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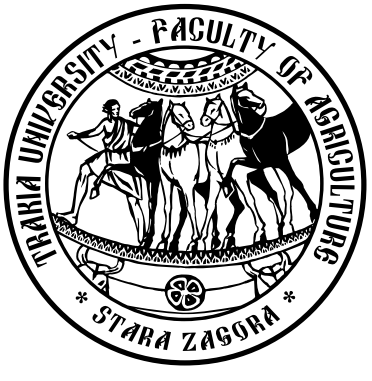

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Effect of rations with fresh leaves of *Gmelina arborea* on some reproductive parameters of rabbit bucks

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Abstract. *Thirty (30) 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 semen characteristics, testicular and epididymal morphometry 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-T3 3 (50g C: 50g FLGA), Treatment 4-T4 (25g C: 75g FLGA), Treatment 5-T5 (00g C: 100g FLGA). The results obtained showed that sperm motility, concentration and percentage of live sperm cells showed significant effects (P<0.05), while semen volume and percentage of normal sperm cells were not significantly affected by the test diets. Rabbits on T4 did not ejaculate within the experimental period. Mean testis density was not significantly affected, while paired testes weight, mean testis length, paired testes volume, paired epididymal weight and mean epididymal length were significantly (P<0.05) influenced by the dietary treatments. The results revealed that rabbit bucks on T2 and T3 performed better, rabbits on T4 performed least, while rabbit bucks in T5 could not survive beyond two weeks. Concentrate to FLGA at the ratios of 75g C: 25g 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, semen characteristics, testicular and epididymal morphometry

Introduction

Nutritional diseases like mental retardation and kwashiorkor are attributed to low protein intake. 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. 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 their production (Nkwocha et al., 2014; Dermendzhieva et al., 2017). 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 non-competitive species with man for cereals and legume grains. These qualities of the species, besides more others, make rabbit breeding one of the solutions for protein deficiency countries (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) established that the cost of feed accounts for about 80% of the total cost of production of farm animals. This is because unavailability of grain and the 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*, commonly 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).

Gmelina arborea is a medium-sized tree up to 30-40m tall;

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bole with an average diameter 50cm but sometimes reaching 140cm. The leaves contain nutrients that can support both ruminant and non-ruminant nutrition. Nkwocha et al. (2014) suggested that *Gmelina arborea* leaf meal could be incorporated in the ration of grower rabbits up to 10% to reduce cost and enhance profitability. Ahemen et al. (2016) reported that inclusion of *Gmelina arborea* leaf meal in rabbit diet has no negative effect on the reproductive organs dimensions. The authors further suggested that *Gmelina arborea* leaf meal up to 15% inclusion in diet might support normal reproduction in male rabbits.

Reproductive inefficiency is a serious constraint to efficient rabbit production in the tropics (Gbadamosi and Egbunike, 1999). The efficiency of sperm production, libido and quality of sperm tend to remain uniform throughout the reproductive life of an animal, but may be significantly altered by age, nutrition, environment, health status, drugs, and chemicals (Togun and Egbunike, 2006). The reproductive performance of the male could be measured using sperm characteristics, testicular morphology, testicular histomorphometry, testicular and epididymal sperm reserves (Ogbuewu et al., 2009; Ahemen et al., 2013).

Fresh leaves of *Gmelina arborea* have not been exploited adequately as a forage for rabbits. Unfortunately, there is inadequate information on the nutritional effects of fresh leaves of *Gmelina arborea* on reproductive performance of male rabbits. Good reproductive performance is necessary for optimal production and profitability of rabbits. Opara et al. (2012) stated that as the quest for unconventional and cheap sources of feedstuffs for livestock continues, it becomes imperative to always investigate the health and physiological implications of such materials on animals. Therefore, this study was designed to evaluate the effect of ratio concentrate with fresh leaves of *Gmelina arborea* on semen characteristics, testicular and epididymal morphometry of rabbit bucks.

