Nutritional assessment of *Gmelina arborea* leaf meal on productive performance and cost/benefit evaluation of growing rabbits

Jiwuba, Peter-Damian C.[1], Ogbuewu, Princewil I.[2], Ume, Smiles I.[3]

[1]*Department of Animal Production Technology, Federal College of Agriculture, P.M.B.7008, Ishiagu, Ebonyi State, Nigeria.*

[2]*Department of Animal Science and Technology, Federal University of Technology, P.M.B.1526, Owerri, Nigeria*

[3]*Department of Agricultural Extension and Management, Federal College of Agriculture, P.M.B.7008, Ishiagu, Ebonyi State, Nigeria.*

Corresponding author: jiwubapc@gmail.com ; +2348063622456

Citation: Jiwuba, P. D. C., Ogbuewu, P. I., & Ume, S. I. (2020). Nutritional assessment of *Gmelina arborea* leaf meal on productive performance and cost/benefit evaluation of growing rabbits. *Zhivotnovadni Nauki*, *57*(6), 21-28 (Bg).

Abstract

A 49-day feeding trial was conducted to evaluate the effects of *Gmelina arborea* leaf meal (GALM) on the productive performance and cost/benefit ratio of 48 growing rabbits. The animals were randomly divided into four experimental groups of twelve animals each, with four rabbits constituting a replicate. Four experimental diets designated as T_1, T_2, T_3 and T_4 were formulated to contain 0%, 10%, 20% and 30% GALM, respectively and fed to the animals in a Completely Randomized Design (CRD). Result on proximate analysis of the GALM revealed 19.35% CP, 17.57% CF and 89.56% DM. Similarly, proximate results of the experimental diets showed a DM, CP and CF range of 90.95–93.29, 18.09–18.79 and 16.23–16.86 respectively. Average daily weight gain (ADWG) differed ($P < 0.05$) with T_4 having the highest value of 24.99 g as against 12.16, 16.32 and 21.30 g for T_1, T_2 and T_3, respectively. Similarly rabbits on diet T_4 had the highest average daily feed intake (ADFI) of 150.30 g as against 129.51, 135.87, 136.31 g for T_1, T_2 and T_3 respectively, and the best feed conversion ratio of 6.01. The dressing percentages for the animals in diet T_1, differed ($P < 0.05$) from that of T_2, T_3 and T_4 respectively. The hind limb, fore limb and thoracic cage weights were significantly higher at 30% dietary levels. Organ weights (liver, heart, lungs and kidney) were similar ($P > 0.05$) among the groups. 30% dietary level of GALM resulted in reduced cost of feed and cost/kg weight gain of rabbit production. Consequently Cost/benefit ratio was best for rabbits in diet T_4 (1 : 4.04). Rabbits in diet T_4 had the best performance and therefore 30% GALM is recommended for enhanced and cheaper rabbit production.

Key words: medicinal plants; alternative feedstuff; growth performance; carcass indices; rabbits.

Introduction

The poor animal protein intake is worrisome among animal scientists in developed and developing countries. This situation may not necessarily be due to insufficient number of livestock needed to meet the recommended animal protein intake, but may be attributed in part to poor performance of the animals as a result of scarcity of conventional feeds and feedstuffs resulting from high cost of the latter. It could also be attributed to little knowledge of the potentials of non-conventional feed materials. These non-conventional feed resources can be better utilized through processing into different forms like leaf meals. Previous reports on the utilization of leaf meals in the diet of livestock and poultry have shown significant responses by animals fed such diets (Jiwuba, 2018; Jiwuba et al., 2017; Ogbuewu et al., 2009). There is great potential for the use of leaf meals for animal feeding in the tropics. Leaf meals have the potential of yielding relatively higher levels of crude protein, dry matter and lower crude fibre levels than most tropical forages, free from chemical additives and contain some benefial phytogenic compounds. One of such possible high nutrient resource is leaf meal made from dried *Gmelina arborea* foliage.

