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GROWTH PERFORMANCE OF KIT RABBITS FED CONCENTRATE DIET SUPPLEMENTED WITH VARYING FOLIAGE LEAF MEALS

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ABSTRACT

The study investigated the effects of supplementing concentrate diets of rabbits with Gmelina, Neem, Leucaena combined w/w with Moringa leaf meals on their growth performance. Four dietary treatments consisting of forage and concentrate were formulated alongside with the control diet (without supplement). Twenty-four weaner rabbits of both sexes equal in numbers of males and females were used for the experiment for a period of 12 weeks. The growth experiment was subjected to 4 x 2 factorial experiment in completely randomized design consisting of four experimental diets and two (2) sexes. Proximate composition of the experimental diets, weekly weight gain, feed intake, feed consumption and feed conversion ratio of the rabbits were assessed. As revealed from the findings, the crude protein, crude fat and crude fiber ranged from 9.36% to 36.73%; 6.75% to 11.58%; and 20.12% to 30.24% respectively, while the carbohydrate, ash and moisture content ranged between 57.90% and 73.27%; 6.20% and 17.75%; and 7.76% and 8.20% respectively. The statistical analysis revealed that the experimental treatments had significant effects on the growth rate, feed consumption and feed conversion ratio of the rabbits ($p \leq 0.05$). A strong positive and significant relationship (*0.01 level*) was observed between feed consumption and growth rate of the rabbit. The results of the finding suggest that the inclusion of the Moringa forage leaves in the experimental diets favoured the growth performance of the rabbits in terms of growth rate, feed consumption and feed conversion ratio of rabbits.

Contribution/Originality: This study is one of very few studies which have investigated, the effects of supplementing concentrate diets of rabbits with mixed foliage augmented Moringa leaf meal and other foliage leafy meals including Gmelina, Neem, Leucaena on optimum growth performance within the shortest possible time.

1. INTRODUCTION

Rabbits have been discovered to be a very good source of animal protein in Nigeria, particularly in the rural and urban areas. They possess some unique qualities that makes them suitable as meat-producing animals, as well as smallholder subsistence integrated farming and business, when compared with other herbivorous animals. Some of these qualities include prolific breeders, rapid growth rate and fecundity, short generational interval, genetic diversity, high nutritional meat quality (including exceptional protein value, low cholesterol content and sodium levels), high efficiency in converting forage to meat, low cost management requirements, ability to utilize wide

arrays of feedstuffs and forages, ability to adapt to different ecological environment and consumption bereft of cultural and religious biases [1-7].

However, feeding of rabbits just like other monogastric animals accounts for about 70 and 80% of its production [8]. The high cost of feed coupled with the ignorance of possible alternative and cheap feed ingredients are among important factors militating against increased commercial rabbit production in Nigeria. As opined by Ahaotu, et al. [9] the high cost of feed ingredients in most tropical countries clearly indicates that the production of feeds for livestock business is grossly inadequate. This major constraint has brought about the search for alternative feed resources that are readily available, inexpensive and less competed for by humans. They can serve as nonconventional replacement or supplements of the conventional feed stuffs in rabbits and other livestock diets.

Although rabbits can survive on most foliage diet, there is the need to explore mixed varying feeding regime that will enhance optimum performance. One priority area of research now is the production of rich nutrient forage based diets alongside concentrates [10]. The inclusion of tree foliage in animal nutrition tends to serve as rich source of protein, minerals, vitamins [11] and important phytochemicals with enhanced anti-microbial, anti-oxidant and palatability [12]. Thus, providing sustainable, locally available and perennial feeding system for rabbits and other livestock [13, 14].

Local farmers, usually in less developed countries adopt the use of several forages to feed rabbits for cheaper feeding cost Kimsé, et al. [15]. Bamikole and Ezenwa [16] reported that feeding rabbits solely on forages in the tropics has resulted in negative effect of weight loss and in some cases positive effects have been reported. The sole use of compounded concentrates has also not given optimum results [17]. However, previous research studies have been reported on the use of tropical forages (*Leucaena leucocephala*, *Morus Alba*, *Gmelina arborea*, *Gliricidia sepium*, *Tridax procumbens*, *Bambusa arundinancea*, *Erythrina poeppigiana*, *Tithonia diversifolia and Azadirachta indica*) as supplements with rabbit concentrate diets [3, 10, 18-22].

