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Potential of Gmelina leaf meal diets on the productive and physiological characteristics of growing rabbits

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Abstract. *Rabbit production is highly attracting attention in the world today due to its reputation in supplying one of the safest meat and other useful animal products. Hence, a 49-day study was carried out to determine the feed intake, body weight gain, serum biochemistry and haematological parameters of 80 growing rabbits fed Gmelina arborea leaf meal (GALM) in their diets. Four diets were formulated: T1, T2, T3 and T4 containing GALM at 0%, 10%, 20% and 30%, respectively. The rabbits were randomly divided into four experimental groups of twenty animals each, with five rabbits constituting a replicate. Blood samples were drawn from each animal on the last day of the trial and evaluated for serum biochemistry and haematological parameters. Results on proximate composition revealed that the nutrient requirements were met. Feed intake and body weight gain (p<0.05) were improved in T4 in comparison with other groups. Feed conversion ratio was however best for T3 and T4 (p<0.05). The haematological parameters differed significantly (p<0.05) and were improved at 30% GALM inclusion across the groups. Results showed that all the serum biochemical parameters studied except globulin differed significantly (p<0.05) among the treatment groups. Cholesterol was reduced at 30% GALM inclusion (p<0.05). All the blood parameters fell within the physiological range for clinically healthy rabbits; an indication that GALM had a beneficial effect on rabbits. Diet T4 had the best performance data among the treatment diets and is therefore recommended for rabbit enhanced production.*

Keywords: rabbits, *Gmelina arborea*, phytogenic plants, growth performance, haematology, blood chemistry

Introduction

Mini livestock production fulfils important socio-economic function in Nigeria due to the position of rabbits as a source of investment, experimental animal and animal protein for the increasing country's population. The rabbit (*Oryctolagus cuniculus*) is the dominant species of mini livestock found in Nigeria where it is raised for different purposes. The number of rabbit farms in Nigeria has been on the increase recently. This may be attributed to its delicious high protein meat that is low in calories and fat, its prolificacy and short gestation length, ease of management, the small investment required to start a rabbitry, the absence of restrictions on eating rabbit meat, and the fact that they can be fed on local forages and by-products that are of no direct use to humans. Furthermore, the animal is a popular companion animal among children and adults, and is also used widely in biomedical research.

Despite this potential, the productivity of rabbits in most tropical countries is low due to the high cost of feed supplement and poor nutrient intake, and this has burdened monogastric nutritionists on how to find cheaper and readily available feed supplements to reduce cost of feed. Availability of several close substitute feed ingredients could solve this problem in rabbit production. Local and non-competitive feed supplement is the only means of reducing the production cost of rabbits (Jiwuba et al., 2017), and this could be achieved through the use of leaf meal of tropical browse plants such as Gmelina.

Gmelina arborea is a multi-purpose tree that has considerable fodder yield during the wet and dry seasons. It is a well-known tree in the semi-arid zone where it is often cultivated for its sapling and medicinal values. Gmelina leaf is rich in protein, energy and mineral content with high bioactive compounds. The leaves have also been reported (Kumaresan et al., 2014) to have high ethno-veterinary properties. The high biological and nutrient contents of this tree species contributes to improving the nutritional quality of the diet of ruminants and pseudo-ruminants and thus could be used as feed supplement for these animals.

Earlier reports by Okpara et al. (2014) and Ukanwoko and Okehielem (2016) indicated that inclusion of Gmelina leaf meal (GLM) in the diet of West African dwarf goats improved feed intake, weight gain and feed conversion ratio (FCR). Ahemen et

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al. (2016) established significant improvement in white blood cell for rabbits fed diet containing GLM. However, in a more recent study, Pius et al. (2019) reported 100% mortality rate among rabbits fed 100% fresh *Gmelina arborea* leaves and poor body weight gain, feed intake and feed conversion ratio among rabbits fed 25g concentrate and 75g fresh *Gmelina arborea* leaves.

Therefore, the aim of the study was to evaluate the effect of Gmelina leaf meal on growth performance, haematology and blood chemistry in rabbits.

