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Effect of rations with fresh leaves of *Gmelina arborea* on growth performance and organ weights of rabbit bucks

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Abstract. *Thirty rabbit bucks of mixed breeds (New Zealand white x Chinchilla) with average live weight of 852g, aged between 12 and 14 weeks were subjected to a feeding trial for 14 weeks, to determine the effects of diets with different ratio concentrate to fresh leaves of Gmelina arborea (FLGA) on growth performance, relative carcass weight and relative organ weights of rabbit bucks. The rabbits were randomly allocated into five treatments: Treatment 1-T1 (100g concentrate /C/: 0g FLGA), Treatment 2-T2 (75g C: 25g FLGA), Treatment 3-T3 (50g C: 50g FLGA), Treatment 4-T4 (25g C: 75g FLGA) and Treatment 5-T5 (00g C: 100g FLGA). The results obtained in this study showed that all the growth performance parameters and relative carcass weights differed significantly (P<0.05) across treatments. Apart from relative liver and lungs weights, which differed significantly (P<0.05) across treatments, other viscera organs were not affected by the dietary treatments. The results revealed that rabbit bucks in T2 and T3 performed better, rabbits in T4 performed the least, while rabbit bucks in T5 could not survive beyond two weeks. Concentrate to FLGA at the ratios of 75g C: 25 FLGA (T2) and 50g C: 50g FLGA (T3) are therefore, recommended as the best combinations for rabbit breeding bucks.*

Keywords: fresh leaves of *Gmelina arborea*, rabbit bucks, growth parameters, relative carcass and viscera organ weight

Introduction

Low protein intake can lead to diseases such as mental retardation and poor development of a child. Nigerians are constantly faced with the problem of low animal protein intake which has influence on the general well-being and health of the ever-increasing population (Onyimonyi and Ene, 2003). According to FAO (2005) livestock production is increasing at the rate below 5% while human population is increasing at the rate above 10%. Nigeria as one of the developing nations with high population is not an exception to this global phenomenon. Previous report by CBN (1993) has shown that North America, Western and Eastern European countries consume 66, 39 and 33g of animal protein/head/day, respectively. Whereas in African countries, FAO (2006) estimated the average animal protein consumption in Nigeria to be 7.4g per capita/day as compared to 38g per capita/day of animal protein consumed in South Africa. Inadequate supply of proteins from such traditional livestock as cattle, goat, sheep, pig and poultry has led to a shift of emphasis towards enhanced productivity of these animals. As a contingent plan, the search for more economical source of animal proteins makes rabbit production attractive (Egbo et al., 2001).

Rabbits have a number of attributes such as short generation interval, high fecundity, rapid growth rate, genetic diversity, ability to utilize forages, high quality proteins, low cost management requirements, adaptation over a wide range of ecological environment which enhance its production (Nkwocha et al., 2014). Ojebiyi et al. (2010) reported that rabbit has a peculiar digestive physiology which permits the use of forages and agro-industrial by-products, thus making it a non-competitive species with man for cereals and legume grains. Rabbits fit well into a balanced farming system and also complement well with vegetable growing. Excess and waste from vegetable gardens and kitchen goes to feed the rabbits, whereas their manure is used to fertilize gardens, thus forming a profitable cycle and aiding the balance of nature (Moreki, 2007). These qualities of the animal species, besides more others, make rabbit breeding one of the solutions for animal protein deficiency countries (Obike et al., 2010; Bud et al., 2011; Blaga and Burny, 2014).

In spite of these advantages over other livestock, feed cost and scarcity still limit profitable rabbit production in the country. Aduku (2004) reported that the cost of feed accounts for about 80% of the total cost of production of farm animals. This is because unavailability of grains and high cost of feed ingredients have made the price of animal feed to increase. This constitutes problems to the expansion of commercial rabbit production in Nigeria. The scarcity and high prices of feedstuffs have led animal nutritionists and researchers to look for alternative, unconventional, and cheap sources of feeding materials (Esonu et al., 2005; Oluremi et al., 2007).

