Chickens Fed Diet Containing *Khaya senegalensis* Leaf Extract

	Khaya senegalensis leaves extract (ml/L)					
Parameters (%)	T1 (0)	T2 (25)	T3 (50)	T4 (75)	T5 (100)	SEM
Dry matter	77.36^{a}	70.60^{c}	70.34^{cd}	76.32^{b}	69.88^{d}	0.26*
Crude protein	79.89^{a}	77.19^{c}	77.09^{c}	78.35^{b}	76.00^{d}	0.23*
Crude fibre	72.99^{a}	68.01^{c}	68.45^{c}	70.06^{b}	66.51^{d}	0.42*
Ether extract	80.04^{a}	76.96^{c}	73.91^{d}	78.44^{b}	73.05^{d}	0.47*
Nitrogen free extract	75.26^{a}	66.38^{c}	65.83^{c}	73.01^{b}	60.32^{d}	0.32*

^{abcd}Means with different superscript within row differ significantly (P<0.05), NS = Non significant, SEM = Standard error of mean

CONCLUSION AND RECOMMENDATION

The result of this study showed that birds fed 0 ml/L and 75 ml/L of *Khaya senegalensis* leaf extract had better performance in terms of final weight and feed conversion ratio. However, chickens fed 50 ml/L of *Khaya senegalensis* had higher feed Intake. *Khaya senegalensis* leaf extract can be administered to broiler chickens at 75 ml/L without having any adverse effect. Similar study can be conducted to investigate the effect of the extract administered through the feed.

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Evaluation of Growth Performance, Carcass Characteristics, and Blood Profile of Broiler Turkeys Reared Under Different Housing Systems

A. Suleiman[1], M.N. Sabo[1], H. B. Usman[1], A.I Maryam[2], C. C. Mbakwe[1], and Z. S. Jibia[1]

[1]Department of Animal Science, Federal University, Dutsin-Ma, Katsina State, Nigeria.

[2]Department of Fisheries and Aquaculture, Federal University, Dutsin-Ma, Katsina State, Nigeria.

***Corresponding Author Email:* saliyu1@fudutsinma.edu.ng *Tel: +234-8052307036*

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ABSTRACT

The experiment was carried out at Livestock Teaching and Research Farm, Federal University Dutsin-Ma, Katsina State to evaluate growth performance, carcass characteristics and blood profile of broiler Turkeys reared under different housing systems. A total of 48-day-old poults were brooded for 4 weeks. The poults were moved to the experimental pens and placed in a 2 x 2 factorial arrangement in a completely randomized design with two housing types (Deep Litter without outdoor (DL-O) access and Deep Litter with outdoor access (DL+O) and two sexes (Jakes and Hen poults) as the factors. Data were collected on body weight, feed intake, mortality, carcass and blood profile of the turkeys. The result indicated that there were significant ($P < 0.05$) differences between male and female Turkeys in terms of final body weight, body weight gain, and total feed intake (11.52, 7.28, 15.60 & 2.17 male and 9.54, 5.88, 14.78, 2.56% female). The carcass characteristics results obtained in this study revealed that, live weight, dress weight and dressing percentage of Turkeys (LW= 9.54 - 11.52, DW= 6.74 – 8.70, DP= 70.58 – 75.48%) had significant ($P < 0.05$) differences between the treatments, while there were no significant differences across all the treatments with regard housing. The result of the of white blood cells, heterophil, and lymphocytes obtained were influenced ($P<0.05$) by sex. However, all other parameters, such as packed cell volume, haemoglobin, monocytes and eosinophil were not affected by sex and were within the normal range of Turkeys. In addition, glucose, total protein, total cholesterol, high density lipoprotein, total bilirubin and conjugated bilirubin were not affected by sex and housing.

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INTRODUCTION

The poultry industry in general requires that producers consider production costs and improve profit margins to enhance productivity and sustainability (Noonari *et al.,* 2015). Nevertheless, confining high-proficiency production is another good area of concern, especially now that consumers demand meat products derived from poultry reared in the optimum environment to ensure their welfare (Ferrante *et al.,* 2019). In the past, attentions on animal regulation has driven changes on how these animals were fed and managed, and will continue, possibly in an accelerated way, with high expectations on considering an environmentally fit and economically suitable approach (Suleiman *et al.,* 2023). The type of compounds to which (these birds) were exposed includes the housing system, the feed they consumed, the climate they were exposed, and the management systems employed, which appeared to affects the performance of the birds (Suleiman *et al.,* 2023). Nicholas White Turkeys (*Meleagris gallopavo*) are adaptable to different types of weather and climates and can be reared in almost any part of the world (Odutayo *et al.,* 2015). The Turkeys industries in Nigeria today has significantly improved from 1.5 to about 2 million tons of Turkeys meat locally annually. This sudden improvement in the Turkeys industries was turned to reality by

strengthening of production and improvement of large breeds like Nicolas White with standard live weights ranging from 15 to about 17 kg for male and 8 to about 10 kg for female at 15 to about 16 weeks of age. At this age, Turkeys are expected to reach table size and be ready for consumption, even with those produced from homesteads (Oyeagu *et al.,* 2022). Turkeys' production is carried out in almost all parts of Nigeria with little or no religious, social, or cultural inhibitions or taboo associated with its consumption (Oyeagu *et al.,* 2022).

Turkey's production is vital, viable, and profitable due to the increased demand for its meat globally. Turkeys are more tolerant of heat than chickens, perform well in the tropics, and produce meat of better quality, which is used for human consumption (Yakubu *et al.,* 2013). In many parts of the world today, turkey production has greatly improved; it has experienced a significant improvement since 1980 (Rasha *et al.,* 2024). Despite the availability of many rearing systems that could be used in rearing poultry, it was indeed obvious that no better housing system was present since each possesses disadvantages and advantages in terms of welfare and health (Lay *et al.,* 2011; Hartcher and Jones, 2017).

MATERIALS AND METHODS

The experiment was conducted at the Livestock Teaching and Research Farm, Federal University Dutsin-Ma, Katsina State. Forty-eight (48) day-old poults were sourced from a reputable commercial hatchery company, and the poults were reared for 4 weeks indoors (brooding). At the end of the 4th week, the poults were moved to the experimental pens. The poults were placed in a 2 x 2 factorial arrangement in a completely randomized design (CRD). The factors were two housing types (Deep Litter without outdoor (DL-O) access and Deep Litter with outdoor access (DL+O) and two sexes (Jakes and Hen poults). The poults were separated according to sex and each having four (4) treatments and three (3) replicates in a completely randomized design. The treatments allocated were Treatment 1: Jakes under DL (Deep Litter) housing (JDL), Treatment 2: Jakes under DLO housing (JDLO), Treatment 3: Hen poults under DL housing (HpDL), and Treatment 4: Hen poults under DLO housing (HpDLO), respectively. All the birds were given same feed types *ad libitum* containing 30% CP and 2800 ME kcal/kg at week 0 to 8 (starter phase) and 23% CP. and 3000 ME kcal/kg at week 8 - 16 week (grower phase) according to recommendations of Ogundipe *et al.,* (2022). Data collected includes; growth performance, body weight and body weight gain, feed intake, feed conversion ratio, mortality, and carcass characteristics (AGW, 2023). All data generated were obtained and analyzed. General Linear Model (GLM) procedures of the Statistical Analysis System package version 9.2 software, and statistical significance were set at $P<0.05$. Statistical difference was separated using DMR Test method.

RESULT AND DISCUSSION

Growth Performance

The result of the study, as presented in Table 1, indicated that there were significant ($P<0.05$) differences between sexes of the turkeys in terms of final body weight, weight gain, and total feed intake. The males have the higher ($P<0.05$) values compared to the female turkeys.

Housing type had no influence ($P>0.05$) on the growth performance of the turkeys. This is similar to the findings of Suleiman *et al.* (2023), who reported that there was no significant difference ($P>0.05$) between indoor and outdoor with pasture (*Lablab purpureus*) in term of final body weight, and body weight gain of Noiler birds reared under different housing types. They also reported similar total feed intake (TFI) among all the treatments. However, Oyegunle *et al.* (2021) findings were not in support of the present study, they reported that animals had higher energy demand living outside or outdoors because they are expending more energy walking around and using more energy to stay warm/cool.