Material and methods

The research was carried out at the Rabbit Unit, Federal College of Agriculture, Ishiagu, Ivo Local Government Area of Ebonyi State, Nigeria. The College is located at about 3km away from Ishiagu main town. The College is situated at latitude 5.56°N and longitude 7.31°E, with an average rainfall of 1653mm and a prevailing temperature condition of 28.50°C and relative humidity of about 80%.

Fresh leaves of *Gmelina arborea* were harvested within the College environment and air dried for some days to a moisture content of about 10%. The dried leaves were processed and milled. Other feed ingredients were procured from a reliable Agro venture in Enugu, Enugu State, Nigeria.

Four (4) experimental diets were formulated and designated as T_1, T_2, T_3 and T_4 with *Gmelina arborea* leaf meal content (GALM) at 0%, 10%, 20% and 30%, respectively. Treatment one (T_1) did not contain the test ingredient, thereby serving as the control group as presented in Table 1.

Table 1. Composition of the experimental diets for rabbits with different content of *Gmelina arborea* leaf meal

	Dietary levels, %				
Ingredients	T_1	T_2	T_3	T_4	GALM
Maize	43.00	40.00	38.00	35.00	
Wheat	22.00	20.00	16.00	12.00	
Fish Meal	3.00	3.00	3.00	3.00	
Soybean	27.00	22.00	18.00	15.00	
Gmelina arborea leaf meal	0.00	10	20	30	
Bone meal	2.00	2.00	2.00	2.00	
Limestone	1.00	1.00	1.00	1.00	
Premix	1.00	1.00	1.00	1.00	
Salt	0.50	0.50	0.50	0.50	
Lysine	0.25	0.25	0.25	0.25	
Methionine	0.25	0.25	0.25	0.25	
Total	100	100	100	100	
Ration composition					
Dry Matter	93.29	92.36	91.98	90.95	89.56
Crude fibre	16.23	16.30	16.30	16.86	19.35
Crude protein	18.09	18.17	18.45	18.79	17.56
Ether extract	5.31	5.64	5.36	5.96	2.36
Ash	3.94	3.46	3.75	3.49	8.24
Nitrogen free extract	49.72	48.79	48.12	45.85	42.05
Metabolisable energy (Kcal/kg)	2824.70	2823.00	2785.55	2771.45	2286.95

*GALM- *Gmelina arborea* leaf meal

Eighty weaner rabbits were randomly divided into four experimental groups of 20 animals each, with 5 rabbits constituting a replicate. The four treatment groups were assigned the four experimental diets in a Completely Randomized Design. Each rabbit received an assigned diet for 49 days. Each animal was housed in a standard hutch (120cm/150cm), situated at 120cm above ground floor. The rabbitls were provided with feeders and drinkers. Each animal was vaccinated against prevalence under current diseases and were quarantined for 21 days before the commencement of the experiment. They were also dewormed and given accaricides bath prior to the experiment.

Initial weights of the animals were taken at the beginning of the trial and weekly thereafter. Final body weights were obtained by weighing the rabbits at the end of the experiment. Total body weight gain, average daily weight gain, total feed intake, average daily feed intake and feed conversion ratio (feed intake divided by body weight gain) were determined accordingly.

Blood samples (5ml) were drawn from each of the animals on the last day of the study. The rabbits were bled through the ear marginal vein. The samples were separated into two lots and used for biochemical and haematological determinations as described by Uko et al. (2000). An initial 2.5ml was collected from each sample in labelled sterile universal bottle containing 1.0mg/ml ethyldiamine tetracetic acid and used for haematological analysis. Another 2.5ml was collected over anti-coagulant free bottle. The blood was allowed to clot at room temperature and serum separated by centrifuging within three hours of collection. Serum biochemistry (total protein, albumin, globulin, urea, creatinine and cholesterol) and haematological parameters (packed cell volume - PCV, white blood cell - WBC, red blood cells) were measured using Beckman Coulter Ac-T10 Laboratory Haematology Blood Analyzer and Bayer DCA 2000+ HbA1c analyzer, respectively. Mean cells haemoglobin (MCH), mean cells volume (MCV), mean cell haemoglobin concentrations (MCHC) were calculated accordingly.