In view of the aforementioned, the quest to search for an alternative feed source that can produce an economically viable end results in a relatively short period becomes expedient. The current study is therefore aimed to investigate the effects of supplementing concentrate diets of rabbits with forage leaf meals on their growth performance.

2. MATERIALS AND METHODS

2.1. Experimental Site, Preparation of Experimental Diets and Feed Formulation

The experiment was carried out in the Animal Farm at the Federal College of Forestry, Jos, Plateau State, Nigeria. Fresh foliage leaves of *Gmelina arborea*, *Azadirachata indica*, *Leucaena leucocephala* and *Moringa oleifera* trees were harvested from the mother tree and air dried under shed until they were crispy to touch. The leaves were then pulverized and stored prior to use. The milled leaves (*G. arborea (G)*, *A. indica (A)*, and *L. leucocephala (L)*) were proportionally mixed at a ratio of 1:1 (DM basis) with the milled leaf of *M. oleifera* using Pearson's square method of ration formulation [23] as shown in Table 1.

2.2. Experimental Animal and Housing Management

Twenty-four weaner rabbits of both sexes equal in numbers of males and females were used for the experiment. The rabbits were housed in cages (25cm × 40cm × 30cm) partitioned with wire mesh Figure 1 and equipped with drinkers and feeders. The rabbits were randomly allocated to the four dietary treatment groups with three (3) rabbit per treatment [24]. Prior to the commencement of the experiment the rabbits were prophylactically treated against internal and external parasites by subcutaneous injection of Ivomec (0.2 ml/rabbit). Broad spectrum antibiotics (Oxytetracycline L.A) were given subcutaneously at the rate of 0.2 ml/rabbit [25].

Table-1. Composition of experimental diets.

Ingredients	Diet 1 (T1) Concentrate	Diet 2 (T2) (G+M)	Diet 3 (T3) (B+M)	Diet 4 (T4) (A+M)	Diet 5 (T5) (L+M)
Maize	19.5	9.5	9.5	9.5	9.5
Corn bran	37	37	37	37	37
G+M		20			
B+M			20		
A+M				20	
L+M					20
Groundnut cake	16	6	6	6	6
Palm kernel cake	20	20	20	20	20
Fish meal	2	2	2	2	2
Bone meal	3	3	3	3	3
Premix	2	2	2	2	2
Salt	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

Note: *Vitamin/mineral premix content per kilogram ration: Vit. A 1251 IU, Vit. D3 2750 IU, Vit. E 151 IU, Vit. K 0.002 g, Vit. B2 0.006 g, Nicotinic acid 0.035, Calcium D-Pantothenate 0.01 mg, Vit. B6 0.0035 g, Vit. B12 0.02 g, Folic acid 0.001 g, Biotin 0.0005 g, Vit. C 0.025 g, Cholin chloride 0.39 g, Zinc bacitracin 0.02 g, Methionine 0.2 g, Avatec (Lasolocid) 0.09 g, Manganese 0.1 g, Iron 0.05 g, Zinc 0.04 g, Copper 0.002 g, Iodine 0.00153 g, Cobalt 0.000225 g, Selenium 0.0001 g.

Figure-1. Housing system of the rabbits.

2.3. Experimental design and Data Collection

The growth experiment was 4 x 2 factorial experiment in Completely Randomized Design with two (2) factors of four (4) types of experimental diets and two (2) sexes. The experiment was composed of 8 treatment combinations and 3 replications.

The rabbits were weighed at the start of the experiment and subsequently on a weekly basis. Variables measured include weight gain, feed intake, feed consumption and feed conversion ratio. Growth rate represents the ratio between weight gained and growth period, the feed consumption was determined by finding the difference between the remaining and the distributed feed, while the feed conversion ratio was calculated as the quantity of feed that produce 1kg weight gain.

The proximate composition of the experimental diets was carried out as outline by AOAC [26]. These include test on Crude protein (%), Crude fibre (%), Ether extract (%), Ash (%) and NFE (%) on dry matter (DM) basis.

2.4. Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA). Differences between the treatment means were separated using Duncan's New Multiple Range Test (DMRT) at 5% level of significance.