Gmelina arborea is of Asian origin but are abundantly found in Nigeria, especially in the rain forest and derived savanna zones of the country. This tree is one of the unconventional materials explored for the production of feedstuff (Jiwuba et al., 2016 a). *Gmelina arborea* leaf is one of the tree leaves considered as an important source of nutrient for ruminants and non- ruminants. The leaves, flower, roots and bark are used in medicine (Kumaresan et al., 2014), which could also serve as natural growth promoters. Previous records by Nkwocha et al. (2014) and Offor (2014) on the nutrient profile of *Gmelina arborea* leaves have shown that the meals contained 18.00–20.05% crude protein, 14.40–15.05% crude fibre, ash 4.55% and crude fat 0.79%. *Gmelina arborea* leaves are however, implicated with anti-nutritional factors like oxalate, tannin, saponin, alkaloids and trypsin inhibitor (Amata and Lebri, 2012) which has been reported to affect nutrient availability and utilization when not properly processed (Jiwuba et al., 2016 b). Amata and Lebri (2012) further stated that the concentrations of the anti-nutrients are low and within the normal range for leafy vegetables. Thus, the shed drying and further milling employed in this study would perhaps further reduce the anti-nutrients to tolerable values for rabbits.

Rabbit reputation for utilization of diverse forage materials and converting the roughages into meat makes them most suited for this research. Rabbits are highly prolific animals and capable of increasing the animal protein intake within a short period. This may be attributed to their high prolificacy, short generation interval, early maturity and excellent feed utilization efficiency (Jiwuba et al., 2016 a). Rabbit meat is highly nutritious, easily digestible, tender, extremely low in cholesterol and sodium, hence suitable for people with some health problems. Therefore, this experiment was carried out to investigate the effects of dietary levels of *Gmelina arborea* leaf meal (GALM) on the growth performance, carcass characteristics and cost/benefit of growing rabbits.

Materials and methods

The experiment was carried out at the Rabbit Unit, Federal College of Agriculture, Ishiagu, Ebonyi state, Nigeria. The College is located at about three kilometers (3 km) away from Ishiagu main town. The College is situated at latitude 5.56 °N and longitude 7.31 °E, with an average rainfall of 1653 mm and a prevailing temperature condition of 28.50 °C and relative humidity of about 80% (Jiwuba, 2018).

Fresh leaves of *Gmelina arborea* were harvested within the College environment and air dried for some days to a moisture content of about 10–15%. The air dried leaves were processed and milled using hammer mill. Other feed ingredients were procured from a reliable Farm associate, Enugu, Enugu State, Nigeria.

Forty eight (48) growing rabbits weighing averagely 831.25 g were randomly divided into four experimental groups of twelve animals each, with four rabbits constituting a replicate. Each rabbit was housed in a standard hutch measuring 120 by 150 cm and raised 120 cm above the ground level. The four treatment groups were assigned the four diets in a Completely Randomized Design. The rabbits were stabilized for 21 days before the commencement of the study in line with the permission and guidelines of research policy of the College's Animal Ethics Committee. Each animal was vaccinated against prevalent disease and were quarantined for 21 days before the commencement of the experiment. They were also dewormed using kepromec (Ivermectin) at the rate of 0.1 ml per rabbit subcutaneously and given accaricide bath using Roys' Amitraz 20 at the rate of 1 ml in 2 litre water prior to the experiment.

Four (4) experimental diets were formulated and designated as T_1, T_2, T_3 and T_4 to contain GALM at 0%, 10%, 20% and 30%, respectively (Table 1). Treatment T_1 did not contain GALM thereby serving as the control.

Data were collected daily for feed intake and weekly for weight gained using weighing scale of 30 kg capacity and 0.001 kg sensitivity. The feed intake of each rabbit was determined by the difference between the feed supplied and the left over in the feeding trough the next day. While body weight changes were measured on a weekly basis and the difference between initial and final weight of the rabbits constituted the live body weight gain. Feed conversion ratio was calculated.

At the end of the feeding trial, three rabbits were randomly selected from each treatment based on the average group weight for carcass analysis. The animals were starved for twelve hours of feed to clear the gut and their weights taken prior to bleeding. Thereafter, the rabbits were stunned and bled. Bleeding of the rabbits involved severing their jugular veins with a sharp knife followed by flaying. They were eviscerated, internal organs (heart, lungs, kidney and liver) were carefully removed and weighed. The dressed carcass and cut parts were also weighed and recorded.

