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# Response of weaner rabbits fed graded levels of *Moringa oleifera* leaf meal (MOLM)-based diets

[1]Abubakar, Z., *Rano, N. B., Nasiru, A., [2]Tamburawa, M. S. and [3]Hassan, M.A.
*1Department of Animal Science, Bayero University Kano, Nigeria*
*[2]Department of Animal Science, Kano University of Science and Technology, Wudil, Nigeria*
*[3]Department of Agricultural Science Education, Sa'adatu Rimi College of Education, Kano, Nigeria*
***Corresponding author:** nbrano.asc@buk.edu.ng; 08093524481

**Abstract**

*The potentials of Moringa leaves in terms of nutrient composition, and palatability has made it an excellent replacement for soybean in non-ruminant diets. Therefore, the experiment was conducted to determine the growth performance, carcass characteristics, nutrients digestibility and haematological parameters of weaner rabbits fed graded levels of Moringa oleifera leaf meal (MOLM) – based diets. Sixty (60) male New Zealand White rabbits of 4 weeks of age (BW 498 ±73g) were randomly allocated to five dietary treatments (12 bucks per treatment each containing 3 rabbits as replicate) in a completely randomized design. The experiment lasted for eight (8) weeks after two weeks of adjustment. Five iso-caloric and iso-nitrogenous diets were formulated in which MOLM was incorporated at levels 0, 5, 10, 15 and 20% respectively replacing soybean meal. Measurement of nutrients digestibility was carried out on the 7th week of the experiment. Blood samples were also collected at the end of the feeding trial for haematological and biochemical indices. The results of growth performance indicated significant (P<0.05) differences for final live weight, average daily weight gain, feed conversion ratio, feed cost per kilogram and total weight gain across the treatments. Rabbits fed 20% MOLM (Diet E) had significantly (P<0.05) higher value for final body weight (1800.00g) compared to those fed other levels of MOLM. The total weight gain and average daily weight gain of rabbits fed diet E were significantly (P<0.05) higher compared to rabbits fed other levels of MOLM. Similarly, carcass and organs weights were significantly (P<0.05) higher for rabbits fed 20% MOLM followed by those fed 15 and 10% MOLM. The results of nutrients digestibility of rabbits showed significant (P<0.05) differences across the treatments. The results of blood analysis indicated the significant (P<0.05) differences in the values recorded for Packed cells volume, Red blood cells count, Haemoglobin concentration, white blood cells count, mean corpuscular volume and mean corpuscular haemoglobin concentration. No significant (P>0.05) difference was observed in mean corpuscular haemoglobin. It was concluded that the inclusion of MOLM at up to 20% in the diets of weaner rabbits improved the growth performance, carcass and organs characteristics, nutrients digestibility and blood indices.*

**Keywords**: Growth performance, nutrients digestibility, haematology, carcass, weaner rabbits, *Moringa oleifera*

## Réponse des lapins sevrés nourris avec des niveaux gradués de régimes à base de farine de feuilles de Moringaoleifera (FFMO)

**Résumé**

*Les potentiels des feuilles de Moringa en termes de composition nutritionnelle et de palabilité en ont fait un excellent remplacement du soja dans des régimes non ruminants. Par conséquent, l'expérience a été menée pour déterminer les performances de croissance, les*