Material and methods

Study area

The experiment was carried out at the Rabbitry unit of Livestock Teaching and Research Farm, Federal 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 of Benue State. 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 of Gmelina arborea - FLGA (g) were weighed and fed to the rabbit bucks in the following ratios:

- Treatment 1 (T1) - 100g C : 00g FLGA;
- Treatment 2 (T2) - 75g C : 25g FLGA;
- Treatment 3 (T3) - 50g C : 50g FLGA;
- Treatment 4 (T4) - 25g C : 75g FLGA;
- Treatment 5 (T5) - 00g C : 100g FLGA.

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

Table 1. Composition of the concentrate feed

Ingredients	%
Maize	43.7
Soybean meal	29.3
Rice offal	23.0
Bone meal	3.0
Vitamin premix	0.5
Salt	0.3
Methionine	0.2
Total	100.0
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	512.21
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 an average live weight of 852g, aged 12 to 14 weeks were obtained from local farmers around Makurdi and Gboko areas of Benue State. The rabbits were housed individually in hutches (wire mesh cages) measuring 60cm x 50cm and 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 acclimatized for two weeks 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).

Experimental procedure

After 2-week adjustment period, the 30 rabbit bucks were

weighed and randomly assigned to 5 dietary treatments with the ratios of 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 of the hutches, feeders and washing of drinkers. The rabbits were fed for 14-weeks with the experimental rations. Water was supplied ad-libitum. Weight gain was determined on a weekly basis. Semen was collected at 13th week. 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). Thereafter, reproductive characteristics of the animals were determined.

Semen collection and evaluation

The semen was collected during cool hours of the day between 8:00am and 9:30am using fabricated artificial vagina (AV), to ensure optimum quality semen. The AV was basically made of polyvinyl chloride tube with external and internal diameter of 27.5mm and 21.7mm, respectively and a length of 37.9mm. Two rubber latex condoms were used, one as the liner and the other as the collecting tube.

The tip of the liner was cut off in order to create room to overturn it into the other end of the AV. The one side of the AV was held in place by a rubber band folded 5 times for a tight grip. Glycerol was poured into the space between the inner part of the AV and the liner was gradually pulled until it was three-quarter filled. The other end of the liner was then turned over the end of the AV and held in place by a rubber band folded 5 times to ensure a firm grip. The collection tube was made from a rubber latex condom fixed to one of the ends of the AV.

Prior to the 13th week of the study, a 2-week training period was used to get the bucks to ejaculate with the aid of the AV. A matured cycling doe was used to tease the buck for proper semen collection, using the locally constructed AV. The AV was warmed by allowing it to stay for 10-15 minutes in warm water at 40°C obtained by using a clinical thermometer. Thereafter, the inner part of the AV was smeared with glycerol to reduce friction, before semen collection.

Semen was collected by inserting AV on the erectile penis of the buck before ejaculation as it mounted on the doe. A total of 3 ejaculates per each treatment were collected 3 times at 2-day intervals. The semen samples collected were analysed for semen characteristics such as semen volume, semen colour, sperm concentration, sperm motility, live sperm percentage and abnormal sperm percentage, as described by Herbert and Adejumo (1995).

Semen volume and colour

As soon as semen was collected from the rabbit bucks, it was emptied into a calibrated test tube from the artificial vagina to determine semen volume and colour. The volume of semen was viewed at an eye level and recorded. Thereafter, the semen colour was also determined through careful observation as reported by Campos et al. (2014).

Sperm motility

The sperm motility was determined as mass motility and progressive motility.

Mass motility

As soon as the semen was collected from the rabbit bucks, a drop of the semen was placed on a pre-warmed glass slide (37°C) and placed under a light microscope at x 40 magnification. A wave motion (mass sperm motility) was determined by a mass sperm motility score. This mass sperm motility was scored objectively from 0 (no motion) to 5 (numerous rapid waves) on a scale with steps equal to 1 according to the original method described by Evans and Maxwell (1987).

Progressive motility

A drop of the semen was placed on a pre-warmed glass slide (37°C) with a cover slip and placed under a light microscope at x 40 magnification as the sperm progressive motility was observed and scored objectively, according to the procedures outlined by Omalaka (1992).

Sperm concentration

The sperm concentration was determined using a dilution factor of 1ml semen to 20ml normal saline solution (0.9% NaCl). A small sterile pipette was used to load few drops of the diluted semen into haemocytometer and was placed under the microscope for evaluation. A visual count of the sperm cells was made under the microscope using an improved Neubauer haemocytometer as described by Ahemen et al. (2013).