All feeds and experimental materials were analyzed for proximate compositions using the method of AOAC (1995).

All data were subjected to Analysis of variance (ANOVA) applicable to Completely Randomized Design (Steel and Torrie, 1980) using the SPSS computer software. Significant means were separated using Duncan's Multiple New Range Test (Duncan, 1955).

Results and discussion

The growth performance of growing rabbits fed on dietary levels of *Gmelina arborea* leaf meal is shown in Table 2. Average daily feed intake differed significantly ($p<0.05$) among the treatment groups. The average daily feed intake value (129.51g/d) for the animals fed control diet (T_1) did not differ ($p>0.05$) from those on diets T_2 and T_3, but however differed significantly ($p<0.05$) from those on diet T_4 (160.50g/d). T_4 animals had the highest average daily feed intake of 160.50g/day. Total feed intake had similar results as the average daily feed intake. Average daily weight gain of the rabbits on diets T_1, T_2 and T_3 differed significantly ($p<0.05$), with rabbits on diet T_4 having the highest average daily weight gain of 24.99 g/day. Feed conversion ratio differed significantly ($p<0.05$), with T_3 and T_4 being statistically ($p>0.05$) similar, but differed ($p<0.05$) from T_1 and T_2. Feed intake is an important factor in the utilization of feed and a critical determinant of energy intake and performance of an animal. The improvement in intake with *Gmelina arborea* leaf meal is in agreement with the results reported by Gaafar et al. (2014).The significant total feed intake obtained in the diet containing 30% GALM may be due to its greater palatability and higher crude protein content of the diet. Average daily feed intake of rabbits was significantly improved with increasing levels of GALM in the diet. Daily feed intake significantly increased ($p<0.05$) in the rabbits from T_4 diet as compared to the control group. Consequentially, rabbits from T_3 had the best feed conversion which statistically is similar ($p>0.05$) to these from T_4, but differed ($p<0.05$) from T_1 and T_2 groups. The total body weight of the animals increased with increasing the levels of the test ingredient among the treatment groups. The value for the rabbits fed control diet differed ($p<0.05$) significantly from these fed T_2, T_3 and T_4. Animals fed T_4 diet had the highest total weight gain (as in Table 2) of 1224.99g, while these fed T_1 had the lowest total body weight of 595.75g. However, the range of values obtained in this present study for total body weight gain for rabbit was higher than the range of 95.00-323.33g reported by Shaahu et al. (2014) for rabbits fed raw or processed Lablab seed. The average daily weight gain showed significant difference ($p<0.05$) among the treatment groups. The average daily weight gain obtained in the present study was lower than the range of the value (20.4-30.5g/d) reported by Nkwocha et al. (2014), but in accordance with the 15.68-25.36g range reported by Ogunsipe et al. (2014) for rabbits. The differences may be due to the experimental diets used, experimental location and season in which the experiment was conducted. The better performance of rabbits on *Gmelina arborea* leaf meal diets probably suggests efficient utilization of nutrients in the diets. This improvement in growth performance may also be due to the increase in feed intake of the rabbits fed the test diets. The improved effects may be attributed to the biological functions that have been essential for growth and the high level of natural substances that can promote health and alleviate illness that are contained in *Gmelina* leaves.

Table 2. Intake and performance of growing rabbits fed dietary levels of *Gmelina arborea* leaf meal

Parameters	T_1	T_2	T_3	T_4	SEM
Initial body weight (g)	675.15	650.82	683.24	680.11	58.98
Final body weight (g)	1270.90^c	1450.50^c	1727.08^b	1905.I0^a	159.99
Total weight gain (g)	595.75^c	799.68^b	1043.84^b	1224.99^a	180.27
ADWG (g/day)	12.16^d	16.32^c	21.30^b	24.99^a	1.9
Total feed intake (g)	6346.10^b	6657.53^b	6679.28^b	7864.64^a	140.55
ADFI (g/day)	129.51^b	135.87^b	136.31^b	160.50^a	4.15
Feed conversion ratio	10.65^a	8.33^b	6.40^c	6.44^c	0.83

T_1, T_2, T_3 and T_4 – experimental diets with *Gmelina arborea* leaf meal content at 0%, 10%, 20% and 30%, respectively
ADWG- Average daily weight gain (g/day);
ADFI- Average daily feed intake (g/day);
$^{a, b, c,}$ means in the same row with different superscripts are significantly different ($p<0.05$).