The prevailing market prices of the feed ingredients at the time of the experiment were used to estimate the unit cost of the experimental diet (N320 = $1 at the time of the experiment). The variable cost of feeding the rabbits was considered as the cost of the feeds as all other costs (i.e. labour, capital investment, housing) were the same for all the treatments. The cost of processing the GALM was included as the feed cost. Feed cost per kilogramme, cost per kilogramme of weight gain and cost benefit ratio were calculated.

All feeds and experimental materials were analyzed for proximate compositions using the method of AOAC (2000).

The results were analyzed using the Statistical Package for Social Science Window 17.0. One-way analysis of variance (ANOVA) was employed to determine the means and standard error. Significant differences between the treatment means were separated using the Duncan Multiple New Range Test (Duncan, 1955).

Table 1. Composition of the experimental diets

	Dietary levels (%)			
Ingredients	T_1	T_2	T_3	T_4
Maize	43.00	40.00	38.00	35.00
Wheat offal	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
GALM	0.00	10.00	20.00	30.00
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
Common 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

Results

The proximate compositions of the test ingredient (*Gmelina arborea* leaf meal) and experimental diets are presented in Table 2. Proximate analysis of *Gmelina arborea* leaf meal and experimental diets revealed the presence of dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract.

The growth performance of growing rabbits fed dietary levels of GALM is shown in Table 3. Daily feed intake significantly increased ($P < 0.05$) in the rabbits on T_4 diet as compared to control group. The average daily feed intake (ADFI) value (129.51 g/d) for the animals fed control diet (T_1) differed ($P < 0.05$) with those on diets T_2 and T_3 and T_4 respectively. T_4 animals had the highest average daily feed intake of 150.30 g/day. Value on total weight gain for the rabbits fed control diet differed ($P < 0.05$) significantly from T_2, T_3 and T_4. Animals fed T_4 diet had highest total body weight of 1224.99 g, while T_1 had the lowest (595.75 g). Average daily weight gain (ADWG) differed ($P < 0.05$) significantly, with rabbits on diet T_4 having the highest of 24.99 g/day. The feed conversion ratio (FCR) differed significantly ($P < 0.05$) among treatment groups.

The carcass characteristics of growing rabbits fed dietary levels of GALM are presented in Table 4. The dressing percentage was significantly ($P < 0.05$) influenced by the treatment diets across the treatment groups. The dressing percentage of the animals in control diet differed ($P < 0.05$) significantly from the test diets (T_2, T_3 and T_4). The dressed weight was significantly ($P < 0.05$) influenced by the treatment diets. However, primal cuts like the thoracic cage, fore limb and hind limbs were significantly ($P < 0.05$) higher in rabbits fed T_4 diet than the control diet. The absolute weight of the heart and lung were not significantly ($P > 0.05$) affected by the dietary treatments, but however the liver, kidney and spleen were significantly ($P < 0.05$) affected by the treatment diets.

Table 2. Proximate analyses of experimental diets and GALM (% dry matter basis)

Diets	T_1	T_2	T_3	T_4	GALM
Dry matter (DM)	93.29	92.36	91.98	90.95	89.56
Crude fibre (CF)	16.23	16.30	16.30	16.86	17.56
Crude protein (CP)	18.09	18.17	18.45	18.79	19.35
Ether extract (EE)	5.31	5.64	5.36	5.96	2.36
Ash	3.94	3.46	3.75	3.49	8.24
Nitrogen free extract (NFE)	49.72	48.79	48.12	45.85	42.05
Metabolisable energy (Kcal/kg)	2824.70	2823.00	2785.55	2771.45	2286.95

Table 3. Intake and growth performance of growing rabbits fed dietary levels of GALM

Parameters (g)	T_1	T_2	T_3	T_4	SEM
Initial body weight	675.15	650.82	683.24	680.11	58.98
Final body weight	1270.90^c	1450.50^c	1727.08^b	1905.10^a	159.99
Total weight gain	595.75^d	799.68^c	1043.84^b	1224.99^a	180.27
ADWG	12.16^c	16.32^b	21.30^a	24.99^a	1.90
Total feed intake	6346.10^b	6657.53^b	6679.28^b	7364.64^a	140.55
ADFI	129.51^c	135.87^b	136.31^b	150.30^a	4.15
Feed conversion ratio	10.65^a	8.33^b	6.40^c	6.01^c	0.83