Except for feed conversion ratio and mortality rate (FCR= 2.17 – 2.56% & Mort= 10.00 – 3.33%), which indicated an insignificant statistical difference between the two sexes. For the housing, TFI obtained shows a significance ($P<0.05$) difference between treatments. This means that final body weight, weight gain, feed conversion ratio, and mortality were statistically the same.

Table 1: Performance Characteristics of broiler turkeys on different housing systems

Parameters	IBWg/kg	FBWg/kg	WGg/kg	TFIg/kg	FCR	MORT%
Sex						
Male	4.24[a]	11.52[a]	7.28[a]	15.60[a]	2.17	10.00
Female	3.66[b]	9.54[b]	5.88[b]	14.78[b]	2.56	3.33
SEM	0.17	0.34	0.36	0.24	0.17	4.08
Housing						
Indoor	4.04	10.62	6.58	15.10	2.31	6.67
Outdoor	3.86	10.43	6.58	15.28	2.42	6.67
SEM	0.17	0.33	0.36	0.24	0.17	4.08
Interaction						
Sex * Housing	NS	NS	NS	NS	NS	NS

[a-b] means within rows bearing different superscripts differ significantly at $p > 0.05$; SEM: Standard error of means, IBW: initial body weight, FBW: final body weight, WG: weight gain, TFI: total feed intake, FCR: feed conversion ratio, and MORT: mortality, NS: non-significant

Weekly feed intake

It can be observed from Figure 1 that feed consumed by the turkeys varies across the sexes and weeks. There were no significant (P>0.05) differences in feed consumption at weeks 9, 10, 11, 13, 15, and 16. Male turkeys consumed a higher (P<0.05) amount of feed compared with female turkeys at weeks 12 and 14. But the housing systems do not influence feed intake across the weeks of the study.

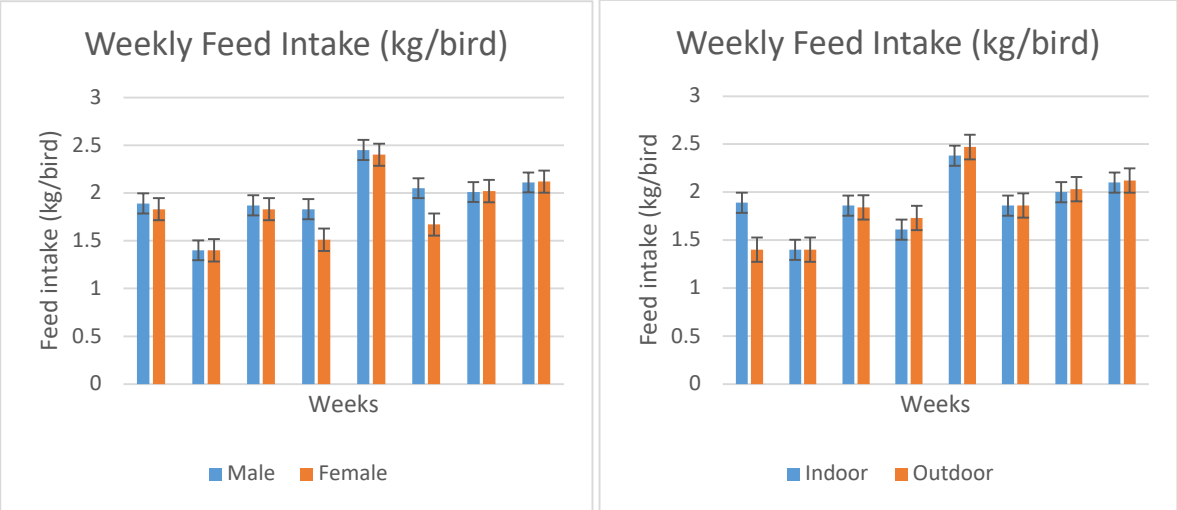

Figure 1: Influence of Sex, and Housing on weekly feed intake of Nicholas White Turkeys

Weekly Body Weight

Figure 2 indicates that there were significant (P < 0.05) differences between male and female turkeys in terms of body weight. The male turkeys presented higher body weight compared to female turkeys across all the weeks. However, the result shows that there was no significant (P > 0.05) difference between turkeys reared under the different housing systems.

Carcass characteristics

The results of the carcass characteristics of Turkeys as shown in Table 2 below revealed that live weight, dressed weight and dressing percentage were lower (P<0.05) in hens compared to toms (9.54 vs 11.52, 6.74 vs 8.70 and 70.58 vs 75.48% respectively). Housing did not affect carcass parameters of the turkeys. The results of the present study are in agreement with the finding of Suleiman *et al.* (2023),

who revealed that housing type did not influence live weight, dressed weight and standard meat cuts of Noiler chickens. On the contrary, Castellini *et al.* (2002), found that the breast and thigh weights increased when broiler chicken had outdoor access and a lower stocking density in an organic production system because of forced motor activity.

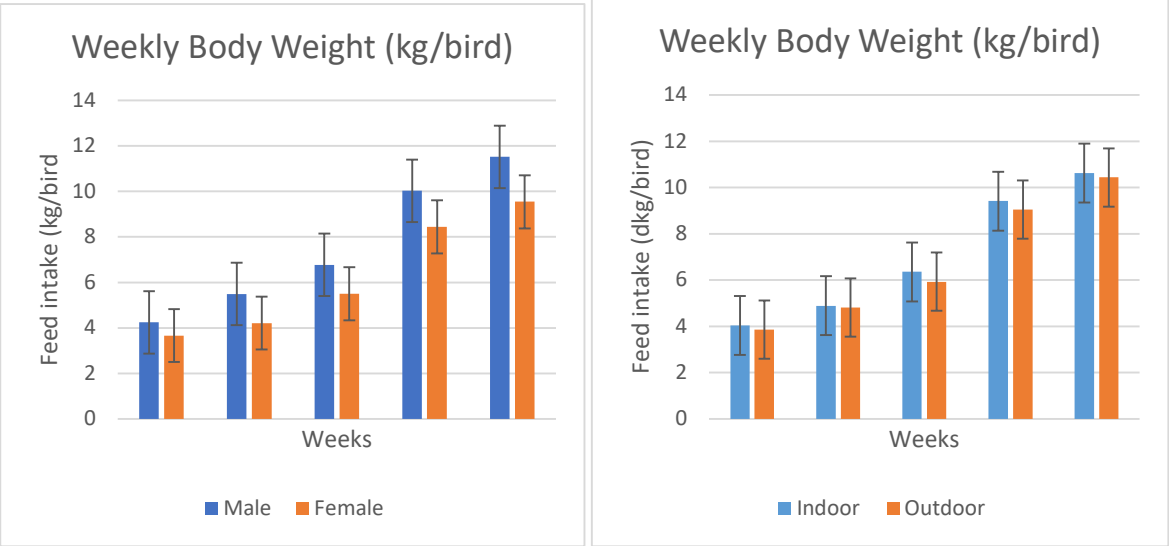

Figure 2: Influence of Sex and Housing on weekly body weight of Nicholas White Turkeys

Table 2: Carcass Characteristics of broiler turkey on different housing systems

Parameters	LWg/kg	DWg/kg	DP%	WWg/kg	BWg/kg	BRSWg/kg	THWg/kg	SHWg/kg	NWg/kg	HWg/kg
Sex										
Male	11.52[a]	8.70[a]	75.48[a]	13.01	14.36	32.89	28.78	4.26	4.27	2.42
Female	9.54[b]	6.74[b]	70.58[b]	12.14	17.90	31.16	27.89	4.15	4.70	2.06
SEM	0.34	0.30	0.92	0.49	1.71	2.53	0.45	0.22	0.47	0.17
Housing										
Indoor	10.62	7.86	73.71	12.73	17.46	29.78	28.91	4.13	4.67	2.32
Outdoor	10.43	7.58	72.34	12.42	14.81	34.26	27.76	4.28	4.31	2.16
SEM	0.33	0.30	0.92	0.49	1.71	2.53	0.45	0.22	0.47	0.17
Interaction										
Sex * Housing	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a-b] means within rows bearing different superscript differs significantly at $p > 0.05$; SEM: Standard error of means, LW: live weight, DW: dress weight, DP: dressing percentage, WW: wings weight, BW: back weight, BRSW: breast weight, THW: thigh weight, SHW: shank weight, NW: neck weight and HW: head weight, NS: non-significant

Haematological Parameters

From the result of the study shown in Table 3, WBC, H and L were influenced ($P < 0.05$) by sex. WBCs defend the body against invasion by foreign organisms and supply antibodies for the immune response. All other parameters, such as PCV, Hb, M and E, were not affected by sex, and were within the normal range for Turkeys. Hb levels are direct reflection of the amount of oxygen in the blood. An increased Hb result in serious dehydration, acute obstructive pulmonary disease while, it decreased Hb. result in anaemia, blood loss, liver disease and

others. Crespo and Grimes (2024) stated that PCV. plays a role in determining the state of health in livestock. Crespo and Grimes (2024) further evaluated that, the haematological profile of animals, which usually provides important information about the bird's response to its internal and external surroundings. Which indicated that the information obtained about the physical wellbeing of the Turkeys in the present study was not compromised by sex (Crespo and Grimes, 2024).