*caractéristiques de la carcasse, la digestibilité des nutriments et les paramètres hématologiques de lapins sevrés nourris à des niveaux gradués de farine de feuilles de Moringaoleifera (FFMO). Soixante (60) Mâle Lapins blanches de 4 semaines de 4 semaines (BW 498 ± 73g) a été allouée au hasard à cinq traitements diététiques (12 dollars par traitement contenant chacun 3 lapins comme répliqués) dans une conception complètement randomisée. L'expérience a duré huit (8) semaines après deux semaines d'ajustement. Cinq régimes iso-caloriaques et iso-azotrogènes ont été formulés dans lesquels la FFMO a été incorporée à des niveaux 0, 5, 10, 15 et 20%, remplaçant respectivement le repas de soja. La mesure de la digestibilité des nutriments a été réalisée à la 7ème semaine des échantillons expérimentations. Des échantillons de poids volés ont également été collectés à la fin de l'essai d'alimentation des indices hématologiques et biochimiques. Les résultats de la performance de la croissance indiquaient des différences significatives (p <0,05) pour le poids vivant final, le gain de poids quotidien moyen, le ratio de conversion d'alimentation, le coût d'alimentation par kilogramme et le gain de poids total sur les traitements. Les lapins nourris 20% ffmo (diète e) avaient de manière significative (p <0,05) plus élevée pour le poids final du corps (1800.00 g) par rapport à ceux de la ffmo. Le gain de poids total et le gain de poids quotidien moyen du régime alimentaire des lapins fed E étaient significativement (p <0,05) plus élevés que les lapins nourris d'autres niveaux de ffmo. De même, les poids de la carcasse et des organes étaient significativement (p <0,05) plus élevés pour les lapins nourris 20% ffmo suivi de la part de la part de 15 et 10% ffmo. Les résultats de la digestibilité des nutriments des lapins ont montré des différences significatives (p <0,05) à travers les traitements. Les résultats de l'analyse sanguine indiquaient les différences significatives (p <0,05) dans les valeurs enregistrées pour le volume de cellules emballées, le nombre de globules rouges, la concentration en hémoglobine, le nombre de globules blancs, le volume corpusculaire moyen et la concentration moyenne de l'hémoglobine corpusculaire. Aucune différence significative (p> 0,05) n'a été observée dans l'hémoglobine corpusculaire moyenne. Il a été conclu que l'inclusion de FFMO jusqu'à 20 % dans les régimes alimentaires des lapins sevrés améliorait les performances de croissance, les caractéristiques de la carcasse et des organes, la digestibilité des nutriments et les indices sanguins.*

**Mots-clés**: Performance de croissance, digestibilité des nutriments, hématologie, carcasse, lapins sevrés, moringaoléifères

## Introduction

Rabbits are unique animals that serve as a flexible financial reserve for rural population and as well play other socio-cultural roles in the customs and traditions of many Nigerian Societies (Akinmutimi and Oguagwu, 2008). The prolific nature of rabbits coupled with its short gestation period and generation interval, makes it the animal of choice for multiplication and a short way of increasing animal protein intake (Akinmutimi, 2006). However, increasing the dietary animal protein intake at a reasonable cost using micro livestock has been part of the National Agricultural Policy (Sabayo *et al.*, 2007). The profitability of rabbit production as an enterprise depends on the number of rabbits kindled per doe per year and the post-natal survival of the kittens. A lot of effort is therefore, required in popularizing the raising of rabbits among the rural populace and other low-income groups. Rabbits multiply and grow rapidly producing an average of 6-8 kittens and kindle 3 - 4 times yearly as a result of their short gestation period of 28-30 days. A rabbit produces high quality meat and can utilize very cheap feed materials (Aduku, 1992). Weaner

rabbits require 2400-2600 ME kcal/kg of feed, 17-18% crude protein and 9-17% crude fibre (Aduku, 2005). The fibre requirement is higher than that of other monogastric animals, because rabbits have a large caecum with microbial organisms which aid in the breakdown of the high fibre. The rabbit has a lot of advantageous attributes (Cheeke *et al*., 1986). It has high feed conversion ratio, high prolificacy short generation interval, relatively short gestation period, and moreover, the meat from rabbit has been described as tasty and nutritious and contains comparatively low fat and sodium (Lukefahr and Goldman, 1990). Nutritionally, rabbit meat has a higher protein (20-21%), and low-fat content (10-11%), when compared with meat from other species. Rabbit meat has the cholesterol value of 169mg/100g (dry matter basis) when compared with beef (200mg), chicken (220mg), and low sodium content (Aduku, 1992). Soybean meal has been widely and successfully used as a protein source in the diets of livestock, but the price in recent times has been escalating continuously while availability is often erratic due to high competition between animals and human. Therefore, researchers have advocated the need to explore the use of non-conventional feed sources that have the capacity to yield the same output as conventional feeds and perhaps at cheaper cost in the diets of livestock, such non-conventional feedstuff is Moringa plants, *Moringa oleifera* belongs to monogeneric family of shrubs and tree. The leaves of Moringa oleifera are an excellent source of Sulphur containing amino acids, methionine and cysteine, which are often limiting in most feedstuffs used for feeding animals (Makkar and Becker, 1996). Moringa leaves have quality attributes that make them potential replacements for soybean in non-ruminant diets (Ufele *et al*., 2013). This study was aimed at evaluating the growth performance, nutrient digestibility, haematological parameters and carcass measurement of weaner rabbits fed shed dried *Moringa oleifera* leaf meal replacing soybeans.