Live sperm percentage

The differential staining (one drop of semen was mixed with a drop of nigrosin-eosin) which was smeared on a slide and few minutes later observed under the microscope for the determination of the total live sperm cells. The unstained cells represented the live cells while the stained cells showed the dead ones as reported by Ahemen et al. (2013).

Abnormal sperm percentage

From the stained smear, shapes of the spermatozoa were examined under the microscope to investigate the proportion of abnormal cells. From the examination, it was observed that abnormal cells did not show progressive motility. The higher the number of abnormal cells, the lower the percentage of motile sperms as reported by Ogbuewu (2008).

Testicular and epididymal measurements

The scrotal sacs were incised to exteriorize the testes. The various reproductive tract components such as: testis and epididymis were separated, trimmed free of fats and linear measurements taken with the aid of a calibrated ruler. The weights of testes and epididymides were also determined using electronic weighing balance. The volume of each testis was recorded, using Archimedes Principle of water displacement as reported by Ahemen et al. (2016). The density of testis was calculated as testes weight (g) / testes volume (ml).

Statistical analysis

The 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

Data on semen characteristics of rabbit bucks fed diets with different ratio concentrate to fresh leaves of *Gmelina arborea* are presented in Table 2. There are no data in T4 and T5 because the rabbits fed by diet T4 did not ejaculate within the experimental period and rabbits fed by diet T5 could not survive beyond 2 weeks of starting the treatment. The results obtained show that the diets T1, T2 and T3 had no significant effects (P>0.05) on semen volume and normal sperm of the rabbit bucks. Significant differences (P<0.05) were observed on mass motility, progressive motility, semen concentration and live sperm.

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

Parameters	T1 n=9	T2 n=9	T3 n=9	P-Value
Semen colour	Creamy white	Creamy white	Creamy yellow	-
Semen volume (ml)	1.50±0.12	1.43±0.23	1.73±0.09	0.43
Mass motility	3.67±0.33^{a}	4.67±0.33^{a}	3.00±0.00^{b}	0.00
Progressive motility (%)	58.33±4.41^{ab}	65.00±2.89^{a}	55.00±2.89^{b}	0.00
Semen conc. (x 106/ml)	59.00±2.31^{b}	73.00±23.40^{a}	79.30±46.50^{a}	0.02
Live sperm (%)	85.00±1.53^{b}	90.00±1.53^{a}	85.00±2.31^{b}	0.00
Dead sperm (%)	15.00±1.53^{b}	10.00±1.53^{a}	15.00±2.31^{b}	0.00
Normal sperm (%)	89.33±2.03	90.67±0.88	88.33±2.67	0.72
Abnormal sperm (%)	10.67±2.03	9.33±0.88	11.67±2.67	0.72

*T1, T2 and T3 – experimental diets; There are no data for T4 and T5 because the rabbits fed by diet T4 did not ejaculate throughout the experimental period and T5 could not survive beyond 2 weeks of the experimental period;
$^{a, b, c}$ = means with different superscripts in the same row are significantly different at P<0.05;
± Standard Error of Mean; n=total number of ejaculates.

The results obtained for testicular and epididymal morphometry of rabbit bucks fed diets with different ratio concentrate to *Gmelina arborea* fresh leaves are presented in Table 3. The results showed that the diets had no significant effects on right testis weight and right testis volume. Significant differences (P<0.05) were observed for left testis weight, paired testis weight, mean testis length, left testis volume, paired testis volume and mean testis density. The diets had significant effects (P<0.05) on left and right epididymal weights, paired epididymal weights and mean epididymal length.