Studies have shown that rabbits can thrive on a number of tropical forages supplemented with concentrates (Ojewola et al., 1999; Adeyemo et al., 2014). Such forages are cheap, abundant and available in many parts of Nigeria (Yusuf et al., 2009). One of such forages is *Gmelina arborea*, which is common found in many parts of Nigeria. It is under-utilized by man, which may help to reduce cost of production and establish a sustainable livestock development in Nigeria, especially in areas with a prolonged dry season (Nkwocha et al., 2014).

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Gmelina arborea is a medium-sized tree up to 30-40m tall; bole (trunk) with average diameter 50cm but sometimes reaching 140cm. The leaves contain nutrients that can support both ruminant and non-ruminant nutrition. Annongu and Folorunso (2003) reported that *Gmelina arborea* fruit meal when processed and at 30% dietary inclusion in pig's ration has no adverse effects on haematology and serum biochemical analysis of the animals. Okafor et al. (2012) revealed that goat bucks fed supplemental forages containing 50% *Gmelina arborea* leaves inclusion recorded the highest dry matter intake, live weight gain, the highest protein digestibility and nitrogen retention. Adeniji et al. (2012) reported that *Gmelina arborea* leaf meal could be fed to grower rabbits up to 40% inclusion level without adverse effect on growth performance.

Fresh leaves of *Gmelina arborea* have not been exploited adequately as forage for rabbits. Besides, there is inadequate information on the nutritional effects of fresh leaves *Gmelina arborea* on growth performance of male rabbits. Effective growth performance is necessary for optimal production and profitability of rabbits. Therefore, this study was designed to investigate the effect of different ratio concentrate with fresh leaves of *Gmelina arborea* on the growth performance of rabbit bucks.

Material and methods

Study area

The experiment was carried out at the Rabbitry unit of Livestock Teaching and Research Farm, University of Agriculture, Makurdi, Nigeria. Makurdi is located on latitude 7°14 North and longitude 8°21 East, which lies within the Southern Guinea Savannah region of Nigeria. The daily temperature ranges between 24 to 36°C and high temperature is experienced between late February and April. Annual rainfall ranges from 508 to 1016mm (TAC, 2009).

Source of Gmelina arborea leaves

Fresh and succulent leaves of *Gmelina arborea* were collected from Gmelina trees within Makurdi Local Government Area (LGA) of Benue State, Nigeria. The fresh leaves of *Gmelina arborea* were slightly chopped for easy handling and consumption by the rabbits.

Experimental diets

Five dietary treatments consisting of concentrate /C/ (g) to fresh leaves *Gmelina arborea* /FLGA/ (g) were weighed and fed to the rabbit bucks in the following ratios:

- Treatment 1 (T_1) - 100g C : 00g FLGA;
- Treatment 2 (T_2) - 75g C : 25g FLGA;
- Treatment 3 (T_3) - 50g C : 50g FLGA;
- Treatment 4 (T_4) - 25g C : 75g FLGA;
- Treatment 5 (T_5) - 00g C : 100g FLGA.

The composition of the concentrate feed is presented in Table 1.

Table 1. Composition of the concentrate feed

Ingredients	%
Maize	43.70
Soybean meal	29.30
Rice offal	23.00
Bone meal	3.00
Vitamin premix	0.50
Salt	0.30
Methionine	0.20
Total	100.00
Calculated nutrients composition	
Crude protein	18.20
Crude fibre	10.68
Ether extract	4.85
Calcium	1.19
Lysine	0.94
Phosphorus	0.55
Methionine	0.48
Metabolizable energy (Kcal/kg)	2512.21
Proximate nutrients composition	
Crude protein	20.03
Crude fibre	10.73
Ether extract	4.23
Ash	9.01
NFE	56.00
Metabolizable energy (Kcal/kg)	3075.12