$^{a, b, c,}$ *Means in the same row with different superscripts are significantly different (p < 0.05)*

Table 5 showsed the economics of production of rabbits fed dietary levels of GALM. The control diet has the highest feed cost per kg feed (N25.95) and the least (N22.65) was recorded by rabbits fed 30% GALM. The feed cost/kg weight gain was significantly ($P < 0.05$) higher (N276.94) in the control diet compared to T_3 and T_4 (N147.37 and N136.19), respectively.

Discussion

The results on proximate analysis of the GALM in this study compared favourably with the findings of Nkwocha et al. (2014), who reported CP content of 18%, CF 14.40%, ash 4.64%, EE 3.59, NFE 47.73% and ME (Kcal/Kg) 2852 for the same leaf meal. The CP value of 19.35% reported in the present study is comparable with 20.05% CP reported by Offor (2014) for GALM. Okagbare et al. (2014) reported lower value for DM (52.75%), CF (11.00%), EE (0.50%) and a comparable ash (9.15%) and CP content of 19.26%. The differences in the proximate compositions of the GALM could be attributed to different climatic conditions, time and age at which the leaves were harvested and processing methods used. Dry matter content of GALM containing diets (T_2, T_3, and T_4) compared well with the control diet (T_1). The DM content of the

Table 4. Carcass characteristics and organ weights of growing rabbits fed dietary levels of GALM

Dietary levels (%)					
Parameters (%)	T_1	T_2	T_3	T_4	SEM
Live weight (g)	1270.90^c	1450.50^c	1727.08^b	1905.10^a	121.20
Dressed weight (g)	756.70^c	992.89^b	1290.91^b	1430.75^a	18.98
Dressing percentage (%)	59.54^c	68.45^b	74.75^a	75.10^a	1.01
Loin (g)	92.50	100.00	112.50	140.00	2.72
Thoracic cage (g)	87.50^b	97.50^b	125.50^a	138.00^a	3.01
Fore limb (g)	93.50^b	95.00^b	102.50^a	155.50^a	2.43
Hind limb (g)	197.00^c	207.50^{bc}	272.00^b	313.00^a	6.03
Liver (g)	17.00	18.50	19.50	20.00	0.50
Heart (g)	5.00	5.00	5.50	6.10	0.11
Kidney (g)	10.50	11.00	11.50	10.90	0.21
Spleen (g)	2.00^b	2.50^b	3.00^b	4.50^a	0.09
Lung (g)	46.50	49.50	51.50	51.50	0.81

a, b, c, d means in the row with different superscripts are significantly different (p < 0.05)

Table 5. Economics of production of growing rabbits fed dietary levels *Gmelina arborea* leaf meal

Parameters	T_1	T_2	T_3	T_4	SEM
Cost/100kg feed (N)	2595^a	2423^b	2346^c	2265^d	22.81
Cost/kg feed (N)	25.95^a	24.23^b	23.46^c	22.65^d	2.28
Total feed consumed (kg)	6.35^b	6.66^b	6.68^b	7.36^a	0.8
Total cost of feed consumed (N)	164.78^{ab}	161.37^{ab}	156.71^b	166.70^a	39.5
Total weight gain (kg)	0.595^c	0.799^b	1.043^b	1.224^a	0.02
Feed cost/weight gain (N)	276.94^a	201.96^b	147.37^c	136.19^d	15.08
Cost/kg live weight (N)	550	550	550	550	0.00
Cost Benefit Ratio	1:1.99	1:2.72	1:3.73	1:4.04	