Packed Cell Volume, and haemoglobin values recorded in this study was within the normal range as reported by Agina *et al.* (2015). Total White Blood Cells, Monocytes, and Eosinophil values were also normal as described by Bounous et al. (2000). This may also reflect a good body immune system, as the latter performed better. The white blood cells increase in the presence of infection and some cancer conditions, including leukemia. Diminished WBCs are also caused by bone marrow disorder, acute and severe illness, and so on (Peter, 2002). The WBC fraction is composed of heterophils, lymphocytes, monocytes, and eosinophils etc. Lymphocytosis (with or without heterophilia) and eosinophilia may be a result of stress-induced factors and allergic or parasitic states, respectively. A chronic disease state may show an increase in monocyte count (monocytosis) (Peter, 2002). Each of the WBC components observed in the present study was within the normal limits (Christine *et al.,* 1990; Gulland and Hawkey, 1990).

This finding is in contrast with Agina *et al.* (2015), who observed a higher PCV in male than female turkeys, and this was attributed to a higher level of testosterone in adult male turkeys, which tends to promote erythropoiesis. Similarly, Agina *et al*. Sex-related differences in all the haematological parameters were nonsignificant in turkeys (Wang et al. Furthermore, Gattani *et al.* 2016) and Kim *et al.* (2010) observed that female turkeys show lower Hb and PCV in comparison to males; this might be due to high oestrogen concentration in females.

In this regard, the haematological studies conducted showed that although haematocrit values differed with the ambient temperature of the turkey, all parameters were not affected by the housing system used in this study. Following the results of Diktas *et al.* (2015), he reported that differences in housing systems associated with white corpses (eosinophils) were not significant. Similarly, Sekeroglu *et al.* (2009) reported that the housing system did not affect white blood cell and blood levels in birds raised under different housing systems. Furthermore, Olaniyi *et al*. (2012) reported no significant differences in haemoglobin concentrations in the housing system. Bounous *et al*. (2000) found high total white blood cells, haeterophyletic lines, and lymphocyte counts. Furthermore, Schmidt *et al.* (2009) within their study showed that heterophils are the most frequently discovered white blood cells in Turkeys. Furthermore, their reports showed that Waveless (Agina *et al.,* 2015), Helmguinea-Gewügel (Nalubamba *et al.,* 2010), Ducks (Okeudo *et al.,* 2003), and Muskovishucks (Sulaiman *et al.,* 2015).

Blood haemoglobin levels in chickens varies from 9.8-13.5 mg/ dl as reported by Diktaş *et al.* (2015). Variations in Heterophil (H), Lymphocyte (L) ratios, and leukocyte counts are considered as a stress factor, as opined by (Altan *et al.,* 2000; Puvadolpirod and Thaxton, 2000). The findings of Altan *et al.* (2000) further revealed that lymphocyte, eosinophil, monocyte counts, and haematocrit values decrease, while basophil, heterophil counts increase under stress conditions. In addition, the heterophil (H), or Lymphocyte (L) ratio of 0.2 shows low stress levels, whereas 0.5 shows medium stress levels, while 0.8 indicates high stress levels (Gross and Siegel, 1983). Altan *et al.* (2000) stated in their findings that exposure of chickens to high temperatures could cause a decrease in blood haematocrit values, therefore, decreased haematocrit values were expected with increasing temperatures.

Table 3: Haematological Properties of Nicholas White Turkeys

Parameters	PCV (%)	Hb (g/dl)	WBC (10^3/µl)	M (%)	H (%)	L (%)	E (%)
Sex							
Male	42.67	14.17	35.33[b]	1.17	37.00[b]	61.50[a]	0.33
Female	42.00	13.97	43.50[a]	0.17	49.33[a]	50.50[b]	0.00
SEM	1.14	0.40	0.80	0.53	2.95	3.00	0.24
Housing							
Indoor	42.17	14.02	35.83	1.17	42.17	56.67	0.00
Outdoor	42.50	14.12	43.00	0.17	44.17	55.33	0.33
SEM	1.14	0.40	0.80	0.53	3.00	3.00	0.24
Interaction							
Sex * Housing	NS	NS	NS	NS	NS	NS	NS

[a-b] means within rows bearing different superscripts differ significantly at $p > 0.05$; SEM: Standard error of means, PCV: packed cell volume, Hb: Haemoglobin, WBC: white blood cell, M: Monocyte, H: Heterophil, L: Lymphocyte, E: Eosinophils, NS: non-significant

Serum Biochemical Parameters

The serum biochemical parameters as presented in Table 4, revealed that glucose, TP, TC, HDL, TG, TP, TB, CB, ALT, Alb, and Glo were not affected by sex. Serum chemistry was usually used to detect organ disease in livestock, and the amount of protein available in the diets, Edeh *et al.,* 2023). The serum parameters obtained were within the normal range in birds as recorded by Edeh *et al.* (2023). In agreement with this finding, Ibrahim *et al.* (2012) explained that, no sex-related differences in serum TP, Alb, and Glo. Irfan *et al.* (2017) finding contradicts the result of this study, where they reported that, significantly higher values of cholesterol were recorded from the serum of male turkeys. However, they reported similar total protein between male and female turkeys. The insignificant increase recorded in TP. Alb., and Glo. in some treatments group could be attributed to the reduced water intake by Turkeys, although, water was provided *ad libitum* during the research period. A high level of globulin often causes high level of infection due to abnormal increase production of antibodies, as reported by Esubonteng (2011). Excess of Alb. in the body usually causes dehydration, whereas, lower concentration of Alb. may be attributed to the liver problem and adequately due to factors such as malnutrition and infection Esubonteng, 2011). Fischbach, and Dunning (2009) reported that, albumin is responsible for transporting insoluble substances in the blood and aids in maintaining oncotic pressure.

Blood biochemical profile, such as LDL, AST, and ALT levels, is of diagnostic value for various disease conditions and has particular reference to liver disorders and kidney diseases, etc, as described by Gattani *et al.* (2016). Ibrahim *et al.* (2012) report contradicts the result of the present study, where they reported that no sex-related differences in ALP, AST, and ALT. On the contrary, Agina *et al.* (2015) reported that the serum aspartate aminotransferase of turkeys was not affected by sex. However, in agreement with this study, they also observed similar alanine aminotransferase and alkaline phosphatase in females and males.