3. RESULTS

3.1. Proximate Composition

The results of the proximate analyses of the experimental diets are presented in Table 2. The crude protein, crude fat and crude fiber ranged from 9.36% to 36.73%; 6.75% to 11.58%; and 20.12% to 30.24% respectively. The carbohydrate, ash and moisture content ranged between 57.90% and 73.27%; 6.20% and 17.75%; and 7.76% and 8.20% respectively. As revealed from the result, the proximate constituents of the experimental diets increased with inclusion of *Moringa oleifera* leaves. Gmelina+Moringa diet had the highest crude protein content (36.73%) and crude fat content (11.58%). Leuceana+Moringa experiment diet had the highest crude fibre content (30.24%), ash content (17.75%) and moisture content of 8.20%. Carbohydrate content was highest in Neem+Moringa experimental diet (73.27%).

Table-2. Proximate composition of the experimental diets.

Proximate Composition	Control	Neem + Moringa	Leuceana + Moringa	Gmelina + Moringa
Crude Protein %	9.36	27.66	30.42	36.73
Crude fat %	6.75	7.24	8.12	11.58
Crude fibre %	20.12	21.72	30.24	27.43
Carbohydrate %	57.90	73.27	72.38	68.47
Ash %	6.20	14.40	17.75	16.93
Moisture %	7.76	7.84	8.20	7.54

3.2. Growth Rate (%)

The result of the effects of the experimental treatments on the growth rate (g/week) of the rabbits after 12 weeks Figure 2 showed that Gmelina (*Gmelina arborea*) and Moringa (*Moringa oleifera*) experimental diet had the highest effect (121.38g/week) on the growth rate of the rabbits. This is followed by Neem (*Azadirachta indica*) and Moringa (*Moringa oleifera*) experimental diet indicating 92.30g/week growth rate of the rabbits. The fourth (Leuceana and Moringa) and control diet (with no incorporation of forage leaves) experimental diets had the lowest effects of 71.05g/week and 74.48g/week on the growth rate of the rabbits respectively.

Further analysis by through mean separation and comparison Figure 2 showed that there were significant differences ($p \leq 0.05$) in the effects of experimental diets of control and Gmelina + Moringa; control and Neem + Moringa; Gmelina + Moringa and Neem + Moringa; Gmelina + Moringa and Leuceana + Moringa; and Neem + Moringa and Leuceana + Moringa. Conversely, there was no significant difference ($p \geq 0.05$) in experimental diets between control and Leuceana + Moringa. In general the combination of Gmelina + Moringa experimental diets had the highest (121.38g/week) significant effect ($p \leq 0.05$) on growth rate of the rabbits, while Leuceana + Moringa experimental diet recorded the lowest (71.05g/week) significant effect on the growth rate of the rabbits which is not significantly different from that of the control diet.

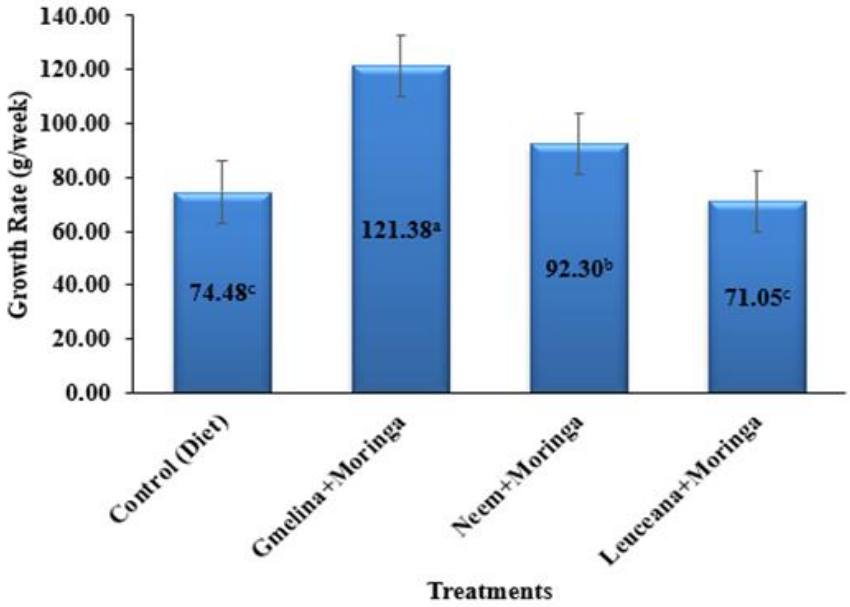

Figure-2. Effects of the treatments on the growth rate (g/week) of the rabbits.
Note: Bars having the same letters are not significantly different (p≤0.05).