a, b, c, d means in the same row bearing different superscripts are significantly (P < 0.05) experiment diets tend to decrease with increasing levels of the test ingredient. However, the dry matter values reported in the present study is higher than the range (85.39 – 89.96%) reported by Ogunsipe et al. (2014) for rabbits. The crude protein values also tend to increase marginally with increasing values of GALM among the treatment groups. The crude protein range of values (18.09–18.79%) for the present study is higher than the range (17.12 –17.43%) reported by Ogunsipe et al. (2014), but favourably compared with the range of (18.45–19.50%) reported by Nkwocha et al. (2014) for rabbits fed GALM diets. The slight increase in the crude protein content of the test diets may be attributed to the higher nitrogen content of the test ingredient. The crude fibre contents of the experimental diets did not show any consistent trend, but fall within the crude fibre requirement of 14–18% on dry matter basis for rabbits as stated by Lebas (2002). The values of ether extract and ash are in agreement with the range of values (4.94–5.73% and 4.82–5.27%) reported by Nkwocha et al. (2014) for ether extract and ash respectively for the rabbits. The NFE in this study tended to decrease with increasing levels of GALM, but however, comparable with the control diet. The ME values of GALM containing diets (T_2, T_3, and T_4) are comparable with the control diet (T_1), but however were decreasing with increasing levels of the test ingredient.

In any feeding trial, 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 observed in the GALM is in agreement with results reported by Gaafar et al. (2014). The significant total feed intake obtained in the diet containing 30% GALM (T_4) may be due to its greater palatability and higher crude protein content of the diet. This is in line with the report of Jiwuba (2018) that diets higher in protein content increases intake. Average daily feed intake of rabbits was also significantly improved with increasing levels of GALM in the diet. The higher feed intake of the rabbits on T_4 diet relative to other treatment groups might have resulted from the lower energy concentration of diet. Similarly, the enhanced intake may be attributed to the increased palatability of the treatment diets conferred by the GALM.

The total body weight, of the animals increased with increasing levels of test ingredient among the treatment groups. However, the range of values obtained in this present study for total body weight gain for rabbit is higher than the range of 95.00–323.33 g reported by Shaahu et al. (2014) for rabbits fed raw or processed Lablab seed. The average daily weight gain obtained in the present study is lower than the range of value (20.4–30.5 g/d) reported by Nkwocha et al. (2014), but compared with 15.68–25.36 g range reported by Ogunsipe et al. (2014) for rabbits. The differences may be due to the experimental diets used, experimental location, age of the rabbits, season in which the experiment was conducted inclusion levels and the duration of the feeding trial. The better performance of the growing rabbits on GALM diets probably suggests efficient utilization of nutrients in the diets. The 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 high level of natural substances that can promote health and alleviate illness that are contained in *Gmelina* leaves; a view corroborated by Deepthi et al. (2015). Vijay et al. (2011) further reported the antimicrobial and anti-oxidative agent contained in the *Gmelina arborea* leaves; this could have positive effects on growth performances of rabbits. T_4 had the least FCR indicating a better feed conversion ratio. The superior feed efficiency of diets T_4 (though not statistical ($P > 0.05$ different with T_3) over the other diets is a reflection of the observed higher feed utilization and indeed higher growth rates of rabbits fed the respective diets.

The significant linear increment observed for the dressing percentage maybe attributed to the significant linear increment in the total weight gain across the treatment groups. The range of values (59.54–75.10 g) obtained for dressing percentage in this present study compared with 66.28–75.60 obtained by Jiwuba (2018) for rabbits fed pawpaw leaf meal. The result of the this study is higher than the report of Fielding (1991), who noted that the dressing percentage of rabbits normally ranges from 50 to 56% and tends to be greater if the rabbits are fully grown and have some fat. The author further stated that the dressing percentage would be 50% or less if the rabbit is young, thin and with a full digestive tract at killing. Dressed weight is an important indices of carcass characteristics because the higher the value the more the degree of meatiness. The significant difference observed in the cut parts are in tandem with the results of Akinmutimi et al. (2006) and Idowu et al. (2006) who reported significant variations in primal cuts of grower rabbits fed sword bean, cassava root sievate and cassava root peel diets, respectively. The present result suggests that the treatment diets influenced good edible parts. The kidney as well as the liver plays important roles in the detoxification and excretion of most toxic materials from body (Ani et al., 2008). The lack of significant difference in the weights of kidney and liver fed GALM based diets is an indication that there were no or tolerable values of toxic factors that can cause cell damage in the diets offered.