The serum globulin value obtained for male turkeys was similar to that documented by Ibrahim *et al.* (2012), where a significant difference (P<0.05) was observed (male: 3.27% & female: 2.70). Similarly, Agina *et al.* (2015) opined that, the higher protein concentration in female Turkeys could be explained by the high level of oestrogen hormones. Significantly higher counts of sodium and calcium level in female turkeys might be as a result of oestrogen response. In addition, the low blood glucose recorded in female turkeys might be due to the oestradiol effects, that decreased the expression of gluconeogenic genes in the liver. Factors such as dietary calcium source, housing system, and interaction between them affected the serum inorganic mineral values, as opined by Gattani *et al.* (2016). In contrast, Agina *et al.* (2015) reported that the serum total protein, albumin, globulin, and uric acid values were numerically higher in females than in males

Table 4: Effect of Different Housing Systems and Sex on Serum Biochemical Parameters of Nicholas White Turkeys

Parameters	GLU(mg/dl)	TC(mg/dl)	LDL(mg/dl)	HDL(mg/dl)	TG(mg/dl)	TP(mg/dl)	TB(mg/dl)	CB(mg/dl)	AST(iu/l)	ALT(iu/l)	ALP(iu/l)	Alb(mg/dl)	Glo(mg/dl)
Sex													
Male	102.7	51.2	3.27[a]	0.95	20.9	7.07	1.23	0.40	12.50[a]	9.33	191.17[a]	5.20	1.90
Female	89.5	47.2	2.70[b]	1.00	20.8	7.13	1.32	0.47	10.33[b]	8.33	176.33[b]	4.85	2.30
SEM	5.4	1.6	0.16	0.05	0.4	0.08	0.03	0.04	0.30	0.33	3.13	0.14	0.17
Housing													
Indoor	98.7	47.5	2.87	0.92	21.0	7.20	1.32	0.47	11.33	8.33	186.83	4.85	2.35
Outdoor	93.5	51.3	3.09	1.03	20.8	7.00	1.23	0.40	11.50	9.33	180.70	5.20	1.80
SEM	5.4	1.6	0.16	0.05	0.4	0.08	0.03	0.04	0.30	0.33	3.13	0.14	0.17
Interaction													
Sex * Housing	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a-b] means within rows bearing different superscripts differs significantly at $p > 0.05$; SEM: Standard error of means, GLU: glucose, TC: total cholesterol, LDL: Low Density Lipoproteins, HDL: High Density Lipoproteins TG: triglycerides, TP: total protein: Glo: globulin, Nitrite, Urea, TB: total bilirubin, CB: conjugated bilirubin, AST: aspartate transaminase, ALT: alanine amino transferase, ALP: Alkaline phosphatase, Alb: albumin, NS: non-significan

The results also indicate that housing systems did not influence the serum biochemical parameters of turkeys in this study. Therefore, the two different housing types employed in the study did not in any way influence the organ functions of the turkeys. The results agreed with findings of Diktas *et al.* (2015), who found no effect of housing system on serum cholesterol. Similarly, Eggum (1989) opined that there was no significant effect of housing system on plasma protein content because the total protein content of plasma is related to the amount and quality of protein intake. Furthermore, Diktas *et al.* (2015) depicted that there was no difference between housing systems in white blood corpuscle (heterophil, eosinophile, basophile, lymphocyte, monocyte, Heterophil/Lymphocyte ratios). In addition, Abdel-Azeem *et al.* (2020) noted that, there were insignificant differences in most blood parameters, including total protein, total albumin, total globulin, and glucose, due to housing systems. The assertion of Diktas *et al.* (2015) that serum glucose, total cholesterol, total protein, and triglyceride levels in chicken varies significantly with different housings does not agree with the result of the present study. In addition, Irfan *et al.* (2017) reiterated that, rearing systems also influenced biochemical parameters of Turkeys, and significantly higher values of cholesterol was recorded in birds reared under the confined rearing system. Similar with the findings of this study, Olaniyi *et al*. (2012) reported non-significant variations in total protein and albumin among confined and free-range reared turkeys.

Conclusion and Recommendation

It can be concluded that sex influenced growth performance, haematological indices (white blood cell, heterophils and lymphocytes) count, also the serum biochemical indices (Low Density Lipoproteins, aspartate transaminase and Alkaline phosphatase) of the turkeys. However, the housing systems used in this study have no detrimental effect on the growth performance, haematological indices and serum biochemical indices of turkeys reared under different housing systems.

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ASSESSMENT OF EXTRINSIC FACTORS INFLUENCING CATTLE PRICING AND PROFITABILITY OF CATTLE MARKETS IN SOUTH-WESTERN, NIGERIA

[1*]Okeowo, T.A., [2]Akanni, K.A., [2]Awotide, D.O., [3]Oloniyo, R.B., [2]Akerele, E.O., and [4]Ogunbameru, A.

[1*]Department of Agricultural Economics, Lagos State University of Science and Technology, Ikorodu.
[2]Olabisi Onabanjo University, Ago-Iwoye, Nigeria.
[3]Department of Agricultural Technology, Ekiti State Polytechnic, Isan- Ekiti, Ekiti State.
rboloniyo@ekspoly.edu.ng
[4]Department of Agricultural Economics, Lagos State University of Science and Technology, Ikorodu.
Corresponding Author: biodunokeowo@gmail.com, 08027282978

Keywords:
Cattle Markets, Hedonic Price Model, Southwest Nigeria

ABSTRACT
This study was carried out in South-western, Nigeria with the aim to assess the extrinsic factors influencing pricing and profitability of cattle in cattle markets. Producers are better informed characteristics of product demand, determinants of short-run cattle prices and price differentials among cattle breeds are communicated, their lack of which can result in inability to alter production and marketing decisions to maximize profitability and meet consumer demands. Cross-sectional data was collected from randomly selected 121 and 379 wholesalers and retailers respectively from three states' where cattle markets are predominant. The sample size was selected through a multistage sampling technique. The result of the estimated co-efficient from the Hedonic model for a wholesalers, show an R^2 value of 87 per cent of goodness of fit. The Age of animal with coefficient of 3.25, body size of 9.42 and body grade of 5.42 were positive and significant at ($P< 0.05$), ($P<0.1$) and ($P<0.05$) respectively which indicates that the higher the age, bigger size and body grade the higher the price of the cattle. Meanwhile, the horn length had a negative significant level with the pricing of the cattle at ($p<0.001$). The estimates for Retailers' Hedonic Regression Model had an R^2 of 58.76. The age of the animal, sex of the animal, body colour, body size, body grade and horn length had a positive relationship with price of a cattle at significant level of ($P< 0.1$, $P<0.05$, $P<0.05$, $P<0.05$, $P<0.05$ and $P <0.001$). The horn length was positive but not significant.

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INTRODUCTION

Cattle marketing provide a range of employment and income-earning opportunities for populations on both sides of the border countries (Lutta, 2023). Contributions of cattle trade to the cash incomes and purchasing power of various population groups within pastoral areas are significant. According to Ekiru *et al. (*2022) livestock is a critical sector for the growth of the economies of many countries, regions and communities throughout the world. The sector is essential because it constantly provides food, income, nutrition, employment and trade. It facilitates the socio-economic transformation of smallholder farmers' livelihoods and is a source of capital for small and medium businesses. Cattle contribute significantly to Nigeria GDP, primarily through livestock sector. Specifically, the livestock sector is estimated to contribute about 5% of Nigeria's total GDP, and it accounts for roughly 17% of the agricultural GDP (Sennuga *et al.,* 2022).

Similarly, despite the seasonality of cattle demand and prices, the cattle trade has a multiplier effect on local economies through the creation of employment opportunities, wealth and extensive inter-sectorial linkages. Some of the population groups benefiting from the livestock sector include cattle owners,

hired cattle herders, breeders, wholesalers, retailers, transport owners, drivers, commission agents, loaders, butchers, brokers, sellers of fodder and water, veterinary professionals and other animal health assistants, truck owners, money vendors among others. Communication of product demand patterns, influencing short-term cattle prices, and price differentials among cattle breeds is crucial to enable producers to make decisions to attain improved profitability and meet consumer expectations (Schroeder *et al.,* 2022).

Hedonism and its impact on consumer behavior are the focus of extensive research in marketing over the last 50 years. It is interesting to observe that the magnitude of theoretical and empirical research on the hedonism phenomena of consumer behavior theory indicates that hedonism as a value statement remains inadequately researched (Tiwari *et al.,* 2022). Livestock production supports the livelihood of many households in the world, especially in Africa through the provision of diverse outputs, including food, and also acts as an important investment 'sink' that generates cash for socio-economic needs.

In Nigeria, the livestock subsector has overtime been a key player in the national economy and has particularly been one the main economic mainstay of the country (Siankwilimba, 2024). Despite the huge contribution of cattle and other livestock to economic growth the main issues with cattle market pricing between 2016- 2025 has been the inconsistent and volatile nature of price, influenced by factors like market dynamics, infrastructure challenges, and security concerns (AFDB, 2019). Price and volume of sales volatility over time has been an ever-present problem because of marketing inefficiencies. Marketing cattle becomes difficult, and this makes the cost of doing business increase, resulting in an increase of the final retail price of cattle and their products. Low-income families, who eat lower protein diets, may not be able to get cattle as a result of the operations of these stakeholders and intermediaries (Saleh *et al.,* 2018).

