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NUTRIENT INTAKE AND DIGESTIBILITY OF RABBIT BUCKS FED GRADED LEVELS OF FERMENTED AFRICAN LOCUST BEAN *(Parkia biglobosa)*

[1]Mandabasu, S.E., [2]Adegbe, J.Y., [3]Amachere, D.D., [4]Enefola, I.M.

[1]Department of Animal Production, Abubakar Tafawa University, Bauchi, Nigeria
[2]Department of Agricultural Technology, Federal Polytechnic, Oko, Nigeria
[3]Department of Agricultural Technology, Captain Elechi Amadi Polytechnic, Port Harcourt, Nigeria
[4]Department of Animal Health and Production Technology, Kogi State Polytechnic, Itakpe Campus, Nigeria

(Corresponding Author Mandabsu, S.E ezikielsuntma@gmail.com, 07062200412)

ABSTRACT

The experiment was conducted at the Rabbit Unit of the College of Agriculture, Bauchi, in Bauchi local government Area of Bauchi state,, Nigeria, for a period of 8 weeks, to investigate the effects of feeding male rabbit graded levels of fermented African Locust Bean Meal (ALBM) on nutrient intake and digestibility Completely randomized design (CRD) was used to allot the experimental diets to the experimental animals. Five dietary treatment levels were formulated as T1, T2, T3, T4 and T5. Each treatment was replicated four times, with two rabbits per unit which made a total number of 40 experimental bucks. The bucks weighed between 1.5-2.0 kg. The experimental diets were fed twice a day (morning and evening) and lasted for 8 weeks and clean drinking water was provided ad-libitum. The nutrient intake was determined from the feed intake values and the proximate composition of the concentrate diets The experimental animals were moved into metabolic crates for fecal collection. The collection lasted for 1 week after an adjustment period of 1 week, the fecal samples was packed, dried and analyzed for their proximate composition Using standard procedure (AOAC 1995), and there after the proximate composition was used to compute dry matter and nutrient digestibility. The data obtained were subjected to statistical analysis of one-way analysis of variance using (SPSS) version 25, 2017. The means were separated using Least Significant Difference. The crude protein content of the experimental Diets, Dried African Locust Bean Meal and Fermented African Locust Bean Meal ranged from 16.02% to 18.14%. The metabolizable energy ranged from 3025.77 to 3.45.74 keal/kg. Dry matter intake ranged from 80.66 – 108 g/day , while crude protein intake ranged from 28.06 - 37.70%, both were significantly different Dry matter digestibility range of 72.30 – 88.50%, which also showed significant(P 0.05) differences across the treatments indicates high digestibility.Crude protein digestibility ranged from 66.30 – 89.10% , it increased steadilt from T1 – T4, and showed significant differences, crude fibre digestibility ranged from 65.00 – 83% and followed similar tend with crude protein .In conclusion, Diets containing graded levels of African locust bean contained better array of nutrients than the control The treatments containing graded levels of African locust bean had better digestibility values than the control. The following recommendations were made i Fermented African locust bean can be included in concentrate diets for rabbits for improved nutrient intake and digestibility ii. Further research to assess cost implications

Key words: African Locust Bean, Digestibility, Nutrient Intake, Rabbit Bucks ,

1.0 INTRODUCTION

Rabbit production in Nigeria plays a significant role in the development and provision of food and family income (Salihu and Abdulrahman, 2020). Rabbit has been identified as an economic livestock that can adequately meet the animal protein requirement of Nigerians due to its ability to convert feeds that are not directly utilized by man. In most developing countries like Nigeria, there is insufficient intake of animal protein due to low animal productivity (Wafar *et al*., 2019).