Table 3. Testicular and epididymal morphometry 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
Left testis weight, g	1.41±0.04^{a}	1.41±0.02^{a}	1.35±0.15^{a}	0.94±0.19^{b}	0.04
Right testis weight, g	1.39±0.08	1.42±0.04	1.39±0.11	0.97±0.24	0.14
Paired testis weight, g	2.82±0.10^{a}	2.84±0.04^{a}	2.74±0.25^{a}	1.91±0.43^{b}	0.04
Mean testis length, cm	3.02±0.25^{ab}	3.08±0.06^{a}	2.52±0.04^{ab}	2.27±0.21^{b}	0.02
Left testis volume, ml	1.47±0.03^{a}	1.30±0.15^{ab}	1.53±0.09^{a}	0.93±0.03^{b}	0.01
Right testis volume, ml	1.37±0.06	1.43±0.07	1.40±0.06	1.17±0.35	0.41
Paired testis volume, ml	2.83±0.09^{a}	2.73±0.14^{ab}	2.93±0.15^{a}	2.10±0.23^{b}	0.03
Mean testis density, g/ml	1.00±0.02^{a}	1.05±0.06^{a}	0.93±0.06^{ab}	0.91±0.17^{ab}	0.04
Left epididymal weight, g	0.46±0.09^{b}	0.88±0.21^{a}	0.57±0.01^{ab}	0.39±0.08^{b}	0.01
Right epididymal weight, g	0.53±0.03^{ab}	0.97±0.26^{a}	0.56±0.06^{ab}	0.40±0.08^{b}	0.01
Paired epididymal weight, g	1.00±0.12^{b}	1.85±0.47^{a}	1.13±0.06^{ab}	0.79±0.15^{b}	0.00
Mean epididymal length, cm	6.00±0.14^{a}	6.27±0.19^{a}	5.05±0.33^{b}	4.82±0.38^{b}	0.02

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

Semen characteristics of rabbit bucks

Semen colour for treatments 1 (T1) and 2 (T2) showed normal sperm colour of creamy-white, while treatment 3 (T3) produced semen with creamy yellow colour. According to Campos et al. (2014), the ejaculate is mostly milky-white, but the best quality is found in creamy-white semen. Chang (1959) revealed that yellowish semen is often contaminated with urine that is normally obtained when the temperature is too high in the artificial vagina, while other colours are regarded as poor. Treatment 4 (T4) could not ejaculate, apart from sniffing which is only an expression of *libido*. Luzi et al. (1996) observed that a restricted dietary protocol reduces *libido* and some seminal traits. Kamel and Attia (2011) revealed that semen characteristics can vary among different breeds and other factors, especially diet. This is corroborated by Osinowo (2006) who affirmed that under-nutrition delays puberty. However, Luzi et al. (1996) established that the most important factor is not the amount of diet furnished, but its chemical characteristics. Therefore, the inability of treatment 4 (25g C: 75g FLGA) to ejaculate may be attributed to delayed puberty caused by under-nutrition of the rabbit bucks. It could also mean that the chemical characteristics of the test diet may have affected the level of feed intake. Treatment 5 (0g C: 100g FLGA) could not survive beyond the second week of experimental trial due to inadequate feed intake. This implies that fresh leaves of *Gmelina arborea* as the sole feed does not support reproductive performance of rabbit bucks. The semen volume observed in this study was higher than the range (0.50 to 0.66ml) reported by Ogbuewu (2008), who also recorded non-significant influence on semen volume in rabbits fed graded levels of Neem (*Azadirachta indica*) leaf meal. The value for mass motility in T2 (75g C: 25g FLGA) means that the spermatozoa moved moderately fast with distinct swirl, while that of T3 (50g C: 50g FLGA) implies that the spermatozoa moved slowly with distinct swirl as described by Evans and Maxwell (1987). This implies that low percentage of FLGA in combination with concentrate in T2 (75g C: 25g FLGA) favours the activities of spermatozoa. The results on progressive sperm motility and sperm concentration were below the range (77.00 to 81.00 % and 156 to 163x10^6 /ml) reported by Abu et al. (2013) who observed similarities when rabbit bucks were fed *Moringa oleifera* leaf. Ogbuewu et al. (2009) established differences in both progressive sperm motility and sperm concentration which agree with the results in this study, though with lower sperm concentration range of 6.46 to 20.15 x 10^6 /ml, when rabbit bucks were fed graded levels of Neem (*Azadirachta indica*) leaf meal. Werner (2004) affirmed that 50% or more of the sperm cells should be moving. The significant increase observed in T2 implies active spermatozoa which could move progressively for effective fertilization as reported by Omalaka (1992). The significant increase observed in treatments 2 and 3 as compared to treatment 1 for semen concentration agrees with the report of Nwagwu and Nzeribe (2006) that feeding a combination of forage and concentrate is superior to feeding concentrate or forage alone with regards to the reproductive performance of rabbits. It, therefore, means that the significant increase observed for progressive sperm motility and sperm concentration at treatment 2 (75g C: 25g FLGA) may be attributed to the effect of test diets. Treatment 2 recorded the significant increase in live sperm cells as compared to treatments 1 and 3 with similar values. The range of values observed for live and dead sperm cells in this study, were similar to that of Abu et al. (2013) who reported 83.00 to 90.00% for live sperm and 10.00 to 17.00% for dead sperm cells, respectively. Arthur et al. (1975) reported that good semen samples should have less than 25% dead sperm cells or more than 75% live sperm cells. Therefore, the significant increase in live sperm cells at T2 (75g C: 25g FLGA) suggests viable spermatozoa and possibly higher fertilizing capacity in the rabbit bucks. The result for the normal spermatozoa agrees with the similarities observed by Ahemen et al. (2013). It was also observed that treatment 2 has numerically higher value for normal sperm than treatment 3, despite their similarities. Abnormal sperm values obtained in this study were within the normal values found by Kuzminsky et al. (1996) that for an acceptable ejaculate, the concentration of spermatozoa with curly tails should not exceed 17 to 18% of 200 cells observed. This result indicates that the spermatozoa produced were normal in the rabbit bucks up to treatment 3. It also agrees with the report of Ogbuewu (2008) that the higher the number of abnormal cells, the lower the percentage of motile sperm cells. The above results suggest that FGAL in combination with concentrate may support normal spermatogenesis of rabbit bucks in treatments 2 (75g C: 25g FLGA) and 3 (50g C: 50g FLGA).