However, several studies have looked into pricing and they lack recent data on specific cattle market sources, pricing, productivity, price drivers, market margins, and marketing information flows (Bui et al., 2023). Furthermore, there is a lack of empirical evidence on the presence or kind of price connections in cattle markets, the effects of marketing costs on gross marketing profitability, and the influence of cow characteristics on price, among other things (Jobirov et al., 2022). The aim of this study is to assess the extrinsic factors influencing cattle pricing and profitability in cattle markets of Southwestern, Nigeria.

According to the study of (Jose *et al.,* 2025) on hedonic analysis of cattle prices in Nicaragua, their study found that weight, lot size, and class are statistically significant factors impacting cattle auction prices. The results are relevant to Nicaraguan cattle buyers and sellers and help understand how the futures market can be used to predict price differences and reduce price risk and uncertainty.

Adam and Usman (2023) analysed the quantitative and qualitative factors influencing cattle price in trans-border trade between Nigeria and Niger Republic. The study revealed that price of cattle in Maigatari (terminal) was significantly ($p<0.01$) higher than that of the Dungass (supplying) market. Also, the result reveals that sex, weight and market supply had positive coefficients and significant ($p<0.001$) influence on cattle price. Seasons of sale and types of buyers had positive coefficients and significant influence on the market price at $p<0.001$ with a value of R^2 of 0.933.

Motta *et al.* (2018) researched the factors influencing cattle prices in order to develop effective policies for long-term productivity and enhanced food supply in Cameroon. In their study, which was conducted Over a 12-month period, they investigated the impact of a range of individual and market-level characteristics on the price of cattle sold in all transactions (n = 118,017) recorded in 31 livestock markets in the country's primary cow production region. The best explanatory model was chosen, and the model's predictive power and the robustness of the discovered drivers were assessed using an information-theoretic technique based on a generalized additive mixed-effect model. It was repeatedly revealed

that the age and gender of the cattle traded were major price drivers.

Lawal *et al.*, (2016) in their study hedonic price analysis of characteristics influencing cattle prices in Ngalda livestock markets in Yobe State, shows that the regression results indicated colour of the ear, shape of the cattle face and type of horn were the factors that influenced the buyer's preference. Hedonic regression shows that female cattle, big carcass size, short horn cattle and height were found to be statistically significant ($P < 0.05$), ($P < 0.001$), ($P < 0.05$) and ($P < 0.001$) respectively with positive coefficient across all the models implies that for any unit increase in these variables, buyers would be willing to pay more premium. It was therefore recommended that research efforts should target the characteristics of these cattle that buyers are sensitive to so as to enhance profitability production and marketing.

The study of Javier *et al.,* (2012) on factors that influence the price of cattle in livestock auctions: the case of the stockyard of Melipilla (Chile) showed that the most influential variables with respect to the price of beef cattle, in decreasing order, are as follows: 'condition', ′breed', 'quarter of sale' and 'year', which are followed far behind by 'lot size' and 'average weight'. The market pays a premium for Red Friesians, Crossbreds and Herefords and punishes the price of Holstein Friesians. Additionally, higher prices are paid in the last two quarters of the year than in the first two, and the third quarter is preferable to the fourth. Finally, the average lot weight and lot size are variables that have a positive, but small, influence on the price of cattle.

Abdullahi (2014) investigated the 'variables affecting the costs of live cattle in Garissa, North Eastern Province's in Kenya main livestock market'. The empirical data revealed that the gender of the cattle (both male and female), the age of the cattle (both mature and young), the cow's physical condition, and the season in which the transaction occurs are the significant variables in explaining the average market price of the cattle. The data indicate that cattle with male and mature characteristics positively shock the average market price, but calves with female, young, and thin characteristics negatively shock the average market price. Weather had a negative impact on average expenses. Long dry seasons are prevalent in the research area, resulting in a decrease in market values. It was proposed to employ institutional and policy reforms to overcome the key constraints that impede the cattle sub-sector's performance on a variety of fronts.

MATERIALS AND METHODOLOGY

The research was carried out in Southwest Nigeria. Nigeria has a population of over 230 million people and a land area of 923,768 square kilometers (Asakitikpi & Aretha, 2024). Crop production is the population's primary traditional activity, with smallholder farming being the most common, encompassing the cultivation of both cash and food crops. In addition, small animals and birds are grown as food. Southwest Nigeria has a tropical climate, with high temperatures all year, heavy rains from April to October, and dry winds from November to March. Because of these positive annual weather swings, approximately 75% of the inhabitants are estimated to rely on farming as their primary or secondary source. of income (Ojo & Baiyegunhi, 2021). States in the Southwest geopolitical zone include Ekiti, Lagos, Ogun, Ondo, Osun, and Oyo. Because of the favorable climatic conditions, the area is agrarian and ideal for the cultivation of permanent crops such as cocoa and oil palm, as well as arable crops (maize, yam, and cassava). The states contain three separate ecological zones: rainforest belt, derived savannah, and Guinea savannah. A huge population creates a correspondingly high demand for cattle. The indigenous Fulani population, who moves their livestock indiscriminately and causes conflicts between farmers and herders, also raised cattle in the area. The area is full of livestock markets.

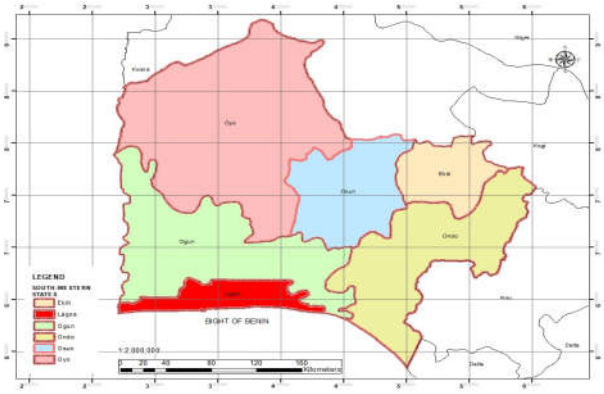

Figure 3: Map of Southwest Nigeria Shows the Study Area (Source: article.sapub.org/sors)

Data Collection Techniques and Resources

For this research, primary data was used. The primary data were collected using a structured questionnaire to capture relevant information on market/marketer characteristics, cattle market prices, elements considered important in price formulation and determination, and market constraints. Data was gathered by randomly sampling livestock markets and market customers in the study area.

Sampling Techniques and Sample Size

The study employed a multistage sampling strategy. Because of the high volume of cattle traders in the states during the early stages, three of the six states in Southwest Nigeria were purposely picked. These are Lagos, Ogun, and Oyo states. The second stage involved selecting five local government areas in each state that were recognized to have flourishing livestock markets. During the third step, one market was selected from each local government region. In the fourth step, leaders of market associations' member registers were utilized to choose 30% of the respondents in each market. Finally, 169 cattle traders were selected from Lagos State, 160 from Ogun State, and 171 from Oyo State, for a total of 500 respondents. In addition, 30 market officials were selected from each research state.

Table 1: Sample size and sampling of respondents in the study area

State	Market Name	Total Registered Marketers	30% of Registered Marketers	Wholesalers	Retailers
Lagos	Sabo	143	43	9	34
	Oko-oba	207	62	15	47
	Alaba Rago	78	23	6	18
	Imota	68	20	5	15
	Igan	68	20	5	15
	Sub-Total	**564**	**169**	**40**	**129**
Ogun	Imowo	138	41	10	31
	Mowe	130	39	10	29
	Ikeoluwa	54	16	4	12
	Corner	55	17	4	12
	Berger	157	47	11	36
	Sub-Total	**534**	**160**	**39**	**121**
Oyo	Kara	129	39	10	29
	Amode	138	41	10	31
	Akinyele	106	32	8	24
	Bodija	142	42	11	31
	Oke-ose	55	17	3	14
	Sub-Total	**570**	**171**	**42**	**129**
Total		**1,668**	**500**	**121**	**379`**

Source: Field survey, 2020

Classification of Cattle Marketers

Marketers were classified into two categories based on the types of jobs they did and the quantities they handled: wholesalers and retailers. Wholesalers are cattle buyers who purchase in bulk. Retailers, on the other hand, are marketers who acquire cattle in small amounts and then sell to end users. However, for the sake of this study, marketers who manage more than 40 herds are classified as wholesalers, while those who handle fewer than 40 are classified as retailers. Girei *et al.* (2013) classified cattle marketers in their study as "the wholesalers or bulk are those that (irrespective of the quantity of the animals) are considered to have uniform weight and thus attract the same average price, while retailers are those that deal with fragmenting the animals into various weights, sizes, breeds, male or female, with each animal attracting different prices to be determined by their above-mentioned attributes.