Over the years, rabbit farming has grown from raising a few rabbits for family consumption to large commercial operations with hundreds of rabbits. Expansion is much simpler than other livestock alternatives because a large range of existing facilities can be modified for rabbits and land requirements are negligible (Robert *et al.*, 2008). The human population growth in developed countries is stabilizing while that of developing countries including Nigeria is still increasing rapidly. Thus, the search for alternative sources of protein to meet up this growing population challenge is imperative. Among such alternatives is the use of livestock species that are yet to be known to play a major role in animal production within these countries is very important. Fast-growing livestock such as rabbits possess a certain number of features that might be of advantage in the small holder subsistence. Rabbit farming is one of the fastest growing micro-livestock enterprises in most countries. Rabbit is preferred as a sustainable source of proteins in an era where concerns over climate change, population and changing meat consumption patterns are growing in developing countries (Chrispinus and Stephen 2020). Additionally, increase in income, growing urbanization, and unfolding globalization are the common factors boosting the demand for high-value commodities including meat due to these fast socio-economic changes in the recent past (Chrispinus and Stephen, 2020). In Nigeria, consumption of animal protein remains very low, at about 6.0-8.4 g/head/day which are far below the 13.5 g/head/day (World Health Organization) and (Amata and Brat, 2008). Diversification into rabbit production sector appears to be gaining popularity and economic importance as a means of alleviating animal protein deficiency in Nigeria compared to the conventional sources that come from goat, sheep and cattle in many developing countries (Ume *et al*., 2017). However, rabbits are perhaps the most economical and profitable of all kinds of livestock as it can utilize inferior feeds and still provide quality meat and fur. Moreover, with a better-quality feeding program, there will be high increase in production, thus allowing a higher profit margin for the producer (Ikhimalo *et al*., 2006). The management of rabbit is done

on a small-scale mostly by peasant farmers for many different purposes; they can play a very significant role in a small sustainable family operation. While the most common use in agricultural industries is for meat, rabbit also is raised for pets, by product for manure in gardens, show, and laboratory uses. Rabbit meat is high in protein 33 g (66 %) and low in fat, 3.5 % (5 %) calories 173 and cholesterol 123 mg (41 %), when compared to most of the meat eaten (Victoria, 2020). Rabbits are prolific and will breed all year-round if well managed (Salihu and Abdulrahman, 2020). Feeding is key for reproduction, and certain ingredient has been known to influence it. Feed is the most important input in a profitable livestock production; it accounts for 70-80% of the total cost of production. High cost of feeding has continued to remain a major impending factor in intensive animal production. Therefore, it is imperative to explore the use of nonconventional feedstuffs that are cheap. Nutritionally adequate and readily available (Wafar *et al*., 2019). Rabbits have unique digestive physiology that requires careful balancing of dietary fiber, protein, energy, and supplemental nutrients. Dietary composition directly influences feed intake, nutrient digestibility, and production outcomes such as growth and FCR. Research demonstrates that optimizing fiber and protein levels improves nutrient utilization, while excessive fiber or imbalanced dietary components reduce digestive efficiency. Rabbits are hindgut fermenters that rely on microbial fermentation in the cecum to break down fibrous plant components. While rabbits can digest proteins efficiently, their ability to digest structural carbohydrates (fiber) differs significantly from ruminants, impacting nutrient utilization. Feeding strategies that balance fiber with digestible carbohydrate and protein sources enhance nutrient utilization and economic viability.

Digestibility responses to diet changes inform practical formulation for both commercial and subsistence rabbit production systems.

This study therefore evaluates the nutrient intake and digestibility of rabbit bucks fed diets containing graded levels of African Locust bean.

2.0 MATERIAL AND METHHODS

2.1 Study Area

The experiment was carried out in a well-constructed rabbit house of the college of Agriculture Bauchi, in Bauchi local Government Area of Bauchi State, Nigeria. . Geographically, Bauchi State

occupies a total land area of 49,119 km^2 (18,965 sq mi) representing about 5.3% of Nigeria's total land mass with 20 local Government Areas. It is located between latitudes 9° 3' and 12° 3' north and longitudes 8° 50'. The state is bordered by seven states, Kano and Jigawa to the North, Taraba and Plateau to the South, Gombe and Yobe to the East and Kaduna to the West.

2.2 Experimental design and Sample Size

The rabbits were grouped into five (5) treatments and were randomly allotted into the experimented cages, as T1, T2, T3, T4, T5 using Completely Randomized Design (CRD) and replicated 4 times. There were 2 rabbits per unit of replication which made a total number of 40 experimental bucks.

2.3 Sources of experimental animal

Rabbit (bucks) of mixed breeds were purchased from local rabbit farmers in Bauchi and neighboring LGAs of different colors, but of same age group and weight.