Cost per kg feed reduced as the inclusion level of GALM in the diets increased. This is expected since it served as a replacement for soya bean in the diets. Soya bean meal is one of the most expensive feedstuffs (N184.00/kg at the time of this experiment) while GALM is hitherto free, except for the cost of milling which was N200 for 100 kg at the time of the experiment. The reduction observed in the feed cost per kilogram feed is an indication that GALM could be used to reduce the cost of rabbit feed. This result agrees with the report of Jiwuba et al. (2018) on the effect of replacing conventional feedstuffs with leaf meals of tropical browse plants. The superiority of the rabbits on diet T_4 compared to the rabbits on the control diet (T_1) arose from the fact that, the amounts of feed required to attain the weight were not similar suggesting that feed cost could be reduced in rabbits using GALM. This is in agreement with Jiwuba et al. (2018) who reported that inclusion of the leaf meal of *Chromolaena odorata* in broiler diets resulted to lower feed cost. The implication of this result is that feeding rabbits with diets containing GALM is beneficial in terms of profitability as well as return on investment. The highest return on investment was recorded on 30% GALM level as shown by cost benefit ratio values of T_4 (1:4.04). The result demonstrates the qualitative benefits and financial returns of using *Gmelina arborea* leaf meal; with rabbits on diet T_4 having the highest ratio and diet T_1 has the lowest value (1:1.99). This entails an expected revenue of N4.04 for every N1 cost on investment for animals on diet T_4 diet. This result also suggest that the optimum level of inclusion of GALM in the diet of rabbits may not have been attained and perhaps incremental level beyond 30% level may still yield higher cost benefit ratio beyond the value recorded for T_4 in this trial. That, however, would be determined by future investigation.

Conclusion

The inclusion of *Gmelina arborea* leaf meal (GALM) in the diets of growing rabbits enhanced feed intake, weight gain, feed conversion ratio, carcass characteristics and cost benefit ratio when compared with the control. The least cost of production was achieved on rabbits fed 30% GALM.

Acknowledgments

The authors are also grateful to the Department of Animal Production Technology, Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria, for the technical support.

Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

References

Adegun, M. K., & Aye, P. A. (2013). Growth performance and economic analysis of West African Dwarf Rams fed Moringa oleifera and cotton seed cake as protein supplements to Panicum maximum. *Am. J. Food. Nutr*, *3*(2), 58-63.

Akinmutimi, A. H., Okoro, U. I., & Abasiekong, S. F. (2006). Effects of Quantitative Replacement of Soya Bean meal with Raw Sword Bean (Canavalia gladiata) Meal in Grower Rabbit Diets. *Journal of Animal and Veterinary Advances*. *5,* 695-698.

Amata, I. A., & Lebari, T. A. (2012). Comparative evaluation of the amino acid profile and anti-nutritional content of the leaves of four selected browse plants in the tropics. *International Journal of Plant, Animal and Environmental Sciences*, *2*(1), 107-111.

Ani, A. O. (2008). The feeding value of processed velvet bean (Mucuna pruriens) for pullet chicks. *Agro-Science*, *7*(2), 149-155.

Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics*, *11*(1), 1-42.

Fielding, D. (1991). Rabbits: the Tropical Agricultural Series. Macmillan Education Ltd. London, UK.

Gaafar, H. M. A., Ragab, A. A., & El-Reidy, K. F. A. (2014). Effect of diet supplemented with pumpkin (*Cucurbita moschata*) and black seed (*Nigella sativa*) oils on performance of rabbits: 1- Growth performance, blood haematology and carcass traits of growing rabbits. *Report and Opinion*, *6*, 52- 59.

Idowu, O. M. O., Sogunle, O. M., Idowu, O. A., Jegede, A. V., Alabi, E. E., Adenugba, A. O., & Bamgbose, A. M. (2006). Performance and carcass characteristics of weaner rabbits fed diets containing cassava root peel and cassava root sievate. *Trop. J. Anim. Sci*, *9*(1), 81-87.

Jiwuba, P. C., & Ezenwaka, L. C. (2016 b). Growth performance and apparent nutrient digestibility of West African dwarf goats fed β-carotene cassava peel-centrosema leaf meal based diets. *Case Studies Journal, 5*(8), 204-2010.