Experimental animals and design

A total of 30 rabbit bucks of mixed breeds (New Zealand white x Chinchilla) with average live weight of 852g, aged 12 to 14 weeks were obtained from local farmers around Makurdi and Gboko area of Benue State. The rabbits were housed individually in hutches (wire mesh cages, 60x50cm) raised 60cm above the ground level in an open sided shade for proper ventilation. The hutches were cleaned and disinfected few days before the arrival of the rabbits. A drinker and feeder were fitted in each hutch to curtail water and feed wastage. The rabbits were given 2-week adaptation period before the commencement of the experiment during which they were treated for both ecto- and endo-parasites using Ivermectin (0.2 mg/kg body weight) as reported by Pius et al. (2019).

Experimental procedure

After a 2-week adaptation period, the 30 rabbit bucks were weighed and randomly assigned to 5 dietary treatments with different ratio concentrate to fresh leaves of *Gmelina arborea* combinations, respectively. The feeds were weighed according to the ratios in grams (g) and administered to the animals daily after cleaning the hutches, feeders and washing of drinkers. Water was supplied *ad-libitum*. Weight gain was determined on a weekly basis. At the end of 14th week of the feeding trial, 3 rabbits from each treatment were starved for 24 hours and sacrificed according to requirements on the protection of animals at the time of killing (Council Regulation /EC/ No. 1099/2009). Then, the carcass weights of the animals were determined (Pius et al., 2019).

Growth performance indices

The growth performance of the experimental rabbits was determined using the feed intake, body weight gain and FCR parameters.

- Body Weight Gain (BWG): The animals were weighed at the beginning of the experiment and on weekly basis. The body weight gain was determined by the difference established;
- Feed Intake (FI): Feed intake was determined by subtracting the left-over/unconsumed feed from the total feed offered;
- Feed Conversion Ratio (FCR): This was calculated as the ratio of feed intake to body weight gain:

FCR = Feed Intake / Weight gain.

Carcass yield

At the end of the feeding trial, 3 rabbits per treatment (15 rabbits) were slaughtered and the carcasses evaluated. Slaughtering was done after the rabbits were starved for 24 hours without water restriction, in order to reduce the volume of gut contents and contamination of the carcass during dressing. Each rabbit was weighed to obtain the fasted live weight before slaughter. The rabbits were stunned after which a sharp knife was used to cut the jugular vein then allowed for proper bleeding. The carcasses were eviscerated, singed, washed and weighed.

The visceral (internal) organs such as the heart, lungs, kidneys, liver, spleen and adrenal glands were carefully removed and weighed using a sensitive electronic weighing scale.

Dressing Percentage = (Dressed weight / Live weight).100, %.

Statistical analysis

Data collected were subjected to One Way Analysis of Variance (ANOVA) using Minitab Statistical Software (Minitab, 2010). Where significant differences occurred among treatment means, they were separated using Duncan's Multiple Range Test of the same statistical package.

Results and discussion

Result on growth performance characteristics of rabbit bucks fed diets with different ratio concentrate to fresh leaves of *Gmelina arborea* are presented in Table 2. The results revealed that the diets had significant (P<0.05) effects on final live weight, body weight gain, daily feed intake. The rabbits fed diet T5 could not survive beyond two weeks of starting the treatment. The mortality ranged between 16.67% and 100%. The highest mortality rate (100%) was recorded in T5, while T1, T2 and T3 had the lowest mortality rate (16.67%).

Table 2. Growth performance characteristics of rabbit bucks fed diets with different ratio concentrate to fresh leaves of *Gmelina arborea*