Analytical Methods

Determining price variations in cattle markets

Hedonic Pricing Model

Zanou *et al.* (2024) investigated the attributes and factors affecting small ruminant price in Benin, West Africa using hedonic analysis. There are several functional ways in which the market price of live cattle and the factors influencing its price might be linked. To evaluate the animal and market factors influencing price variations, this study used multiple regression analysis. The model argues that a product consists of multiple distinct attributes that consumer's value differently. These attributes encourage buyers to buy the goods.

The estimated model was described as follows:

$$P = b_0 + b_1X_1 + b_2X_2 + \ldots\ldots\ldots\ldots\ldots + b_8X_8 + e_1 \quad \ldots (6)$$

Where:

P = Price of the Cattle (₦)
X_1 = Age (years)
X2 = Sex (Male =1; Otherwise = 0)
X_3 = Colour of the Skin (White =1; Otherwise=0)
X_5 = Body Size (Extra Large= 3, Large=2, Medium=1, Otherwise=0)
X_6 = Season (Wet = 1; Otherwise=0)
X_7 = Body Grade ((Good=1; Otherwise =0)
X_8 = Breed Type (White Fulani =1; Otherwise = 0)
X_7 = Location (Far = 1, otherwise=0)
b_o = Intercept
e_1 = Error term

The regression model was implemented in three functional forms: double-log, semi-log, and linear. Based on the magnitude of R2, importance of t-values, F-value, and a priori predictions of the signs and sizes of the regression coefficients, lead equation was ultimately chosen following Gujarati (2003).

RESULTS AND DISCUSSIONS

Price Variation Determinants for Cattle Market in Southwestern Nigeria

Hedonic Price Analysis Results for Wholesalers

The result on table 2 revealed that Age was positively significant at (P< 0.05) relevant in the logarithmic model used in cattle markets in the Southwest, indicating that wholesalers paid more for older cattle. The body size and body grade were significant at (P> 0.1 and P>0.05) respectively and they exhibit positive relationship with price which means the bigger the body size and higher body grade the higher the associated price of the cattle. This result was in line with study of (Wanyoike *et al.*, 2015) who found out that the size and body grade affects the pricing of cattle.

Table 2 also showed that horn length is significant at (P>0.01) with a negative relationship with the price this implies that the shorter the horn length of the cattle the higher the price buyer would offer at the market while the longer the horn the less the price premium. This was in line with the study of (Mohammed *et al.,* 2016). The logarithmic

model's judgment of wholesaler coefficients yield an R^2 value of 0.86, suggesting that the model's components indicated 86% of the total variation in basis is explained by the independent variables of the regression model.

Table 2: Wholesalers' Estimates of Hedonic Cattle Prices

Variable/Parameters	Logarithmic model Coefficient	T-value
Age	0.0391	3.25**
Sex	-0.0020	-0.53
Body Color	-0.0339	-0.82
Body Size	0.5908	9.42***
Body Grade	0.4962	5.43**
Tail Length	-0.0002	-0.01
Horn Length	-0.0076	-2.02*
Season	-0.0053	-1.20
Location	.01713	0.87
Constant	4.9872	111.35
R^2	0.8731	
Adj R^2	0.8641	
P value	0.0000	
No of obs	121	

Source: Computed form survey data, 2020 *= 1%; ** = 5%; *** = 10% significant levels

The Hedonic Model Results for Cattle Retailers

Table 3 shows the results of the cattle retailers' hedonic model where six variables out of nine variables were statistically significant. The result showed that sex of animal, body colour, body size and body grade were positive and significant at (P>0.05) respectively, while age of the cattle was positive and significant at (P>0.1) this means the older the cattle the higher the price at the cattle market. This was also reported in the study of (Baenyi *et al.,* 2020). Also, horn length was positive but insignificant at (P>0.01) that is buyer would pay more for cattle with longer horn.

The Adjusted R^2 for the semi-logarithmic model is 58.76%, indicating that the model reasonably fits the data and that the variables included in the models explained 58.76 percent of the variation in pricing.

Table 3: Estimates for Retailers' Hedonic Regression Model

	SEMI-LOGARITHMS EQUATION	
PRICE OF CATTLE	**COEFFICIENT**	**T-VALUE**
Age of animal	.4296	12.63***
Sex of animal	.0815	2.16**
Body colour	.0311	3.39**
Body size	.0361	2.22**
Body grade	-.0444	2.98**
Horn length	.0331	1.83*
Tail length	-.0012	-0.09
Season	-0.013	-0.04
Location	.01713	0.87
Constant	4.7663	80.14
R^2	0.5876	
F –statistic	26.71	
AIC	-107.1147	
Prob (F- stat)	0.0000	
BIC	-69.84542	

Source: Computed from Survey Data, 2020.
*= 1%; ** = 5%; *** = 10% significant levels

CONCLUSION AND RECOMMENDATIONS

The study revealed that cattle price for both the wholesalers and retailers had better market ground based on the identified variables that influenced cattle market in the southwestern Nigeria. The extrinsic factors of the animal body trait that positively influenced the market price were age, sex, body size, and colour all had a significant impact on cattle pricing, highlighting the necessity of paying great attention to body conformation at sales point.

Based on the study's findings and conclusions, a number of policy implications developed, and important recommendations for enhancing cattle markets in Southwest Nigeria are provided below:

i. The study found that size, age, and body color all affect the price per head of cattle. Adopting subjective pricing techniques will not help marketers get lucrative returns on their investments. Therefore, farmers should identify the extrinsic factor that was pronounced in their market as basis for their price tag.
ii. Since the identified trait at the southwest market are had positive relationship with price, cattle breeders should concentrate on those factors such as body colour, body side, age and sex that will positively increase their customer base and income.

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ASSESSMENT OF ENDOPARASITES AND ECTOPARASITES IN SMALL RUMINANTS IN ODO-ERAN, OBANTOKO, OGUN STATE

[1*]Olawale-Success, O. O., [2]Ajani, A. R., [3]Oyetayo, O. P., & [4]Oluwajinmi, A. L.
[1]Department of Microbiology and Biotechnology, Dominion University, Lagos-Ibadan Expressway, Oyo State, Nigeria.
[2]Department of Biology Education, Faculty of Education, Lagos State University, Ojo, Lagos, Nigeria.
[3] Department of Animal Science, Faculty of Agriculture, Obafemi Awolowo University, Ife, Nigeria.
[4]Department of Microbiology and Biotechnology, Dominion University, Lagos-Ibadan Expressway, Oyo State, Nigeria.
*Corresponding author: o.olawale-success@dominionuniversity.edu.ng 08029998323

Keywords: Prevalence, Gastro-Intestinal, Ectoparasites, Small Ruminants

ABSTRACT
The study investigates the prevalence of gastrointestinal parasites (GIPs) and ectoparasites (EPs) in small ruminants in Odo-Eran, Obantoko, Ogun State'. The objective of the study is to characterize GIPs as well as EPs present to determine level of prevalence of parasites and evaluate the risk factors of insect pest and parasite in sheep and goat using an experimental research approach. A cross sectional study using random sampling technique was used to select thirty (30) sheep and goats from five different farms. 2.5% potassium dichromate was used to preserve the parasite morphology and halt development of eggs and larva after collection. The samples were taken to the laboratory and were examined utilizing the floatation and sedimentation techniques. The statistical analysis of the collected data was done using SPSS 21. The findings of the study revealed that GIP prevalence was influenced by agro-economic zones in which intensive systems show a GIP prevalence of 75% and an EP prevalence of 60%, semi-intensive systems have a higher GIP prevalence of 83% and an EP prevalence of 64% while extensive systems exhibit the highest prevalence rates with 90% for GIPs and 70% for EPs. The research revealed that various species of parasites were present in the study population, with higher prevalence of gastro-intestinal parasites compared to ectoparasites. Based on the findings of this study, the research recommends collaboration between farmers, veterinarians, and the use of integrated parasite control measures, such as rotational grazing and use of anthelmintic should be promoted among farmers.