Testicular and epididymal morphometry of rabbit bucks

Left and paired testis weights were affected by the dietary treatments. The result obtained in this study for paired testis weight was higher than the range (1.05 to 2.00g) reported by Amao and Oladele (2016), but lower than 4.41 to 4.61g found by Ogbuewu et al. (2009), who observed similarities in paired testis weight when rabbits were fed diets containing cotton seed cake supplemented with carrot or ginger and graded levels of Neem (*Azadirachta indica*) leaf meal, respectively. The differences observed for mean testis density followed the same trend in the paired testis weight. The reduced mean testis length observed in T4 (25g C: 75g FLGA) may be attributed to under-nourishment, while the highest value recorded in T2 (75g C: 25g FLGA) could be due to the fact that low percentage of FLGA in combination with concentrate supports better testicular length of the rabbit bucks. Ahemen et al. (2016) reported that testicular length is one of the parameters for the assessment of spermatogenesis. Mean testis length disagrees with the findings of Amao and Oladele (2016), who observed similarities with lower values (1.72 to 2.13g). The highest value for mean testis length at treatment 2 might be an indication for good sperm production, whereas the significant decrease at treatment 4 may be associated with low feed intake. Akpa et al. (2012) revealed that testicular length is the measure of testicular size which had been found to be significantly correlated with sperm production. The differences observed for paired testis volume in this study, followed a fluctuating trend. The results, therefore, imply that the test diets may not have negative effect on spermatogenesis up to treatment 3. The differences observed for paired epididymal weight agree

with that of Ahemen et al. (2016), who also established differences among treatment groups. The significant (P<0.05) effect in treatment 2 for paired epididymal weight is indicative of the fact that treatment 2 has better percentage combinations of the dietary treatments as compared to treatment 4. The mean epididymal length was also significantly (P<0.05) influenced by the dietary treatments. The significant values for paired epididymal weight and mean epididymal length imply that treatment 2 may enhance greater spermatozoa storage capacity among treatments.

Conclusion

The results obtained in this study showed that the combinations of concentrate with fresh leaves of *Gmelina arborea* (FLGA) - treatments 2 (75g Concentrate /C/: 25g FLGA) and 3 (50g C: 50g FLGA) supported good quality of semen characteristics and normal reproductive organ development of rabbit bucks with better effect at treatment 2. Therefore, both treatments are recommended for rabbit breeding bucks.