The haematological profile of rabbits fed dietary levels of *Gmelina arborea* leaf meal is presented in Table 3. There were significant differences ($p<0.05$) among treatment groups for all the haematological parameters. Similarly, all the haematological parameters examined except packed cell volume (PCV) tend to increase with increasing levels of the test ingredient. PCV values (32.41-41.37%) in all the dietary groups were within the reported range of 33.00-50.00% for rabbits (Burke, 1994). Rabbits from diet T_4 had the highest value of 41.37%, while these from diet T_2 had the lowest value of 32.41%. The haemoglobin (Hb) concentration compared favourably with the values of 9.70-13.70g/dl established by Njidda and Isidahomen (2009) for rabbits fed grasshopper meal. Rabbits from diet T_4 had the highest Hb concentration of 12.62g/dl, and fell within the reported by Fudge (1999) range of 9.4-17.4 for healthy rabbits. The significantly high Hb values among rabbits from diets T_2, T_3 and T_4 indicated that the quality of the proteins in the treatment diets was better to that of the control. This is in agreement with Okagbare et al. (2004) who stated that the leaves of *Gmelina arborea* are rich in protein with eight essential amino acids. The RBC values were within the range of 3.07 to 7.50x10^6/mm^3 reported by Fudge (1999). Hackbath et al. (1983) found that increased RBC values were associated with high quality dietary protein and with disease free animals. These observations were related to the composition of the diet and the health status of the rabbits since no rabbit died during the experiment. The values were close to the normal range of 60-73fl, 16.23pg and 26-34% for MCV, MCH and MCHC, respectively (Anon, 1980). MCV range of 78.97-88.97fl was in tandem with the values reported by Burnett et al. (2006) for MCV (63.4±0.7fl) and higher than the values (54.71-68.34fl) reported by Ogunsipe and Agbede (2012) for rabbits. Similarly, the values 28.34-33.51% observed for MCHC in this study relatively compared well with 31.00-31.70% reported by Ogunsipe and Agbede (2012). Johnson-Delaney (1996) explained that the MCV and MCH values could reflect anemic condition and the capacity of the bone marrow to produce RBC of normal size and metabolic capacity. However, MCHC was very significant in the diagnosis of anemia. The normal MCV, MCHC and MCH recorded in this study for the rabbits gave a clear indication of the absence of anemia among the experimental groups. The white blood cell count (WBC) ranged from 3.80-9.70x10^{12}/l, the values were within the range of 5-13x10^9/l reported by Burke (1994) for healthy young rabbits. These results indicated that the animals were healthy because decrease in number of WBC below the normal range (leukocytopenia) is an indication of allergic conditions and certain parasitism, while elevated values (leukocytosis) indicate the existence of a recent infection. This perhaps highlights the ethno-veterinary properties of *Gmelina arborea* as reported by Kaswala et al. (2012) and corroborated by Deepthi et al. (2015).

Table 3. Haematological profile of growing rabbits fed dietary levels of *Gmelina arborea* leaf meal

Parameter	T_1	T_2	T_3	T_4	SEM
Packed cell volume (%)	35.31^c	32.41^d	37.96^b	41.37^a	1.25
Haemoglobin (g/dl)	9.55^b	11.06^a	11.31^a	12.62^a	0.48
Red blood cell (x10^6/ul)	4.39^d	5.36^c	6.51^b	7.10^a	0.40
MCHC (%)	28.34^d	30.45^c	32.60^b	33.51^a	0.76
Mean corpuscular haemoglobin (pg)	19.21^c	21.51^b	22.37^b	23.41^a	0.60
Mean corpuscular volume (fl)	78.97^c	84.01^c	86.00^b	88.97^a	1.39
White blood cell (x10^6/dl)	4.90^c	5.69^c	7.95^b	10.52^a	0.83

T_1, T_2, T_3 and T_4 – experimental diets with *Gmelina arborea* leaf meal content at 0%, 10%, 20% and 30%, respectively;
MCHC= Mean corpuscular haemoglobin concentration;
$^{a, b, c}$ means in the row with different superscripts are significantly different (p<0.05).