3.3. Feed Consumption (g)

The findings on the effects of the treatments on the feed consumption (g) of the rabbits after 12 weeks Figure 3 indicated that the second experimental diet composed of Gmelina+Moringa forage leaves resulted into the highest (5327.08g) feed consumption level of the rabbits. This is closely followed by the Neem and Moringa experimental diet (5031.50g) and control diet (4452.42g). The lowest feed consumption level by the rabbits after eight weeks was observed in the Leuceana + Moringa experimental diets which recorded a value of 4057.50g.

The analysis for mean comparison Figure 3, further revealed that there was no significant differences ($p \geq 0.05$) between Gmelina + Moringa and Neem + Moringa on feed consumption level of the rabbits. In comparison, significant differences ($p \leq 0.05$) were observed between control diet and Gmelina + Moringa; control and Neem + Moringa; control and Leuceana + Moringa; Gmelina + Moringa and Leuceana + Moringa; and Neem + Moringa and Leuceana + Moringa experimental diets on feed consumption level of the rabbits.

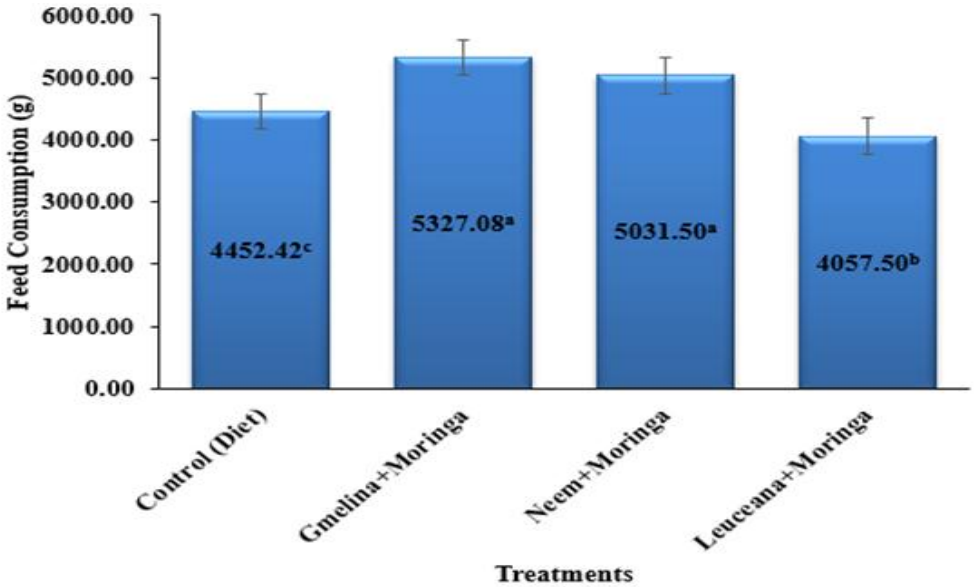

Figure-3. Effects of the treatments on the Feed Consumption (g) of the rabbits.
Note: Bars having the same letters are not significantly different (p≤0.05).

3.4. Feed Conversion Ratio/Efficiency

The result of the effects of the treatments on the feed conversion efficiency/ratio of the rabbits Figure 4 after eight weeks showed that Neem and Moringa experimental forage leaves gave the highest feed conversion ratio (8.66). This observed occurrence is closely followed by Gmelina + Moringa (7.06) and control (feed concentrate with no forage leaves) diets. (5.12). Leuceana + Moringa (4.65) experimental diet recorded the lowest feed conversion efficiency.

Further analysis for mean comparison Figure 4 showed that there were no significant differences ($p \geq 0.05$) were observed between control and Leuceana + Moringa; Gmelina + Moringa and Neem + Moringa; and Gmelina + Moringa and Leuceana + Moringa experimental treatments on feed conversion ratio/efficiency of the rabbits after eight weeks of experimental subjection. Significant difference ($p \leq 0.05$) were observed between the control and Gmelina + Moringa; control and Neem + Moringa; and Neem + Moringa and Leuceana + Moringa experimental diets on feed conversion efficiency of the rabbits after eight weeks of experimental subjection.