Parameters	T1 (n=3)	T2 (n=3)	T3 (n=3)	T4 (n=3)	T5 (n=3)	P-value
Initial live weight (g)	828.7±90.4	860.0±46.2	812.7±47.9	899.3±91.0	859.0±123.0	_
Final live weight (g)	1544.0±152.0^{a}	1672.0±165.0^{a}	1414.7±80.0^{ab}	1178.0±91.4^{b}	_	0.04
BWG (g)	715.0±76.6^{a}	812.3±143^{a}	602.0±48.30^{a}	241.3±31.1^{b}	_	0.01
DWG (g)	7.30±0.78^{a}	8.29.23±1.46^{a}	6.14±0.49^{a}	2.46±0.31^{b}	_	0.01
DFI (g)	63.19±0.88^{a}	64.25±2.66^{a}	52.02±0.63^{b}	40.60±1.03^{c}	_	0.00
FCR	8.85±0.88^{a}	7.88±1.49^{a}	8.58±0.65^{a}	17.01±2.09^{b}	_	0.01
Mortality (%)	16.67	16.67	16.67	50.00	100.00	_

*T1, T2, T3, T4 and T5 - experimental diets; the incomplete data for T5 is because the rabbits fed T5 could not survive beyond 2 weeks of the experimental trial; ^{a,b,c}= means with different superscripts in the same row are significantly different (P<0.05); ± Standard Error of Mean; BWG= Body Weight Gain, DWG= Daily Weight Gain, DFI= Daily Feed Intake, FCR= Feed Conversion Ratio; n-total number of samples collected after slaughtering.

The weekly growth rate curves of rabbit bucks fed diets with different ratio concentrate to fresh leaves of *Gmelina arborea* are represented in Figure 1. Treatment 2 (T2) recorded the highest growth rate, while T4 had the lowest.

Data on relative carcass weights of rabbit bucks fed diets with different ratio concentrate to fresh leaves *Gmelina arborea* are presented in Table 3. The results revealed that the diets had significant (P<0.05) effects on eviscerated weight, singed weight and dressing percentage among treatments. Treatments 1, 2 and 3 were similar, and differed significantly from T4. Treatment 1 recorded the highest value for dressing percentage, while T4 recorded the lowest value for dressing percentage.

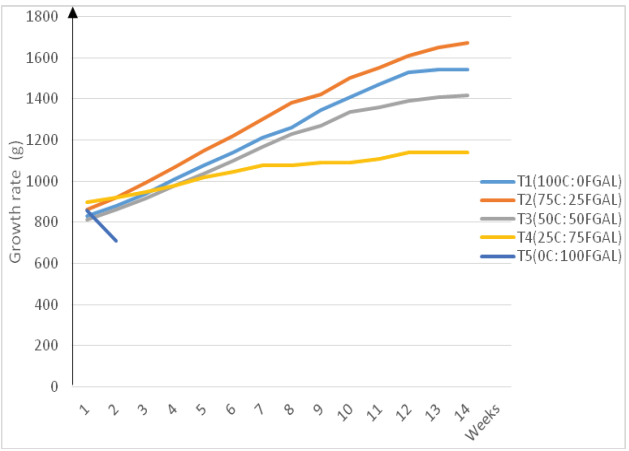

Figure 1. Weekly growth rate curves of rabbit bucks fed diets with different ratio concentrate to fresh leaves of *Gmelina arborea*

Table 3. Relative carcass weights (%) of rabbit bucks fed diets with different ratio concentrate to fresh leaves of *Gmelina arborea*

Parameters (%)	T1 (n=3)	T2 (n=3)	T3 (n=3)	T4 (n=3)	P-Value
Fasted live weight	1486.7±140.0^{ab}	1626.0±158.0^{a}	1449.0±105.0^{ab}	1140.7±60.0^{b}	0.02
Eviscerated weight	79.26±0.55^{a}	78.78±1.29^{a}	76.49±4.16^{ab}	65.91±4.99^{b}	0.01
Singed weight	70.70±1.01^{a}	69.82±0.85^{a}	67.76±2.69^{a}	51.42±5.76^{b}	0.01
Dressing percentage	60.66±1.14^{a}	59.80±1.51^{a}	56.67±2.38^{a}	40.20±5.89^{b}	0.01

*T1, T2, T3, and T4 - experimental diets; there are no data for T5 because the rabbits fed diet T5 could not survive beyond 2 weeks of the experimental trial; ^{a,b,c}= means with different superscripts in the same row are significantly different (P<0.05); ± Standard Error of Mean; n-total number of samples collected after slaughtering.