## Materials and methods

### *Experimental site*

The experiment was conducted at the Rabbitry unit of the Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture and Agricultural Technology, Kano State University of Science and Technology, Wudil. The farm is located on Latitude 11°51'N & Longitude 9°20' E at an altitude of 430m above sea level. The mean annual rainfall is 800mm with relative humidity of 75% during the rainy season with a mean annual temperature of 26°C (Olofin *et al.*, 2008).

### *Experimental animals and their management*

A total of Sixty (60) male New Zealand White weaner rabbits at 4 weeks of age (BW 498 ±73g) were used for the study. The rabbits were housed in wooden hutches measuring 40 x 60 x 60 cm dimensions which were suspended from the ground. The rabbits were purchased from National Animal Production Research Institute (NAPRI), Shika, A.B.U Zaria. They were individually caged and fed their respective experimental diets. The rabbits were administered Ivomectin® and antibiotics (Oxytetrin® LA) injections at 0.5mls per rabbit as a prophylactic measure against endo and ecto-parasites and then, Embazine-Forte; Amprolium-300$^{WS}$ were used against coccidiosis disease. Feed and water were offered *ad libitum* daily.

### *Experimental diets and treatments*

Five iso-caloric and iso-nitrogenous diets were formulated to meet the nutritional requirements of the rabbits according to NRC (1995). The diets contained averagely 18% crude protein and 2985.70-2987.72kcal ME/kg diet for treatments one to five ($T_A$, $T_B$, $T_C$, $T_D$, and $T_E$). *Moringa*

*oleifera* leaf meal was included at graded levels of 0, 5, 10, 15, and 20% as partial replacement for soybean meal. Treatment A served as control, while treatments $T_B$, $T_C$, $T_D$ and $T_E$ served as treatment groups respectively. The ingredients composition of the experimental diets is presented in Table 1.

**Table 1: Composition of the experimental diets**

| | Treatments (MOLM %) | | | | |
|---|---|---|---|---|---|
| Ingredients | 0 | 5 | 10 | 15 | 20 |
| Maize | 55.00 | 55.00 | 55.00 | 55.00 | 55.00 |
| Soybean meal | 20.00 | 15.00 | 10.00 | 5.00 | 0.00 |
| MOLM | 0.00 | 5.00 | 10.00 | 15.00 | 20.00 |
| Wheat offal | 20.65 | 20.65 | 20.65 | 20.65 | 20.65 |
| Bone meal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Salt | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Methionine | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Lysine | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| P.Vitamin /mineral mixture | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Total | 100 | 100 | 100 | 100 | 100 |
| Calculated analysis | | | | | |
| Crude protein (%) | 18.01 | 18.07 | 18.02 | 18.08 | 18.00 |
| ME(kcal/kg) | 2985.70 | 2988.69 | 2986.55 | 2989.41 | 2987.72 |
| Crude fiber (%) | 7.39 | 8.52 | 10.86 | 11.15 | 11.56 |
| Ether extract (%) | 3.49 | 3.96 | 3.92 | 3.84 | 3.80 |
| Ash (%) | 2.93 | 2.96 | 2.99 | 3.00 | 3.11 |
| Ca (%) | 0.17 | 0.14 | 0.15 | 0.19 | 0.11 |
| P (%) | 0.60 | 0.69 | 0.59 | 0.58 | 0.57 |
| Lysine (%) | 0.86 | 0.88 | 0.89 | 0.91 | 1.00 |
| Methionine (%) | 0.27 | 0.28 | 0.29 | 0.31 | 0.35 |

**Bio-premix supplied per kg of diet: Vitamin A, 12500I.U; Vit. D3, 2500 I.U;Vit E,50mg; Vit K3, 2.5mg; Vit B3.0mg; VitB6 6.0mg; Niacin, 40.0mg; Calcium pantothenate, 10.0mg; Biotin, 0.8mg; VitB 12 0.25mg; Folic acid, 1.0mg; Choline chloride, 300mg; Mangane se 100mg: Iron, 50mg; Zinc 45;2mg; Iodine 1.55I.U; Selenium 0.1mg.ME Metabolizable energy*

## Data collection

### *Body weight*

At the beginning of the experiment, the initial weight of each rabbit was measured using top loading weighing scale and thereafter the body weight were measured on weekly basis. Weekly weight gain was computed by subtracting weight obtained the previous week from the current week.