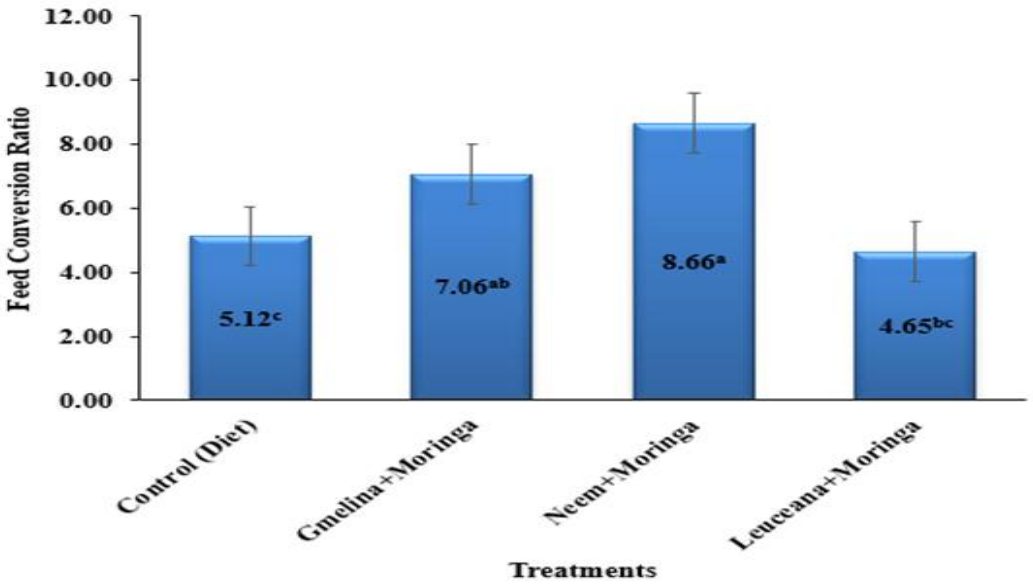

Figure-4. Effects of the treatments on the feed conversion ratio of the rabbits.
Note: Bars having the same letters are not significantly different (p≤0.05).

3.5. Correlation Analysis between Feed and Growth Parameters of the Rabbits

The correlation analysis between the feed and growth parameters Table 3 revealed that a strong positive and significant relationship (*0.01 level*) exist between feed consumption and growth rate of the rabbit twelve weeks after experimental subjection. The implication of this is that increase in the feed consumption of the rabbits brought about an increase in the growth rate of the rabbits. A weak and significant relationship was found between feed consumption and feed conversion efficiency while the relationship between growth rate and feed conversion efficiency 8weeks after the experiment was weak and not significant.

4. DISCUSSION

4.1. Proximate Composition of the Experimental Diets

The study investigated the growth performance of rabbits fed concentrate diet supplemented with different forage leaf meals. The proximate composition of the experimental diets ranged from 9.36% to 36.73% for crude protein, 6.75% to 11.58% for crude fat and 20.12% to 30.24% for crude fiber, 57.90% to 73.27% for carbohydrate, 6.20% to 17.75% for ash and 7.76% to 8.20% for moisture content Table 2. The proximate analysis further revealed that there was increase in the proximate constituents of the experimental diets with inclusion of *Moringa oleifera* leaves. This is corroborated by Jiwuba and Ogbuewu [6] who discovered abundant essential nutrients in *Moringa*

oleifera leaf meal (MOLM) diet. This according to them could improve productivity and enhance performance of rabbit.

Table-3. Correlation analysis between feed and growth parameters of the rabbits.

Parameters	Growth rate	Feed consumption
Growth Rate	1	
Feed Consumption	0.731**	1
Feed Conversion Ratio/Efficiency	0.287	0.448*

Note: **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

As posited by Ajayi, et al. [25] the variations in crude fiber value may be due to the stage of growth of the plant at harvest as well as the method used in the processing of the meal, while the differences in the values of protein obtained may be attributed to the differences in soil nutrients in the soils on which the plants were grown. Fuglie [26] attributed these observed variations in the nutrients to the age of cutting or harvesting, climatic conditions, edaphic factors, agronomic practices as well as methods of processing and analysis.