Results of the relative organ weights of rabbit bucks fed diets with different ratio concentrate to fresh leaves of *Gmelina arborea* are presented in Table 4. The results showed that the diets had no significant influence on heart, kidney, spleen and adrenal glands weights. Significant (P<0.05) differences were observed on lungs and liver weights. The highest relative liver weight was observed in T4, while T1 recorded the lowest value.

Table 4. Relative organ weights (%) of rabbit bucks fed concentrate to fresh diets with different ratio concentrate to fresh leaves of *Gmelina arborea*

Parameters (%)	T1 (n=3)	T2 (n=3)	T3 (n=3)	T4 (n=3)	P-Value
Heart weight	0.22±0.01	0.20±0.02	0.20±0.01	0.24±0.04	0.70
Lungs weight	0.68±0.04^{ab}	0.54±0.10^{b}	0.78±0.11^{ab}	0.82±0.01^{a}	0.01
Spleen weight	0.02±0.00	0.03±0.01	0.03±0.01	0.04±0.01	0.74
Liver weight	1.94±0.14^{c}	2.59±0.04^{ab}	2.47±0.24^{bc}	3.12±0.24^{a}	0.01
Paired kidney weight	0.44±0.07	0.60±0.05	0.54±0.04	0.70±0.10	0.14
Paired adrenal weight	0.02±0.01	0.02±0.01	0.02±0.03	0.02±0.00	0.95

*T1, T2, T3, and T4 - experimental diets; there are no data for T5 because the rabbits fed diet T5 could not survive beyond 2 weeks of the experimental trial;^{a,b,c}= means with different superscripts in the same row are significantly different (P<0.05); ± Standard Error of Mean; n-total number of samples collected after slaughtering.

Growth performance characteristics of rabbit bucks

The reduced final live weight was observed in T4 (25g C:75g FLGA), this components ratio suggests that the diet does not favour rabbits' growth performance. There was no record for final weight in T5 because the rabbit bucks could not survive beyond two weeks of the feeding trials. Bamikole and Ezenwa (1999) reported that feeding rabbits solely on some forage species in the tropics has resulted in negative effect, in terms of weight loss. However, studies have shown that rabbits can be raised on cheap and readily available forages (Linga and Lukefahr, 2000; Ironkwe and Ukanwoke, 2016). This study revealed that, as the percentage of FLGA increases in the dietary treatments, body weight gain decreases. The reduced body weight gain recorded in T4 could be attributed to high percentage of FLGA in T4 (25g C : 75g FLGA). This agrees with the report of Ironkwe and Ukanwoke (2016) that rabbits' performance on the mixture of concentrate and forage depends on the type of forage and the level of combinations with concentrate. The body weight gain obtained in this study as shown in Table 2, was below the range of 540.31 to 927.53g and 512.5 to 1000g as reported by Adeyemo et al. (2014) and Ironkwe and Ukanwoke (2016), respectively. The highest value for body weight gain recorded in T2 (75g C: 25g FLGA) contradicts the results of Adeyemo et al. (2014) and Ironkwe and Ukanwoke (2016) who recorded the highest values for body weight gain at T3 (50C: 50FLGA) and T1 (100C: 0FLGA), respectively, using concentrate to forage combinations on rabbits. The significant decrease in average daily weight gain in T4 may also be attributed to low feed intake. Similarity exists between the daily feed intake in treatments T1 and T2, which was significantly (P<0.05) higher than treatments T3 and T4 with the least values. The result obtained on daily feed intake, is lower than the ranged values (65 to 71g) reported by Nwocha et al. (2014). The significant decrease in daily feed intake in T4 may be due to the high percentage inclusion of FLGA as compared to T2 with low percentage of FLGA. Iyeghe-Erakpotobor and Muhammad (2008) reported that for rabbits to perform well on forage diets, they need to consume the forages in significant amounts. Further reports revealed that tannin as an anti-nutritional factor in *G. arborea,* decreases protein quality, reduces digestibility and palatability (Amata and Iwelu, 2012). These might be the reasons for low levels of FLGA intake in T3 and T4. However, Adeyemo et al. (2013) affirms that inclusion of forage in the diet of rabbit is also needed to enhance feed intake. Though, it was observed that more concentrate was consumed than FLGA. It therefore, suggests that the concentrate was more palatable. It also appears that the odour and taste of the test feed (FLGA) may have created a palatability problem which has affected the level of consumption (Ogbuewu, 2008). The result obtained for feed conversion ratio as shown in Table 2, is above the range of 4.53 to 7.71; 9.20 to 11.71 as reported by Adeyemo et al. (2014) and Ahemen et al. (2016), respectively. This may be attributed to ages of the rabbits used in the study. Treatment 2 had the best value for feed conversion ratio among treatments. Amata and Okorodudu (2013) found that growth performance of rabbits depends largely on their ability to obtain and digest feed effectively. The elevated value observed for feed conversion ratio in treatment T4 may be attributed to poor consumption and