### *Determination of daily feed intake*

This was determined by measuring known quantity of feed offered to the animals and subtracting the quantity of feed leftover from the previous day.

$$\text{Feed consumed} = \frac{\text{Feed offered (g)} - \text{Feed leftover (g)}}{\text{Number of rabbits}}$$

### *Feed conversion ratio*

This was calculated from the records of feed intake and weight gain by dividing the feed intake of the rabbits by the weight gain.

$$\text{Feed conversion ratio} = \frac{\text{Feed intake (g)}}{\text{Weight gain (g)}}$$

### *Digestibility trial*

The digestibility trail was carried out in the 7th week of the experiment. One rabbit (1) each from each replicate (20 rabbits in all) having an average weight representing the treatment group was selected and kept in separate hutches for total faecal collection. Known quantity of feed was offered and left over each morning was measured. The trial lasted for a period of 7 days. The

digestibility values for DM, CP, EE, CF and NFE were calculated using the following formula:

Digestibility (%) = Nutrient in feed (g) x feed intae (FI) – Nutrient in Faeces (g) x faecal output Fo) x 100
% Nutrient in feed x feed intake (FI).

***Blood sample collection and analysis***

At the end of the feeding trial, blood samples were collected from the ear vein of one rabbit from each replicate of each treatment using a sterilized disposable syringe and needle. The 2ml blood was collected into labeled sterile vacuum tube containing ethylenediamine- tetra-acetic acid (EDTA) as anticoagulant which was used for haematological analysis. The blood analysis was carried out at Aminu Kano Teaching Hospital, Kano. The Red Blood Cells (RBC) count, White Blood Cells (WBC) count, haemoglobin (Hb) concentration and Packed Cell Volume (PCV) parameters determined as described in Ewuola and Egbunike (2008). Blood constants (MCH, MCV, and MCHC) were determined using appropriate formulae as described by Ahamefule *et al*. (2006). MCV was calculated by multiplying the PCV by 10 and dividing by RBC count, while MCHC was calculated by multiplying the Hb concentration by 10 and dividing by PCV value respectively.

***Measurement of carcass and internal organs***

At the end of the experiment, one rabbit with an average weight close to their mean weight in each replicate was taken for carcass and organs evaluation. The final live weight was recorded before slaughtering. The rabbits were fasted overnight in order to empty the gut and prevent carcass contamination. The selected rabbits were slaughtered by severing the jugular vein with the aid of a sharp knife using Standard Slaughter Procedures of Abdullah *et al*. (1998). After slaughtering and complete bleeding, carcass measurements were carried out according to the norms of the World Rabbit Scientific Association (WRSA) (Blasco *et al*., 1993), modified in the 2nd Meeting of the International Commission on Rabbit Carcass Criteria Harmonization).

Dressing percentage=
Dressed weight (g) x 100
Live weight (g)

***Chemical analysis***

Feed samples from each treatment were collected and taken for proximate analysis. However, the proximate compositions of fresh moringa leaf and *Moringa oliefera* leaf meal were carried out according to procedures described by AOAC (2005).

***Statistical analysis***

All data collected were analyzed using analysis of variance (ANOVA) in statistical analysis system (SAS, 2002) version 6$^{th}$ statistical software. Significant differences between the treatment means were compared at 5% probability using Duncan Multiple Range Test (Silva and Azevedo, 2009).

**Results and discussion**

The proximate composition of *Moringa oleifera* leaf is presented in Table 2. The result of Proximate analysis of *Moringa oleifera* leaf meal revealed the following; dry matter (91.76%), crude protein (28.25%), crude fibre (18.41%), ash (8.2%) nitrogen free extract (41.98%) and ME (2910.10%) respectively. The crude protein (CP) value of 28.25% obtained for MOLM in the present study favorably compare with the values of 28.80% reported by Amao *et al*. (2014) but lower than the 29.25% reported by Nuhu (2010) and 31.68% by El-Badawi *et al*. (2014). The CP content (28.25%) of MOLM reported in this study is within the range (20-35%) of protein content reported by Foidl and Paul (2008) for *Moringa oleifera* leaf. The contents of other parameters were; crude fibre

(18.41%), ash (8.2%) nitrogen free extract (41.44%) and ME (2602.14%). The crude fibre (CF) content (18.41%) in this study is higher than the values of (14.94 and 11.1%) reported by Adeniji and Lawal (2012) but lower than the 19.25% reported by Nuhu (2010) and 19.20% reported by Booth and Wickens (1988). The metabolizable energy (2602.14 kcal/kg) was in agreement with the value of 2612.08 (kcal/kg) reported by Jiwuba, *et al*. (2016) respectively. The Ash content obtained for MOLM (8.20%) in this study is higher than the 7.92% reported by Tesfaye *et al*. (2005) but lower than the 11.35% reported by Yahaya and Kibon (2013). The differences in the current data and those reported in literature may probably be due to various factors such as the differences in varieties, agronomic practices, soil, age of the tree, season of harvesting and climatic conditions and additionally, methods of processing (Nuhu, 2010). This also, agrees with the finding of El-Badawi *et al*. (2014).