2.4 Sources of experimental diets

All experimental diets were available within the study area. African Locust Bean was purchased from a nearby market in Bauchi, Dass and Bogoro market and its environs. The seeds were then processed to obtain a Fermented Locust Beans “daddawa in hausa” dried and ground then added to other ingredients purchased from different sources that will be used to formulate the experimental diets.

2.5 Processing Techniques

Processing of Locust Beans Meal into food condiment involves series of unit of operations: decortication of matured pods, boiling, dehulling, separation of hull from beans and fermentation into various forms of condiments. These of unit operations are still done manually with women being the key player in locust bean processing

Bayer, (1988) gave graphic details that locust beans would be boiled for at least 24 hours with water being added frequently. Cooked beans – still quite firm are then mixed with wood ash and pounded and washed several times to remove the seed coats. The beans were boiled for another 3-4 hours until they became softer, and are then spread in a large flat basket, covered with leaves and allowed to ferment for two days. On the third day, the locust bean mass was transferred to a deep bowl and allowed to ferment for another 24 hours. It was then spread out again in a large flat basket and partially dried in sun for several hours, before it is pounded with mortar and pestle

The paste was molded into ball-like shapes and then dried thoroughly in the sun in order to maintain its preservation and good keeping qualities

2.6 Method of compounding the experimental diet and replacement percentage

The following ingredients were used to formulate the experimental diets: Maize: T1 50.1 %, T2 42%, T3 46.88 %, T4 47.73 %, and T5 36.92 %. While Soya bean was: 9.84 %, 12.37 %, 3.11 %, 0.26 % and 3.0 % respectively. Ground nut husk was 20 % across the treatments. African Locust Bean was 0 %, 5 %, 10 %, 15 % and 20 % respectively. wheat offal was 10 % across all the treatments, Fish meal 5.6 % in all the treatments, Bone Meal was 3% across the treatments, Premix, methionine, lysine and Salt were fixed at 05 %, 0.2 %, 0.2 % and 0.5 respectively. A conventional method (Pearson square method) was adopted in the formulation the experimental diet

2.7 Method of feeding

Typically, there are two types of feeding method in rabbit, limited feeding and free-choice feeding method of feeding rabbits. Limited feeding involves placing a measured amount of feed slightly less than the animals would normally consume in a dish for rabbit each day. While free-choice feeding allows unlimited feed to be available to the animals at all time, a rabbit is to be fed twice daily in the morning and evening and their daily diet should be given 25 g per kg of the total body weight (Michigan, 2017). Thus, a limited feeding method and daily diet intake of 25 g per kg of total body weight (125 g per head), which was adjusted to 0.5 kg (500 g) per cage per day.

2.8 Left over feed analysis

The left-over feed was periodically collected and weight on daily basis for daily feed intake analysis.

2.9 Management and medications

Clean feed and fresh water were provided on daily basis, other management practices during the research period include sweeping and cleaning of cages and surrounding building to prevent disease outbreak. Prophylactic use of antibiotics was periodically administered prior to and during the research period. Adequate water and feed were provided *ad libitum*. The treatments were fed with different concentration of fermented African locust beans in the diet at 0, 25, 50, 75 and 100 % designated to treatment(s) as T1, T2, T3, T4 and T5.

The animals were pre-treated with antibiotics as earlier mentioned at the recommended dosages before allocation to their various cages by randomization to kick start or commence the experiment.

2.10 Age and weight group of the experimental animals

Young male rabbits (mix breed) of different colors with well descended testicles of the same age group between 3 to 4 month of age weighing 1.5- 2.5kg were used for the research.

2.11 Duration of the research

The research period lasted for eight weeks and a total of 40 buck rabbits of mixed breed with well descended testes were used to conduct the research.

2.12 The Research House

The rabbits were housed in cages using the rabbitry unit of the College of Agriculture Bauchi under the same environmental conditions and acclimatized for a period of one week before the commencement of the research proper, A cage measuring 30 inches x 36 inches (2.5 x 2.5 feet), which is often considered the standard size cage for the medium breeds, would provide the required area. (James, 2009; Ewuola, and Odefemi, (2019).