utilization of the test feed. It could imply that the percentages of the test ingredient at T2 (75g C: 25g FLGA) and T3 (50g C: 50g FLGA) support better growth performance of rabbit bucks.

The results for weekly growth rate in Figure 1 corroborate the better growth performance of rabbit bucks at T2 and poor performance at T4.

Relative carcass weights (%) of rabbit bucks

All the relative carcass weights differed significantly ($P<0.05$) among treatments. The differences observed for fasted live weight and dressing percentage agree with the report of Adeyemo et al. (2014) who also observed differences on fasted live weight and dressing percentage in their studies on performance and carcass characteristics of growing rabbits fed concentrate to forage ratio. The authors state that dressed weight is an important index of carcass characteristics because the higher the value, the greater the degree of meatiness and its economic value. This suggests that high percentage of FLGA in combination with concentrate in T4 (25g C: 75g FLGA) did not support deposition of tissues in rabbit bucks. The significant decrease in values for dressed weight and dressing percentage in T4 may also be attributed to decrease in feed intake due to poor palatability of the FLGA.

Relative organ weights (%) of rabbit bucks

The results obtained for relative heart and kidney weights in this study, compared favourably with that of Ogbuewu (2008) who also reported similarities for both heart and kidney weights, when rabbit bucks were fed graded levels of Neem (*Azadirachta indica*) leaf meal. The similarities observed in the relative heart, spleen, paired kidney and adrenal weights imply that these organs were not adversely affected by the dietary treatments. The differences observed for relative lungs and liver weights agree with those of Adeyemo et al. (2014), who established significant differences on relative lungs and liver weights, though with a slightly higher values (0.67 to 1.06% and 2.79 to 4.08%), respectively, when rabbits were fed with concentrate and forage at different ratios. Liver as the most tolerant and vital organ in the mammalian body has numerous functions such as detoxification of various metabolites, protein synthesis and the production of biochemical necessary for digestion to impact all the body systems (Malarkey et al., 2005). Taub (2004) reported that Kupffer cells are resident macrophages in liver, which are essential for the phagocytosis of foreign particles, infecting organisms as well as cytokine products. Thus, the significant increase in relative liver weight at T4 with high percentage of FLGA may be attributed to phytochemical effect of the test feed, which might have triggered excessive division of the liver cells in order to neutralize toxic substances. It could also mean that the liver was over stretched in response to the effect of anti-nutritional component of the test feed, which resulted in increase in the relative weight of the liver as the percentage of the test ingredient increased.

Conclusion

The results obtained in this study showed that a combination of concentrated fodder to 25% with fresh leaves of *Gmelina arborea* does not adversely affect the rabbit bucks' growth characteristics and the development of their internal organs and could be recommended for the rations of rabbits.

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