Table 4 shows the serum biochemistry of rabbits fed dietary levels of *Gmelina arborea* leaf meal. The total protein (g/l) values obtained differed significantly (p<0.05) with T_1 having the highest value and T_4 having the lowest value. Blood albumin (g/l) concentrations differed (p<0.05) significantly among the treatment groups. However, globulin (g/l) was not affected (p>0.05) by the treatment diets, but tended to increase with increasing levels of the test ingredient. Blood urea concentrations (mg/dl) differed (p<0.05) among all the groups and, however, decreased with increasing levels of *Gmelina arborea* leaf meal. T_1 differed significantly from T_2, T_3 and T_4, while T_3 and T_4 were similar (p>0.05). The creatinine values tended to increase with increasing levels of the test ingredient with T_4 differing significantly (p<0.05) from T_1, T_2 and T_3. The cholesterol values of this study showed significant (p<0.05) difference among the treatment groups. The values for total protein (55.99-61.07g/l) were lower than the values (69.7-70.5g/l) for rabbits reported by Burnett et al. (2006). However, the values fell within the normal range of (5-8 g/dl) reported by Mitruka and Rawnsley (1977) for healthy rabbits. The result suggests that there was no muscle wastage in the rabbits and that the animals did not survive at the expense of body reserves since protein synthesis is related to the amount of dietary protein. This entailed better utilization of the dietary proteins by the animals within each treatment, thereby facilitating total protein availability. The range of values (28.23-38.21g/l) for albumin obtained in this present study fell within the normal range (2.5-4.5 gl dl^{-1}) reported by Annon (1980), which is an indication of proper functioning of the liver in the rabbits. However, the values established in this study favourably compared well with 2.81-3.91g/dl reported by Njidda and Isidahomen (2009) for growing rabbits fed grasshopper meal as a substitute for fish meal. The globulin values showed no difference, but were the highest numerically for T_4 and the lowest for T_1, and fell within the normal range (1.5-3.3 g/dl) reported by Burke (1994), which is indicative of high immunity and good resistance to disease in the experimental animals. This perhaps highlighted the ethno-veterinary properties of *Gmelina arborea* as reported by Kaswala et al. (2012) and corroborated by Deepthi et al. (2015). Blood urea concentrations (mg/dl) differed among the groups and fell within the range of 31.37-38.00 mg/dl reported by Wafar et al. (2014) for weaner rabbits. The low and non-significant blood urea observed in T_3 and T_4 is an indication that the amino acids of *Gmelina arborea* were balanced since high blood urea levels were associated with poor protein quality (Eggun, 1970) or excess tissue catabolism associated with protein deficiency (Oduye and Adadevoh, 1976). The result of this study was in agreement with the findings of Eggum (1970) who observed that an amino acid imbalance would result in an increase in blood urea concentration. This perhaps highlighted the high quality protein of *Gmelina arborea* as reported by Okagbare et al. (2004). Creatinine values of the experimental rabbits followed a particular trend, with the rabbits receiving the treatment diets exhibiting significantly higher values than these in the control group. Similar results were obtained by Annongu and Folorunso (2003) and Annongu et al. (2004) in their experiments with *Gmelina arborea* on swine and broiler chicks, respectively. Harita et al. (2008) associated lower serum creatinine level with increased risk of type 2 diabetes. The increased level of serum creatinine of the animals receiving the test ingredient relative to those in the control group could suggest the anti-diabetic property of *Gmelina arborea*; a view corroborated by Kaswala et al. (2012). This is corroborated by the significant ($p<0.05$) decrease in serum cholesterol of the test animals. Since glucose and cholesterol levels were within the normal range, possibilities of anorexia, diabetes, liver dysfunction and mal-absorption of fat, which are the symptoms of abnormal glucose and cholesterol levels in the blood, are ruled out (Bush, 1991).