The range of values obtained in this study is significantly higher than range of values reported by previous researchers. Makinde [24] determined the proximate constituents of rabbits fed concentrate diet supplemented with white lead tree (*Leucaena leucocephala*) or Siratro (*Macroptilium atropurpureum*) leaves as 15.75 – 18.72% for crude protein, 4.75 – 11.42% for crude fiber and 10.30 – 14.90% for Ash content. Ajayi, et al. [25] reported crude protein as 15.95-78.35%, crude fiber as 1.46-16.64% and ash content as 3.96-14.0%. Grubben and Denton [27] reported that the leafy tips of *Moringa oleifera* contain per 100 g edible portion: water 78.7 g, protein 9.4 g, fat 1.4 g, carbohydrates 8.3g, Oduro, et al. [28] reported that *Moringa oleifera* leaves contained crude protein 27.51%, crude fiber 19.25%, crude fat 2.23%, ash 7.13%, moisture 76.53% and carbohydrates 43.88%.

The effect of feed on the growth performance of rabbits showed that the Moringa supplemented feed is better in terms of growth rate, feed consumption and feed conversion ratio. This could be explained by the presence of Moringa in the feed. Improved proficiency of protein utilization in Moringa supplemented experimental diets might be attributed to its high protein and low fiber and lignin contents [29, 30]. It has strengthened the content of the feed protein and fiber. Proteins of Moringa have very high biological values. All essential amino acids present in Moringa are in a concentration greater than the one recommended by FAO and WHO as posited by Zarkadas, et al. [31].

4.2. Growth Rate (g/week)

The result of the findings of this study revealed that homogenous mixture of the forage leaves with Moringa forage leave gave a better growth performance on the rabbits after 12 weeks Figure 2, 3 and 4. Experimental diet mixture of Gmelina and Moringa as well as Neem and Moringa experimental diets had the highest significant effects of 121.38g/week and 92.30g/week respectively on the growth rate of the rabbits. The homogenous combination of Leuceana and Moringa gave a poor significant performance compared to the control diet (with no incorporation of forage leaves) experimental diet.

The results obtained in this study is in agreement with the findings of Ojewola, et al. [32] and Adeyemo, et al. [19] that rabbit perform better when fed mixture of forage and concentrate. Growing rabbits on concentrate recorded the lowest final weight and this could be attributed to concentrate feeding only without inclusion of forage in their diet.

Also, this is in accordance with the works of Adeyemo, et al. [19] and Kishawy, et al. [33] who both reported lower live weight in rabbit fed concentrate alone without supplementation with forage. Although the combination of Leuceana and Moringa contradicted this assertion by recording a lower growth rate than the control. This observed occurrence can be attributed to the fact that improved efficiency of protein utilization in Moringa

experimental diet fed rabbits might be due to the presence of high protein and low fiber and lignin contents in the foliage of this plant species. The high content of Moringa fibers facilitates the digestive transit of the rabbits Djakalia, et al. [29] thus enhancing the growth performance of the rabbits. The high content of crude protein supplemented by the inclusion of Moringa forage leaves apparently enhanced digestibility of the diets by the rabbits. Uko, et al. [34] in their study affirmed that as dietary fiber or cell wall material levels increased, apparent digestibility of dry matter declined. This finding corroborates with the observed reduced apparent dry matter digestibility of Abegunde, et al. [35] when *Garcinia kola* leaf meal was fed to rabbits and Oloruntola, et al. [20] when rabbits were fed with *Gliricidia* leaf meal. The initial increase in digestibility observed in rabbits fed the control diet might be attributed to better utilization of the feed by the animal which triggered better movement in the tract and improved digestion [36]. In line with the above, Pius, et al. [22] submitted that the consumption of *Gmelina arborea* foliage supplemented with concentrated fodder has not adverse effect on rabbit growth performance.

Abu, et al. [30] reported that *Leucaena leucocephala* is composed of considerable amounts of mimosine (a toxic, non-protein amino acid) which could be responsible for growth depression and increased mortality. Sugur, et al. [37] reported that 20-25% *L. leucocephala* forage leaves inclusion in the rabbit's diet may have deleterious effect on mortality as observed in this study. Like protein, fat is an intra-cellular component which is readily degraded having therefore a good digestibility. Moringa leaves being poor in fat have no effect on the fat digestibility [29].