References

Abu AH, Ahemen T and Ikpechukwu P, 2013. The testicular morphometry and sperm quality of rabbit bucks fed graded levels of *Moringa oleifera* leaf meal (MOLM). Agrosearch, 13, 49-56.

Adeyemo AA, Taiwo OS and Adeyemi OA, 2014. Performance and carcass characteristics of growing rabbits fed concentrates to forage ratio. International Journal of Modern Plant and Animal Sciences, 2, 33-41.

Aduku AO, 2004. Animal nutrition in the tropics. Feeds and feeding, pasture management, monogastric and ruminant nutrition. Typeset by davcon computers and business bureau. Samaru, Zaria, Nigeria, pp. 5-143.

Ahemen T, Abu AH and Orakaanya TT, 2013. Sperm quality and testicular morphometry of rabbits fed dietary levels of water spinach (*Ipomoea aquatica*) leaf meal. Agriculture and Biology Journal of North America, 4, 352-357.

Ahemen T, Abu AH and Akuba JO, 2016. Effect of *Gmelina arborea* leaf meal on sperm production and sperm reserves in rabbit bucks. International Journal of Livestock Research, 6, 98-104.

Akpa GN, Ambali AL and Suleiman IO, 2012. Relationships between semen cation concentration semen characteristics, testicular measurement and body conformation trait in red Sokoto goat. Nature and Science, 11, 94.

Amao OA and Oladele PO, 2016. Testicular and epididymal characteristics of rabbits fed diet containing cottonseed cake supplemented with carrot Daucus carota or ginger *Zingiber officinale* Roscoe. Journal of Biology, Agriculture and Healthcare, 6, 48-53.

Arthur GH, Noakes DE and Pearson H, 1975. Veterinary reproduction and obstetrics. Baillere Tindal, London, pp. 509-589.

Blaga CB and Burny P, 2014. Rabbit production and rabbit market in Romania: The most frequent breeds, half breeds and their characterization. Rabbit Genetics, 4, 1-6.

Bud I, Vladau VV and Petrescu-Mag V, 2011. Rabbit breeding. Ceres Publishing House, Bucharest, Romania.

Campos ACN, Gadelha CRF, Guerreiro MEF, Pereira ES, Lima ICS, Linard MAB, Meneses HM, Castelo-Branco KF and Estevam FNL, 2014. Male rabbit reproductive physiology. Standard Research Journal of Agricultural Science, 2, 120-128.

Chang MC, 1959. Fertilizing capacity of spermatozoa. Recent progress in the endocrinology of reproduction. Academic Press, New York, USA, p. 131.

Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing. Official Journal of the European Union L 303/1.

Dermendzhieva D, Kostadinova G, Petkov G, Dinev T and Vasilev V, 2017. Hygienic and ecological assessment of the microclimate in a farm for intensive breeding of rabbits. Macedonian Journal of Animal Science, 7, 97-105.

Egbo ML, Doma UD and Lacdaks AB, 2001. Characterization of small-scale rabbit production and management. Proc. NSAP, 26, 160-161.

Esonu BO, Izukanne KO and Inyang OA, 2005. Evaluation of cellulolytic enzyme supplementation on production indices and nutrient utilization of laying hen fed soybeans hull based diets. International Journal of Poultry Science, 4, 213-216.

Evans G and Maxwell WMC, 1987. Salamon's artificial insemination of sheep and goats. Butterworths, Sydney.

FAO, 2005. Food and agricultural organization. Annual report, Rome, Italy.

FAO, 2006. Food and agricultural organization statistical data base. Rome, Italy, pp. 234-236.

Gbadamosi AJ and Egbunike GN, 1999. Studies on cock semen (1). Effects of frequency of ejaculation and breed on physical characteristics. Tropical Journal Animal Science, 1, 157-164.

Herbert U and Adejumo DO, 1995. Concentration and evaluation of artificial vagina for collecting rabbit semen. Delta Agric, 2, 99-108.

Kamel IK and Attia YA, 2011. Effect of dietary lecithin supplementation on improvement of semen quality, reproductive performance plasma biochemical traits and antioxidant changes in rabbit bucks. Egyptian Poultry Science Journal, 31, 667-680.