Table 4. Serum biochemistry of growing rabbits fed dietary levels of *Gmelina arborea* leaf meal

Parameter	T1	T2	T3	T4	SEM
Total protein (g/l)	61.07^{a}	58.70^{b}	57.52^{b}	55.99^{c}	1.38
Albumin (g/l)	38.21^{a}	35.72^{b}	34.46^{b}	32.23^{c}	1.00
Globulin (g/l)	22.86	22.98	23.06	23.76	0.31
Urea (mg/dl)	35.40^{a}	33.61^{b}	31.57^{c}	30.96^{c}	0.68
Creatinine (mg/dl)	0.85^{b}	0.91^{b}	0.94^{b}	1.17a	0.05
Cholesterol (mg/dl)	46.47^{a}	20.39^{b}	15.99^{c}	11.58^{d}	5.13

T_1, T_2, T_3 and T_4 – experimental diets with *Gmelina arborea* leaf meal content at 0%, 10%, 20% and 30%, respectively; $^{a, b, c, d}$ means in the same row bearing different superscripts are significantly different ($p<0.05$).

Conclusion

In conclusion, this study revealed that Gmelina arborea leaf meal supported feed intake, body weight gain, haematological and serum biochemical parameters of growing rabbits and therefore could be included in the diets of rabbits up to 30% without any detrimental effect on the performance and erythropoiesis of the animals.

References

Ahemen T, Shaahu DT and Kwaghve NN, 2016. Growth performance, genital organ dimensions, visceral organ weights and haematology of male rabbits fed graded levels of *Gmelina arborea* Leaf meal. Journal of Pharmacy and Biological Science (IOSR-JPBS), 11, 28-32.

Annon, 1980. Guide to care and use of experimental animals. Canadian Council on Animal Care, 1, 185-190.

Annongu AA and Folorunso AS, 2003. Biochemical evaluation of *Gmelina arborea* fruit meal as a swine feedstuff. Tropical and Subtropical Agro ecosystems, 15, 207-215.

Annongu AA, Atteh JO, Joseph JK, Apata, DF and Fasanya EA, 2004. Dietary effects of chemically treated *Gmelina arborea* nuts on the performance and certain biochemical indices in broiler chicks. Journal of Agricultural Research and Development, 3, 113-118.

AOAC, 2000. Animal feed. In: AOAC Official Methods of Analysis (6th Edition), pp. 5-15, AOAC International, Washington DC, USA.

Burke J, 1994. Clinical Care and Medicine of Pet rabbit. In: Proceedings of the Michigan Veterinary Conference, pp. 49 -77.

Burnett N, Mathura K, Metivier KS, Holder RB, Brown G and Campbell M, 2006. An investigation into haematological and serum chemistry parameters of rabbits in Trinidad. World Rabbit Science, 14, 175-187.

Bush BM, 1991. Interpretation of Laboratory Results for Small Animal Clinicians. Blackwell Scientific Publications. London, UK.

Deepthi P, Harini A and Prakash LH, 2015. A Review on Gambhari (*Gmelina arborea* Roxb.). Journal of Pharmacognosy and Phytochemistry, 4, 127-132.

Duncan DB, 1955. Multiple New Ranges and multiple F-tests. Biometrics, 11, 1-42.

Eggun BO, 1970. Blood Urea-measurement as a technique for assessing protein quality. British Journal of Nutrition 24, 985-988.

Fudge CS, 1999. Laboratory Medicine: Avian and Exotic Pets. WB Saunders, Philadelphia, USA.

Hackbath H, Buron V and Schimansley G, 1983. Strain difference in inbred rats: Influence of strain and diet on haematological traits. Laboratory Animals, 17, 7-12.

Harita N, Hayashi T, Sato KK, Nakamura Y, Yoneda T, Endo G and Kambe H, 2008. Lower serum creatinine is a new risk factor of type 2 diabetes: The Kansai healthcare study. Diabetes Care, 32, 8-26.