**Table 2: Proximate composition of *Moringa oleifera* leaf**

| Parameters | % Composition |
|---|---|
| Dry matter | 91.76 |
| Crude protein | 28.25 |
| Crude fibre | 18.41 |
| Ether extract | 3.7 |
| Ash | 8.2 |
| Nitrogen free extract | 41.98 |
| Metabolizable energy (kcal/kg) | 2910.10 |

The proximate composition of the experimental diets is presented in Table 3. The crude protein (CP) ranged between 18.03 - 18.68% and compare favorably with the range of 18.11 and 18.25 % reported by El-Badawi *et al*. (2014) when they fed growing New Zealand red rabbits with supplemented levels of *Moringa oleifera* leaves. The CP of the experimental diets also fall within the range (15-18%) reported by Lebas (1987) as the CP requirements for weaner rabbits. The crude fibre (CF) contents of the experimental diets increased with increasing levels of MOLM although the (CF) of (8.81 -11.46%) is comparable with 11.98% reported by Fadiyimu *et al*. *(*2010). Moreover, it met the crude fibre requirement of 9 – 18% on dry matter basis as stated by Lebas (2002) for rabbits.

**Table 3: Proximate composition of experimental diets**

| | Treatments | | | | | |
|---|---|---|---|---|---|---|
| Parameters | A (0%) | B (5%) | C (10%) | D (15%) | E (20%) | SEM |
| Dry matter | $93.95^{ab}$ | $92.77^{ab}$ | $91.00^{b}$ | $92.41^{a}$ | $93.30^{b}$ | 2.34 |
| Crude protein | $18.03^{a}$ | $18.68^{bc}$ | $18.06^{bc}$ | $18.51^{a}$ | $18.67^{ab}$ | 3.51 |
| Crude fibre | 8.81 | 9.24 | 9.61 | 10.24 | 11.46 | $22.3^{NS}$ |
| Ether extract | $3.11^{ab}$ | $3.51^{ab}$ | $3.62^{a}$ | $3.70^{bc}$ | $3.81^{ab}$ | 6.67 |
| Ash | $2.85^{b}$ | $2.63^{b}$ | $3.75^{ab}$ | $4.83^{b}$ | $4.85^{b}$ | 0.12 |
| Nitrogen free extract | 45.14 | 58.68 | 58.68.68 | 58.35 | 59.67 | 4.32 |

*a,b,c,d =Means with different superscripts on the same row differ significantly (P<0.05);*
*SEM =Standard error of mean; NS = not significant*

The data on the performance of weaner rabbits fed graded levels of *Moringa oleifera* Leaf Meal, presented in Table 4 indicated that, the initial body weights of rabbits were nearly similar for the different treatment groups. The final body weight, total weight gain and daily weight gain increased significantly (P< 0.05) with

increasing level of MOLM. MOLM supplement resulted in significant (P<0.05) increase in final body weight to 1800.21g and total weight gain by 1303.21g in diet E (20% MOLM) inclusion level. The positive effect of moringa leaves on growth performance of rabbits has been observed in some previous studies (Kpodékon *et al*., 2008). Similarly, Nuhu (2010) has attributed the better growth rate to protein quality and amino acids content of moringa leaves. El-Badawi *et al*. (2014) has also reported that weight gain and ADG of rabbits fed 0.15 and 0.30% moringa supplemented rations were higher (P<0.05) than those fed (0% MOLM) control diet.

The average daily feed intake (ADFI) was significantly (*P<0.05*) different among the dietary treatments. The rabbits showed a steady increase in daily feed intake from treatment A to E. This trend in feed intake by the rabbits is understandable, since leaf meals contain relatively high fibre which tends to increase the total fibre content of the diets. This assertion generally agreed with the findings of other researchers (Spreadburg and Davidson, 1978; Aduku *et al*., 1988) who reported higher feed intake with increasing level of CF in the diets of rabbits.