Table 1 Composition and Calculated Analysis of Experimental Diet

INGREDIENTS	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Maize	50.16	42.64	46.88	44.73	36.92
Soya bean	9.84	12.37	3.11	0.26	3.0
Wheat offal	10	10	10	10	10
Groundnut husk	20	20	20	20	20
ALBM	0	5	10	15	20
Fish meal	5.6	5.6	5.6	5.6	5.6
Bone	3	3	3	3	3
Premix	0.5	0.5	0.5	0.5	0.5
Methionine	0.2	0.2	0.2	0.2	0.2
Lysine	0.2	0.2	0.2	0.2	0.2
Salt	0.50.5	0.5	0.5	0.5	0.5
TOTAL	100	100	100	100	100

Calculated analysis					
ME (Kcl/kg)	3026.58	3025.77	3039.51	3045.74	3041.65
Crude protein (%)	16.02	17.62	16.18	16.41	18.14
Crude fibre (%)	5.93	6.77	7.36	8.30	9.41
Ether Extra EE (%)	4.48	4.61	4.58	4.51	5.18
Calcium Ca (%)	0.53	0.81	0.55	0.55	0.57
Phosphorus P (%)	0.44	0.44	0.39	0.34	0.40

ALBM- African locust bean meal, ME= Metabolizable energy.

Mineral/Vitamin Premix contained the following: Vitamin A 7,0000IU, Vitamin D3 1,800IU,Vitamin B2 1,000mg Vitamin E 1,000IU, Vitamin K3 1,500mg,Vitamin B6 1,500mg, Vitamin B12 10mg Folic 500mg, Niacin 3,000mg, Pantothenate 3,000mg, Biotin 400mg, Choline 160g, Thyroxine 300mg, Copper 1,000mg, Iron 4g, Manganese 5.5g, Iodine 0.2mg, Zinc 5g, Cobalt 100mg, Seleniun 100mg. Antioxidant 1,250mg.

2.13 Feed intake , Weight Gain and Nutrient Intake Determination

Weight Gain: Initial weights and final weights of the animals were recorded. The initial weights were subtracted from the final weights to determine the weight gain of the animals.

Feed intake: The concentrate offered to the rabbits was weighed daily and the left over was also weighed and subtracted from the quantity of feeds that was served to determine the feed intake of the animals.

Weekly weight gain: The animals were weighed on weekly basis to determine their weights

2.14 Nutrient Intake Determination

The nutrient intake was determined from the feed intake values and the proximate composition of the concentrate diets

2.15 Determination of Dry Matter and Nutrient Digestibility

The experimental animals were moved into metabolic crates for fecal collection. The collection lasted for 1 week after an adjustment period of 1 week, the fecal samples was packed, dried and analyzed for their proximate composition Using standard procedure (AOAC 1995), and there after the proximate composition was used to compute dry matter intake(g/day) and nutrient digestibility percentage (%) as described by (Baba, *et al.*,2021). Digestibility was calculated using the formula.

$$\text{Digestibility (\%)} = \frac{\text{Nutrient Intake} - \text{Nutrient in Feaces}}{\text{Nutrient Intake}} \times 100$$

2.16 Chemical Analysis

Sample of the five (5) Experimental Diets , Dried African Locost bean meal and fermented African Locust bean meal were analyzed for their proximate composition using the methods of AOAC 2000.

2.17 Statistical Analysis

Data obtained from this study were expressed as mean (±SEM) and subjected to a one way analysis of variance using the statistical package , statistical package for social science (SPSS) version 25, 2017 , significant differences between treatment means were considered at $P<0.05$, using T-test and the means were separately using Turkey range test.