Jiwuba PC, Ahamefule FO, Ogbuewu IP and Ikwunze K, 2017. Blood chemistry and haematology of West African Dwarf goats fed *Moringa oleifera* leaf meal (MOLM) in their diets. Comparative Clinical Pathology, 26, 621-624.

Johnson-Delaney CA, 1996. Exotic companion medicine handbook for veterinarians. Winger, Lake Worth Florida.

Kaswala R, Patel V, Chakraborty M and Kamath JV, 2012. Phytochemical and pharmacological profile of Gmelina arborea: an overview. International Research Journal of Pharmacy, 3, 61-64.

Kumaresan P, Jeyanthi KA and Kalaivani R, 2014. Biochemical evaluation of antidiabetic activity of aqueous extract of *Gmelina arborea* in Alloxan induced albino rats. International Journal of Herbal Medicine, 2, 90-94.

Miturka BM and Rawnsely HM, 1977. Clinical, biochemical and haematological reference values in normal experimental animals. Mason Publishing New York, USA.

Njidda AA and Isidahomen CE, 2009. Haematology, blood chemistry and carcass characteristics of growing rabbits fed grasshopper meal as a substitute for fish meal. Pakistan Veterinary Journal, 30, 85-90.

Nkwocha GA, Agbabiaka LA, Beketin TO and Anukam KU, 2014. Effect of graded levels of *Gmelina arborea* leaf meal on the performance of grower Rabbits. International Journal of Agricultural Science, 4, 370-373.

Oduye OO and Adadevoh BK, 1976. Biochemical values of apparently normal Nigerian sheep. Nigeria Veterinary Journal, 5, 43 -50.

Ogunsipe MH and Agbede OJ, 2012. Effect of millet offal-based diets on performance, carcass cuts and haematological profile of growing rabbits. African Journal of Food Science, 6, 280-286.

Ogunsipe MH, Agbede JO and Adedeji OA, 2014. Performance response, carcass evaluation and economic benefit of rabbits fed sorghum offal-based diets. African Journal of food, Agriculture, Nutrition and development, 14, 595-8601.

Okagbare GO, Akpodiere OJ, Esiekpe O and Onagbesan OM, 2004. Evaluation of *Gmelina arborea* leaves supplemented with grass (*Panicum maximum* and *Pennisetum purpureum*) as feed for West African Dwarf goats. Tropical Animal Health and Production, 36, 593–598.

Okpara O, Akporhuarho PO and Okagbare GO, 2014. Determination of Browse Intake and Nutrient Digestibility of Grazing West African Dwarf (WAD) Goats Fed Varying Levels of *Gmelina arborea* Leaves as Supplements in Delta State Nigeria. International Journal of Animal and Veterinary Advances, 6, 52-57.

Pius O, Ahemen T and Addass PA, 2019. Effect of rations with fresh leaves of *Gmelina arborea* on growth performance and organ weights of rabbit bucks. Agricultural Science and Technology, 1, 317-322.
DOI: 10.15547/ast.2019.04.053.

Shaahu DT, Carew SN and Dzungwe NE, 2014. Effect of Using Raw or Processed Lablab Seed as Major Protein Source in Diets on the Economics of Feeding and Growth Performance of Rabbits. Journal of Agriculture and Veterinary Science, 7, 22 -26.

Steele RGD and Torrie JH, 1980. Principles and Procedure of Statistics: A biometrical approach. Mc Graw Hill Inc, New York, USA.

Ukanwoko AI and Okehielem OV, 2016. Effect of Gmelina (*Gmelina arborea*) leaf meal based diets on growth performance of West African dwarf bucks. Asian Journal of Animal Sciences, 10, 154-158.

Uko OJ, Ataja AM and Tanko HB, 2000. Weight gain, haematology and biochemistry of rabbits fed cereal offals. Sokoto Journal of Veterinary Science, 2, 18-26.

Wafar RJ, Yakubu B and Obun CO, 2014. Effect of processing methods of Leptadenia hastata leaves on haematology and serum biochemistry of weaner rabbits. International Journal of applied sciences and engineering research, 3, 94-103.