Vitamin A is important in rabbit growth. Moringa is reported to have a high vitamin A [27]. The control diet (with no inclusion of forage leaves) might have provided insufficient vitamin A for the rabbits, hence resulting in poor growth, since vitamin A aids in promoting growth in rabbits. Pond, et al. [38] stated that vitamin A deficiency in the diets of rabbits makes the rabbits to exhibit poor growth.

The low growth rates observed in the leuceana+moringa experimental fed rabbits Figure 2 could be explained by the fact that the rabbits did not consume a lot of the feeds to ensure higher growth because of poor palatability of the experimental diet. This might also be attributed to subclinical infections which adversely affected their growth rate resulting in some degree of mortality in the number of rabbits assigned in this experiment diet treatment as revealed in this present study. Ajayi, et al. [25] opined that, another possible reason may be linked to poor genetic constitution of the rabbits used.

4.3. Feed Consumption (g)

The result of the findings showed that the range of 4057.50g and 5327.08g feed consumption or feed intake (g) by the rabbits obtained in this study is significantly higher than amount of feed intake or consumption recorded in previous research findings. This can be attributed to the inclusion of Moringa forage leaves in the experimental diet with contributed significantly to the growth performance of the rabbits after eight (8) weeks. The experimental combination of Gmelina+Moringa and Neem and Moringa resulted into better and significant growth performance of the rabbits Figure 3. This occurrence is evident in the correlation relationship in which strong positive and significant relationship (*0.01 level*) exist between feed consumption and growth rate of the rabbit eight weeks after experimental subjection. Implying that increased feed consumption of the rabbits brought about an increased growth rate.

Makinde *et al.* [24] reported feed consumption ranging between 2664.46g and 3185.51g, while Ajayi, et al. [25] recorded feed intake ranging between 3450g and 3710g. Abubakar and Bello [39] reported that weaned rabbits can utilize varying levels of *M. oleifera* leaf meal at up to 45% level in diets without adverse effects on growth performance, carcass yield, organ and gut characteristics. Adedeji, et al. [40] reported that the inclusion of increasing levels of *L. leucocephala* leaf meal (from 5 to 15%) improved rabbit performance and daily weight gain compared with the control diet (without supplement), although feed intake was decreased. Previous studies have indicated that the presence of some anti-nutritional factors like tannins in the diets results in poor palatability and

consequent decrease in feed intake due to its astringent property as a result of its ability to bind with protein of saliva and mucous membrane [41].

4.4. Feed Conversion Ratio/Efficiency

The feed conversion ratio (FCR) values of 4.65, 5.12, 7.06, and 8.66 obtained in this study were higher than the range of 2.63 to 4.00 reported by earlier researchers in the tropics [42]; 5.32 to 5.63 reported by Eustace, et al. [43] 4.09 – 6.33 reported by Makinde [24] and feed conversion ratio ranging from 5.30 to 6.03 reported by Ajayi, et al. [25]. However, the values obtained in this study are within the range and in line with the findings of Adu, et al. [44] and Ladipo, et al. [45] who reported 3.32 to 16.76 and 5.92 to 8.66 feed conversion ratio in rabbits fed dietary. According to Adejinmi, et al. [46] several factors including the nature of the feed and age of the animal are known to affect feed conversion ratio (FCR) of rabbits. Iyeghe-Erakpotobor [47] in her study on utilization of *Arachis hypogea* (groundnut) and *Lablab purpureus* (lablab) forage meal fed sole or mixed by growing rabbits reported a maximum feed conversion ratio of 13 which is higher than maximum feed conversion ratio of 8.66 reported in this study.

5. CONCLUSION

The results of the finding suggest that the inclusion of the Moringa forage leaves in the experimental diets favoured the growth performance of the rabbits. Gmelina and Moringa diet had the highest crude protein content and crude fat content. Leuceana and Moringa experiment diet had the highest crude fiber content, ash content and moisture content, while Neem and Moringa experimental diet had the highest carbohydrate content. In view of the result of the findings of these study, *Moringa oleifera* supplements in the diets of rabbit will help in enhancing the growth and development of the rabbits as well as saving cost of production in terms of rabbit farming enterprise. There is need to encourage massive afforestation of Moringa plant so as to enable farmers to produce the rabbit diets at a lower cost for economic use in animal feed formulation. In addition, further studies can be carried out to determine the phytochemical constituents of the forage leaves so as to investigate the presence of any anti nutritional constituents of the plant species.

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