3.0 RESULTS AND DISCUSSION

3.1 Proximate Composition of Experimental Diets, Dried African Locust Bean Meal and Fermented African Locust Bean Meal

The Proximate Composition of the Experimental Diets, Dried African Locust Bean Meal and Fermented African Locust Bean Meal are presented in Table 2

The crude protein content of the experimental Diets, Dried African Locust Bean Meal and Fermented African Locust Bean Meal ranged from 16.02% to 18.14%. The values are adequate for male rabbits.(Onyimonyi and Onukwafor, 2003) The metaboligable energy ranged from 3025.77 to 3.45.74 keal/kg they are isocaloric and adequate for rabbit bucks Ocheja *et a*l 2000: Ngodigha and Okejim 1999).The protein values were almost the same(iso nitrogenous) across the treatments The ether extracts levels of 4.48-5.18% are adequate for rabbits Ocheja et *al* 2008. The dry matter of the experimental diets are very high (90-94%) and can providee adequate dry matter intake for the rabbits (Taiwo *et a*l 2005) and also help in feed preservation The crule protein content of the DALBM increased from 13.18 to 40.16 % in FALBM but the NFE decreased from 12.62% to 0.02%, this was a sharp decrease, this may be due to fermentation

Table 2: Proximate Composition of Experimental Diets, Dried Locust Bean Meal and Fermented Locust Bean Meal

	Experimental Diets						
	T1	**T2**	**T3**	**T4**	**T5**	**DALBM**	**FALBM**
Crude protein	16.80	16.95	17.40	17.90	18.10	13.18	40.16
Crude fibre	6.0	6.20	6.60	6.50	6.80	18.50	21.70
Nitrogen free extracts	56.80	56.35	55.25	55.84	57.70	12.32	0.02
Ether extracts	5.20	5.25	5.10	5.30	5.40	43.80	29.70
Ash	6.20	6.30	6.35	6.40	6.60	4.15	5.50
Dry matter	91.00	90.05	92.00	93.00	94.00	92.58	83.25

DALBM- Dried African Locust Bean Meal

FALBM- Fermented African Locust Bean Meal

3.2 Dry Matter and Nutrient Intake (g/day) of Rabbit Bucks fed Diets containing Graded Levels of Fermented African Locust Bean

Dry Matter and Nutrient Intake (g/day) of Rabbit Bucks fed Diets containing Graded Levels of Fermented African Locust Bean is presented in Table 3

The dry matter intake/day increased steadily from 80.66 g/day (T_1) to 108g/day (T_5) and showed significant difference. This range of daily dry matter intake is sufficient to sustain rabbits (onyimonyi and Ene 2003),and higher than value of 63.23-88.36g/day reported by Ocheja et. *al.* (2014) for rabbits fed concentrates and browse plants crude protein, ash and either extract intake increased steadily from T_1 to T_5, this could be due to increasing levels of fermented locust bean meal. Nutrient intake was least in the control (T_1) showing that locust bean contains good array of nutrients. Crude protein intake ranged from 28.06 - 37.70%, and was significantly different. The intake of all the other nutrients increased from T1 – T4 and were significantly ($P< 0.05$) different

Dry matter intake (DMI) is influenced by diet composition, especially fiber and energy density.(Wafar *et al.*, 2019)

In trials evaluating forage and legume diets in wild rabbits, dry matter, nitrogen, and energy assimilation correlated with fiber content – higher fiber often corresponds to slower digestion rates. Diets optimized for balanced protein, energy, and fiber normally yield higher nutrient absorption and weight gain (Taiwo *et al.*, 2005)

TABLE 3: Dry Matter and Nutrient Intake (g/day) of Rabbit Bucks fed Diets containing Graded Levels of Fermented African Locust Bean

Parameter	T_1 (0% LL)	T_2 (5% LL)	T_3 (10% LL)	T_4 (15% LL)	(T_5) (20%LL)	SEM	LOS
DMI	80.66^{d}	90.50^{c}	100.00^{b}	102^{b}	108^{a}	5.19	*
CPI	23.06^{d}	30.35^{c}	35.00^{b}	35.50^{b}	37.70^{a}	2.32	*
CFI	7.00^{b}	8.50^{9}	8.00^{a}	8.00^{d}	7.00^{b}	0.78	*
NFEI	38.60^{b}	40.10^{b}	45.00^{b}	46.00^{a}	48.30^{a}	3.56	*
ASHI	5.00^{c}	6.05^{c}	6.70^{bc}	7.00^{b}	8.00^{a}	0.85	*
EEI	4.00^{c}	4.50^{c}	5.30^{b}	5.50^{b}	7.00^{a}	0.65	*

$^{Abc.}$ Means in the same row with different super scripts differs significantly ($p<0.05$), * means at 95% ($p<0.05$), DMI = Dry matter intake, CPI = crude protein intake, CFI = crude fibre intake, NFEI = Nitrogen Free Extracts intake, EE , Ether Extracts Intake ASHI, Ash Intake SEM = Standard Error of Mean, LOS = Levels of Significance.