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INTRODUCTION

Small ruminants, particularly sheep and goats are essential component of livestock which are integral to the livelihoods of rural communities in Nigeria, serving as vital sources of meat, milk, wool and income (Chukwudi *et al.,* 2020). However, their productivity is significantly hindered by parasitic infections, notably gastrointestinal parasites and ectoparasites, which are prevalent across various regions of the country (Ezenwaka *et al.,* 2024).

Small ruminants like goats can adapt to several production systems and could be raised with relatively few inputs but they face huge production challenges (Hale and Coffey, 2011). Gastrointestinal parasites are considered the main diseases-causing organisms of small ruminants in Nigeria, leading to reduced production and productivity (Hassan *et al.,* 2013; Odogu and Okaka, 2016).

Goats and sheep are highly susceptible to gastro-intestinal parasites (GIP) and ectoparasites (EP) due to their reduced innate immune response against specific helminths as a result of their evolutionary history and the nomadic nature of goat husbandry. Ectoparasites, such as ticks, lice, and mites, are arthropods that live on the skin or hair of animals and can transmit diseases, while endoparasites live inside the body of their host, typically in the gastrointestinal tract. These gastrointestinal parasites cause a range of health problems in small ruminants, such as anaemia, weight loss, poor growth, and reduced milk production (Rizwan *et al.,* 2021). The prevalence of ectoparasites and endoparasites in small ruminants has been a subject of interest to researchers, veterinary practitioners, and animal health policymakers. In Nigeria, several studies have been conducted on the prevalence of ectoparasites and endoparasites in small ruminants (Karshima and Karshima, 2020); however, there is limited information on the prevalence of endoparasites in these animals in Ogun State. Understanding the prevalence of these parasites is critical for the effective management of small ruminants and the prevention of disease outbreaks (Ani and Nshiwu, 2015). This study aims to investigate the presence of endoparasite and ectoparasite in small ruminants in Odo-Eran, Obantoko, Ogun state.

MATERIALS AND METHODS

Study Location

The study was conducted in Odo-Eran, Obantoko, which lies in the centre of Odeda Local Government. The study was conducted at Abeokuta Metropolis, precisely sheep and goat farms available at Odo-Eran, Obantoko, Odeda Local Government Area, Ogun State, Nigeria. The local government has a land area of 2.053km^2 with the population of about 158,355, coordinate of Odeda $5^0 46^0$N and $3^0 2^0$ 20E.

Study Design

This cross-sectional study assesses the use of an experimental research which primarily involved the investigation of fecal sample from group of ruminant animals (goat and sheep) for prevalence of gastro-intestinal parasite. The prevalence of ectoparasites was determined by brushing animal's fur and examining with naked eyes, and under microscope.

Study Population And Size

This study was carried out by sampling three hundred (300) ruminant animals in five randomly selected farms within Odo-Eran, Obantoko, Ogun State in which thirsty sheep and thirty goats were analysis from each of these five randomly selected farm locations. The study was conducted for the duration of two month (April to May), in 2024.

Sample collection

Identification Of Endoparasite

Fresh fecal sample were directly collected from sheep and goats with cardboard paper and were placed inside a universal bottle at 7.00 am to 8.00 am in the morning. And the fecal samples were conveyed to the laboratory for further examination of the presence of gastrointestinal parasite.

Identification of ectoparasite

A pre-survey visit was made to the five randomly picked location to interact with the farmers and obtained their consent for the study through verbal acceptance and letter approval. The goats and sheep were examined visually for ectoparasites infestation on different body regions. This was done by brushing the animals' fur with fine-toothed brush to capture any arthropods insect. The insect were handpicked and forceps were used to pick some of these insect to retain mouthparts. The insects were kept in a 2.5% potassium dichromate solution, which helped to retain the ectoparasite morphology.

Laboratory Procedures

The fecal samples were examined by floatation and sedimentation techniques at the Federal University of Agriculture, Abeokuta Laboratory.

Floatation technique

This method was commonly used to detect intestinal parasite of nematode and cestode eggs because the eggs have a specific density (SG) that falls between 1.05 and 1.23, this technique allows the eggs to float. 3 grams of feces were transferred to a mortar and mixed with saturated sodium chloride solution. The mixture was stirred gently until the feces were thoroughly suspended and then poured through

a tea strainer into a container and gently pressed the excess fluid from debris remaining in the strainer. The mixture was immediately poured into the 15ml centrifuge tube. It was then centrifuge for five minutes at 1000rpm. After centrifugation, a drop of methylene blue (for staining) and additional saturated sodium chloride solution were added and mixed properly. A drop of the mixture was then placed on a clean slide and a coverslip was placed on the slide and was viewed at 10X and 40X magnification. Photographs of cyst, eggs and parasites were taken and identified based on egg's color, shape, and size.

Sedimentation Technique

This technique was used for detecting trematodes eggs with lower specific gravity. It provides good results as the eggs of the trematode are bit heavier than the other, where sediments of centrifuged contents were taken for eggs detection (Veterinary Lab. Techniques 2019). After analyzing the floatation section, the saturated salt solution was carefully removed from the test tube. The sediment content was then poured into the watch glass and gently stirred to blend it. To make a second slide, a single drop of the mixture was extracted. Iodine wet mount solution was used to stain the specimen. In order to find helminthe eggs, trophozoites, or cysts of gastrointestinal protozoans, two slides were made from a single sample (one from flotation and one from sedimentation) and viewed under a microscope at 10X and 40X magnifications.

Intensity of Infection

A sample was considered to have a heavy parasitic infection if six or more ova or oocysts were found per field; the number of eggs/oocyst and larvae found per field was used to measure the intensity of parasitic infection.

Data Analysis

Descriptive statistical tools such as percentages and chi square were used to analyse the data.

RESULTS

Tables 1 and 2 shows the prevalence of ecto- and endo-parasites in the sheep and goats studied. The presence of specific gastro-intestinal parasites (GIPs) and ectoparasites (EPs) varies across different farming management systems. In intensive farming systems, the predominant GIPs are *Strongyloides spp* with a value of 12.3% and *Trichostrongylus spp*., show highest prevalence value 18.1% while the main EPs are *Boophilus spp*. (13.2) and *Sarcoptes scabiei* (15.9). In semi-intensive systems, *Haemonchus contortus* (16.1) and *Nematodirus spp* (17.3) are the common GIPs, and *Amblyomma spp* (15.9) and *Demodex spp* (17.9) are the prevalent EPs. In extensive farming systems, *Oesophagostomum spp* (19.3) and *Cooperia spp* (16.9) are the key GIPs, and *Hyalomma spp* (19.6) and *Psoroptes spp* (11) are the main EPs. This distribution indicates that different farming practices and environmental conditions influence the different types of endoparasites and ectoparasites that sheep and goats are exposed to.