Kuzminsky G, Fausto AM and Monera P, 1996. Morphological abnormalities of rabbit spermatozoa studied by scanning electron microscope and quantified by light microscope. Reproduction, Nutrition, Development, 36, 65-75.

Luzi F, Maertens L, Mijen P and Pizzi F, 1996. Effect of feeding level and dietary protein on libido and semen characteristics of bucks. In: Proceedings of the 6th World Rabbit Congress, Toulouse, France, 2, pp. 87-92.

Minitab, 2010. Minitab statistical software version 16.1.1. Mintab Incoporation, USA.

Nkwocha GA, Agbabiaka LA, Beketin TO and Anukan KU, 2014. Effect of graded levels of Gmelina arborea leaf meal on the performance of grower rabbits. International Journal of Agriscience, 4, 370-373.

Nwagwu AC and Nzeribe AG, 2006. Effect of feeding concen-

trate and forage on the reproductive performance of rabbits and their kids. In: Proceedings of the 31st Annual Conference for the Nigerian Society for Animal Production, Bayero University Kano, Nigeria, pp. 123-125.

Ojebiyi OO, Oladunjoye IO and Eso IR, 2010. The grain replacement value of sun-dried cassava *Manihot esculenta* Crantz. Leaf Peel Meal with or without DL-Methionine supplementation on Performance of Rabbit Bucks in the Derived Savannah zone of Nigeria.

Ojewola GS, Ukachukwu SN and Abasiekong SF, 1999. Performance of growing rabbits fed concentrate alone and mixed concentrates-forage diets. Journal Sustain Agriculture Environment, 1, 51-55.

Ogbuewu IP, 2008. Physiological responses of rabbits fed graded levels of neem *Azadirachta indica* leaf meal. Thesis for MSc in Animal reproductive physiology, University of Technology, Oweri, Nigeria.

Ogbuewu IP, Okoli IC and Ibeje MU, 2009. Semen quality characteristics, reaction time, testis weight and seminiferous tubule diameter of buck rabbits fed neem *Azadirachta indical* A. Juss leaf meal based diets. Iranian Journal of Reproductive Medicine, 7, 23-28.

Oluremi OIA, Ngi J and Andrew IA, 2007. Phyto-nutrients in citrus fruit peel meal and nutritional implication for livestock production. Livestock Research for Rural Development, 19, 16-25.

Omalaka EE, 1992. The effect of time and frequency of collection on the quantity and quality of boar semen. In: Bachelor of Agricultural Technology Project Report, B. Tech. Project Report, Department of Animal Science and Technology, Federal University of Technology, Owerri, Nigeria.

Onyimonyi AE and Ene JC, 2003. Performance of growing rabbits fed *Panicum maximum* with graded levels of a concentrate diet proc. Animal Science Ass. Nig. Conf., pp. 73-74.

Opara MN, Iwuji TC, Mbah GU, Etuk IF, Ogbuewu IP, Olaifa AK and Okoli IC, 2012. Haematological and biochemical responses of rabbits to aqueous extracts of *Gmelina arborea* leaves. Rabbit Genetics, 2, 5-9.

Osinowo OA, 2006. Introduction to animal production, 1st edition. Sophie Academic Services, Abeokuta, Nigeria. pp. 29.

SAS, 2000. Statistical Analysis for Science. User's Guide, SAS institute. Inc. Cary, NY, USA.

TAC, 2009. Makurdi weather elements records, Makurdi metereological station. Nigeria Air Force, Tactical Air Command, Makurdi, Nigeria.

Togun VA and Egbunike GN, 2006. Seasonal variations in the sperm production characteristics of Zebu (white Fulani) cattle genitalia in the humid tropical environment. Middle-East. Journal Science Research, I, 1.

Werner MA, 2004. Semen analysis, maze laboratories. www.Wernermd.com/semen.

Yusuf AM, Garba MH, Olafedehan OA and Okafor CI, 2009. Evaluation of the feeding potentials of *Vitelleria paradoxum*, *Naucleau latifolia* and *Terminali amacroptera* forage as supplements to concentrate feed for weaner rabbits. In: Proceeding of the 34th Annual Conference of Nigerian Society for Animal Production Calabar, pp. 117-119.