Jiwuba, P. C., Ahamefule, F. O., Ogbuewu, I. P., & Ikwunze, K. (2017). Blood chemistry and haematology of West African Dwarf goats fed Moringa oleifera leaf meal (MOLM) in their diet. *Comparative Clinical Pathology*, *26*(3), 621-624. DOI: 10.1007/s00580-017-2434-2

Jiwuba, P. C., Ugwu, D. O., Kadurumba, O. E., & Dauda, E. (2016). Haematological and serum biochemical indices of weaner rabbits fed varying levels of dried Gmelina arborea leaf meal. *International Blood Research & Reviews*, *6*, 1-8.

Jiwuba, P. C. (2018). Effect of pawpaw (Carica papaya) leaf meal on productive parameters of growing rabbits. Agricultural science and technology, 10(2), 102-106. DOI: 10.15547/ast.2018.02.022.

Jiwuba, P. C., Ogbuewu, I. P., & Nwachukwuguru, K. (2018). Performance and economy of production of broilers fed Siam weed (Chromolaena odorata) leaf meal (SWLM). *Tropical animal health and production*, *50*(6), 1305-1311. (Springer). https://doi.org/10.1007/s11250-018-1559-x.

Kumaresan, P., Jeyanthi, K. A., & Kalaivani, R. (2014). Biochemical evaluation of anti diabetic activity of aqueous extract of Gmelina arborea in Alloxan induced albino rats. *International Journal of Herbal Medicine*, *2*(2), 90-94.

Lebas, F. (2002). Role of dietary fibre in rabbit nutrition and in digestive troubles prevention. 2d Rabbit Congress of the Americas, Habana City, Cuba, June 19-22.

Nkwocha, G. A., Agbabiaka, L. A., Beketin, T. O., & Anukam, K. U. (2014). Effect of graded levels of Gmelina arborea leaf meal on the performance of grower rabbits. *International Journal of Agriscience*, *4*(7), 370-373.

Offor, C. E. (2014). Phytochemical and proximate analyses of dry Gmelina arborea leaves. *Int. J. Curr. Res. Acad. Rev*, *2*, 101-105.

Ogbuewu, I. P., Okoli, I. C., & Uwaezuoke Iloeje, M. (2009). Semen quality characteristics, reaction time, testis weight and seminiferous tubule diameter of buck rabbits fed neem (Azadirachta indica A. Juss) leaf meal based diets. *International Journal of Reproductive BioMedicine*, *7*(1), 23-28

Ogunsipe, M. H., Agbede, J. O., & Adedeji, O. A. (2014). Performance response, carcass evaluation and economic benefit of rabbits fed sorghum offal-based diets. *African Journal of Food, Agriculture, Nutrition and Development*, *14*(1), 8585-8601.

Okagbare, G. O., Akpodiete, O. J., Esiekpe, O., & Onagbesan, O. M. (2004). Evaluation of Gmelina arborea leaves supplemented with grasses (Panicum maximum and Pennisetum purpureum) as feed for West African Dwarf goats. *Tropical animal health and production*, *36*(6), 593-598..

Pathala, D., Harini, A., & Hegde, P. L. (2015). A review on gambhari (Gmelina arborea Roxb.). *Journal of Pharmacognosy and Phytochemistry*, *4*(2). 127 – 132

Shaahu, D. T., Carew, S. N., & Dzungwe, N. E. (2014). Effect of using raw or processed lablab seed as major protein source in diets on the economic of feeding and growth performance of rabbits. *Journal of Agriculture and Veterinary Science*, *7*(5), 22-26.

Vijay, T., Rajan, M. D., Sarumathy, K., Palani, S., & Sakthivel, K. (2011). Cardioprotective, antioxidant activities and Phytochemical analysis by GC-MS of Gmelina arborea (GA) in Doxorubicin-induced myocardial necrosis in Albino rats. *Journal of Applied Pharmaceutical Science*, *1*(05), 198-204.

AOAC. (2000) Association of Official Analytical Chemists: Official Methods of Analysis. 6th Edition. Washington DC, USA.