3.3 Dry Matter and Nutrient Digestibility of Rabbit Bucks fed Diets containing Graded Levels of Fermented African Locust Bean

The results of the dry matter and nutrients digestibility of the experimental rabbit bucks fed with Diets containing the graded levels of African Locust Bean meal is presented in Table 4.

Dry matter digestibility range of 72.30 – 88.50%, which also showed significant($P<0.05$) differences across the treatments indicates high digestibility, this corroborates the reports of Moore and Jung (2010) and Pattanaik *et al.*(2018) that a digestibility coefficient of above 65% indicates good nutritive value and that below this levels intake is limited by low digestibility and that dietary modifications such as supplemental corn, additives, or leaf meals impact intake and digestibility. For example, supplemental corn in forage diets can influence feed intake and improve apparent nutrient digestibility metrics, this is an indication that the fermented African Locust bean meal

positively influenced digestibility .Crude protein digestibility ranged from 66.30 – 89.10% , it increased steadily from T1 – T4, and showed significant differences, crudr fibre digestibility ranged from 65.00 – 83% and followed similar tend with crude protein

Mineral levels (e.g., iron) in diets can affect intake, average daily gain, and digestibility coefficients moderate iron supplementation has been shown to help crude protein digestion .Digestibility coefficients are vital for understanding feed efficiency. Diets with excessive neutral detergent fiber (NDF) may reduce DMI and digestibility.Increased NDF leads to reduced digestibility of dry matter (DM), organic matter (OM), and fiber itself. High fiber particularly reduces overall nutrient utilization and daily weight gain.(Taiwo *et al.*, 2005)

Better digestibility is generally associated with improved growth performance and lower feed conversion ratios (FCR). Diets optimized for balanced protein, energy, and fiber normally yield higher nutrient absorption and weight gain.

Digestibility can vary with physiological states (e.g., pregnancy, lactation), where energy and protein requirements shift, altering nutrient absorption dynamics.(Wafar *et al*, 2019)

The digestibility of all the nutrients were consistently lowest in $T_{1.}$ This could indicate that fermented African locust bean meal had a significant influence on nutrient digestibility in rabbits. The digestibility values for all the nutrients showed significant differences across all the treatments, the crude protein digestibility value range of 66.30% - 89.10% were higher than 67.80% - 80.00% reported by Ocheja et. Al. 2014 for rabbit fed browse plants supplemented with a concentrate diet.

TABLE 4: Dry Matter and Nutrient Digestibility of Rabbit Bucks fed Diets containing Graded Levels of Fermented African Locust Bean (%)

Parameters	(T_1) 0% LL	(T_2) 5% LL	(T_3) 10% LL	(T_4) 15% LL	(T_5) 20%LL	SEM	LOS
DM	72.30^b	79.00^b	80.00^a	86.75^a	88.50^a	7.50	*
CP	66.30^c	69.00^c	75.00^b	83.50^a	89.10^a	7.30	*
CF	65.00^b	67.00^b	71.60^b	82.70^a	83.00^a	7.25	*
EE	76.20^b	76.80^a	74.20^b	79.30^b	84.30^a	7.30	*
NFE	72.30^b	72.50^b	73.50^b	79.00^a	81.00^a	7.33	*

Abc. Means in the same row with different super scripts differs significantly ($p<0.05$), * means at 95% ($p<0.05$), DM = Dry matter, CP = crude protein, CF = crude fibre, CHO = Nitrogen free extracts, Ether ExtractsLL = *Leucaena leucocephala*, SEM = standard error of mean, LOS = levels of significant.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Diets containing graded levels of African locust bean contained better array of nutrients than the control

The treatments containing graded levels of African locust bean had better digestibility values than the control

4.2 Recommendations

i. Fermented African locust bean can be included in concentrate diets for rabbits for improved nutrient intake and digestibility

ii. Further research to assess cost implications is recommended

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