Table 1: Prevalence of Ectoparasite infestation on the ruminant (sheep and goat)

Management system	Ectoparasites	Ruminants infested Frequency n=189	Prevalence %
Intensive	*Boophilus spp*	25	13.2
	Sarcoptes scabiei	30	15.9
Semi-intensive	*Amblyomma spp*	30	15.9
	Demodex spp	34	17.9
Extensive	*Hyalomma spp*	37	19.6
	Psoroptes spp	33	11

Table 2: Prevalence of Endoparasite in the ruminant (sheep and goat)

Management system	Ectoparasites	Ruminants infested Frequency n = 248	Prevalence %
Intensive	*Strongyloides spp*	30	12.3
	Trichostronglus spp	45	18.1
Semi-intensive	*Haemnchus contortus*	40	16.1
	Nematodirus spp	43	17.3
Extensive	*Oesophagostomum spp*	48	19.3
	Cooperia spp	42	16.9

The prevalence of GIPs and EPs varies significantly across different farming systems (Table 3). Intensive systems show a GIP prevalence of 75% and an EP prevalence of 60%. Semi-intensive systems have a higher GIP prevalence of 83% and an EP prevalence of 64%. Extensive systems exhibit the highest prevalence rates, with 90% for GIPs and 70% for EPs. These findings suggest that more extensive and semi-intensive farming practices are associated with higher levels of parasite infections, potentially due to increased exposure to contaminated environments and limited parasite control measures. It was observed that there is a significant relationship between farming managing system and the infection of GIPs in sheep and goats, with a critical value of $r = 0.02$ at $P \leq 0.05$. This suggests that the prevalence of GIPs varies significantly across different agro-economic zones. However, for EPs, across different farming management system shows no significant relationship $r = 0.3$ at P 0.05

Table 3: Prevalence of GIPs and EPs base on Farming System

Infections	System	Infected	Not Infected	Total	Prevalence %
GIPs	Intensive	75	25	100	75
	Semi-Intensive	83	17	100	83
	Extensive	90	10	100	90
	Total	248	52	300	82.67
EPs	Intensive	60	40	100	60
	Semi-Intensive	64	36	100	64
	Extensive	70	30	100	70
	Total	194	106	300	64.67

Several risk factors contribute to the prevalence of GIPs and EPs in sheep and goats reared in low-input, low-output systems (Table 4). Poor housing conditions are associated with higher prevalence rates of both GIPs (89.1%) and EPs (86.5%) compared to good housing conditions. Continuous grazing practices result in a higher prevalence of GIPs (80.1%) and EPs (79.0%) compared to rotational grazing which only resulted in high GIPs (85.5%). Irregular or no health management practices lead to significantly higher prevalence rates for GIPs (96.5%) and EPs (91.2%) compared to regular health management. These findings highlight the importance of improving housing, grazing practices, and health management to reduce the burden of parasite infections in sheep and goats.

Table 4: Factors that enhance ruminant animal exposure to GIP and EPs

Risk Factors	Groups	Infected GIPs	Not Infected GIPs	GIPs (%)	Infected EPs	Not Infected EPs	Eps (%)
Housing condition	Poor housing	139	17	89.1%	135	21	86.5%
	Good housing	109	35	75.6%	59	85	40.9%
Grazing practices	Continuous	130	32	80.1%	128	34	79.0%
	Rotational	118	20	85.5%	66	72	47.8%
Health management practice	Regular	106	47	69.2%	60	93	39.2%
	Irregular	142	5	96.5%	134	13	91.2%

The results in Table 5 show the prevalence of GIPs and EPs during the sampling season of April and May. It was observed in the month of April that 130 ruminant animals were infected with GIPs and 20 animals were free from GIPs infection while in the month of May 118 ruminants animals were infected with GIPs and 32 animals were not infected. The prevalence of GIPs showed no significant relationship ($r = 0.07$, $P \leq 0.05$) between the sampling period and the infection rates of both GIPs. During the month of April 100 ruminant animals were infected with EPs and 50 animals were not infected and during the month of May 94 ruminant animals were infected with EPs while 56 animals were free of EPs. The prevalence of EPs across the sampling season suggests that there is no significant difference $r = 0.47$, at $P \leq 0.05$.

Table 5: Infection of GIP and EP by Sampling Season

Infections	Period	Infected	Not Infected	Total
GIPs	April	130	20	150
	May	118	32	150
	Total	248	52	300
EPs	April	100	50	150
	May	94	56	150
	Total	194	106	300

Out of 164 male ruminant animals examined for GIPs, only 164 were infected and 118 out of 136 female ruminant animals were infected with GIPs infection which show no significant difference ($r = 0.22$, at $p \leq 0.05$) among the sexes (Table 6). 108 out of 172 male ruminants animals examined for EPs were infected and 88 0ut of 128 were infected with EPs no significant differences was observed ($r = 0.55$, at $p \leq 0.05$). These findings suggest that the prevalence of GIPs and EPs infections does not significantly differ between male and female animals.

Table 6: Infection of GIPs and EPs by Sex

Infections	Sex	Infected	Not Infected	Total
GIPs	Male	130	34	164
	Female	118	18	136
	Total	248	52	300
Eps	Male	108	64	172
	Female	88	40	128
	Total	196	104	300

Table 7 shows the prevalence of GIPs and EPs according to the animal age group. 80 ruminant animals of age < 1 year were examined for GIPs and 68 were infected while 12 were not infected. However, 75 out of 90 ruminant animals were infected with EPs from the age of < 1 year and 119 out of 210 were infected with EPs from the age group of > 1 years. The prevalence of GIPs and EPs observed between the ages indicates a significant relationship with p-value less than 0.001. These results suggest that the prevalence of GIPs and EPs infections significantly varies with the age of the animals, with younger animals (<1 year) showing higher prevalence rates compared to older animals (>1 years). This highlights the increased susceptibility of younger animals to parasite infections.

Table 7: Infection of GIPs and EPs by Age

Infections	Age	Infected	Not Infected	Total
GIPs	< 1 year	68	12	80
	> 1 years	180	40	220
	Total	248	52	300
Eps	< 1 year	75	15	90
	> 1 years	119	91	210
	Total	194	106	300

Discussion

This study investigated the prevalence of gastro-intestinal parasites and ectoparasites in sheep and goats in Odo-Eran, Obantoko, Odeda Local Government, Ogun State. The results showed a high prevalence of gastrointestinal parasites (82.67) and ectoparasites (64.67) in the study area. This high prevalence suggested that different farming management system favours the multiplication of both GIPs and EPs in Odo-Eran, Ogun state. The 82.67% of GIPs and 64.67% in this study was high when compared to the 38.6% and 61.3% reported by Abah *et al.* (2022).

Six different GIPs were observed which includes *Strongyloides spp*, *Trichostronglus spp*, *Haemnchus contortus*, *Nematodirus spp*, *Oesophagostomum spp* and *Cooperia spp*. Although the *Oesophagostomum spp* was the most common gastrointestinal parasite (19.3) among the extensive farming system, *Haemnchus contortus* was abundant in semi-intensive farming system (16.1) while *Trichostronglus spp* (18.1) was the common GIPs found within intensive farming system. Six different ectoparasite were also observed in the study which includes *Boophilus spp*, *Sarcoptes scabiei*, *Amblyomma spp*, *Demodex sp*, *Hyalomma spp* and *Psoroptes spp*. And the most prevalent are *Sarcoptes scabiei* (15.9) in intensive farming management, *Hyalomma spp* (19.6) were the most common ectoparasite found in extensive farming system while *Demodex spp* (17.9) was observed in semi-extensive farming system. This is in line with a study conducted with Mohammed *et al.* (2025) and Biu *et al.* (2018). The prevalence of GIPs (130) and EPs (100) in the month of April is higher compare to the month of May. There are more GIPs (130) and EPs (108) in male ruminant animals compare to the Female ruminant animals. The ruminant animals > 1 years had more GIPs and EPs than the ruminant animals in the age bracket < 1 year this was collaborated with the finding of Biu *et al.* (2018) and Abah *et al.* (2022). The risk factors of age, sex and season are significant to the prevalence of GIPs and EPs.

The results show a high prevalence of gastrointestinal and ectoparasites in sheep and goats in Odo-Eran, Obantoko, Odeda Local Government, Ogun State. The study findings are consistent with previous studies in Nigeria. This study highlights the need for effective control measures to reduce the prevalence of gastro-intestinal parasites and ectoparasites in sheeps and goats in Odo-Eran, Obantoko, Odeda Local Government, Ogun State.

CONCLUSION

The prevalence of gastro-intestinal parasites and ectoparasites in sheep and goats in Odo-Eran, Obantoko, Odeda Local Government, Ogun State has been found to be significant. The study revealed that various species of parasites were present in the study population, with a higher prevalence of gastro-intestinal parasites compared to ectoparasites. The presence of these parasites can have significant implications for the health and productivity of sheep and goats, as well as the overall livestock industry. Farmers should be educated on the importance of parasite control and the available methods for preventing and treating infestations. Regular deworming and ectoparasite control measures should be implemented by farmers to reduce the prevalence of gastrointestinal. Collaboration between farmers, veterinarians, and extension workers is essential to develop and implement effective parasite control programs that can help reduce the prevalence of gastro-intestinal and ectoparasites in sheep and goats in Odo-Eran, Obantoko, Odeda Local Government, Ogun State

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