The higher feed conversion ratio (4.66%) for the 20% MOLM diets might have also contributed to the higher growth rate and weight gain by the rabbits on 20% MOLM diet compared to other treatment groups.

**Table 4: Growth performance of weaner rabbits fed graded levels of *Moringa oleifera* leaf meal**

| | Treatments (Diets) | | | | | |
|---|---|---|---|---|---|---|
| Parameters | A (0%) | B (5%) | C (10%) | D (15%) | E (20%) | SEM |
| Initial live weight (g) | 498.73 | 499.58 | 498.75 | 498.42 | 497.00 | $0.65^{NS}$ |
| Final live weight (g) | $1300.00^{d}$ | $1425.00^{c}$ | $1475.00^{c}$ | $1562.50^{b}$ | $1800.21^{a}$ | 21.16 |
| Total weight gain (g) | $801.28^{d}$ | $925.42^{c}$ | $976.25^{c}$ | $1064.08^{b}$ | $1303.21^{a}$ | 24.07 |
| Average daily weight gain (g) | $14.31^{d}$ | $16.53^{c}$ | $17.43^{c}$ | $19.00^{b}$ | $23.27^{a}$ | 0.43 |
| Total feed intake (g) | $4200.00^{b}$ | $4700.27^{b}$ | $5100.30^{b}$ | $5537.30^{ab}$ | $6057.50^{a}$ | 10.97 |
| Average daily feed intake (g) | $75.00^{b}$ | $83.93^{b}$ | $91.10^{b}$ | $98.88^{ab}$ | $108.16^{a}$ | 1.95 |
| Feed conversion ratio % | $6.74^{a}$ | $5.89^{b}$ | $5.50^{bc}$ | $4.99^{cd}$ | $4.66^{d}$ | 0.21 |
| Feed cost/ (Kg) | $303.35^{a}$ | $292.61^{b}$ | $286.51^{c}$ | $270.86^{d}$ | $250.12^{e}$ | 2.03 |
| Mortality (%) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | $0.00^{NS}$ |

*a,b,c,d, =Means with different superscripts on the same row differ significantly (P<0.05);*
*SEM =Standard error of mean; NS = not significant*

Carcass weight is a very important parameter in assessing rabbit productivity since the higher the carcass weights the higher the degree of meatiness and economic value for the farmer. It was observed that the values tend to increase with increasing levels of MOLM in the diets. This observation may be a reflection of the relatively higher feed intake by the rabbits on the MOLM diets resulting in higher daily weight gain. The carcass weight values ranged between 987.50g and1375.00g. The upper limit being close to the values (1375.00g - 1425.00g) reported by Iyayi *et al*. (2003). However, the values are lower than the 1595.83 g - 2290.00 g reported by Biya *et al*. (2008) but generally, higher than the values of 801.67 g -1019.67 g obtained by Nuhu (2010). The values of 988.24 g – 1335.00g observed compare well with the values reported by other researchers in the tropics (Biya *et al*., 2008; Iyayi *et al*., 2003). The significant increase observed may be due to the ability of MOLM-based diet to support carcass development in growing rabbits.

**Table 5: Carcass characteristic of weaner rabbits fed graded levels of *Moringa oleifera* leaf meal**

| | Treatments | | | | | |
|---|---|---|---|---|---|---|
| Parameters | A (0%) | B (5%) | C (10%) | D (15%) | E (20%) | SEM |
| Final live weight (g) | 1300.00$^{d}$ | 1425.00$^{c}$ | 1475.00$^{c}$ | 1562.50$^{b}$ | 1800.21$^{a}$ | 17.69 |
| Carcass weight (g) | 987.50$^{c}$ | 1050.00$^{bc}$ | 1112$^{bc}$ | 1250.00$^{ab}$ | 1375.00$^{a}$ | 44.01 |
| Dressing percentage (%) | 73.13$^{a}$ | 73.52$^{a}$ | 74.21$^{ab}$ | 76.05$^{ac}$ | 76.77$^{ab}$ | 5.51 |
| Head (%) | 9.94$^{e}$ | 10.42$^{d}$ | 10.57$^{c}$ | 10.67$^{b}$ | 11.79$^{a}$ | 2.00 |
| Full GIT (%) | 15.32$^{e}$ | 16.25$^{d}$ | 18.31$^{c}$ | 21.66$^{d}$ | 22.97$^{a}$ | 2.11 |
| Fore limb (g) | 16.36$^{e}$ | 17.31$^{d}$ | 19.62$^{c}$ | 21.92$^{b}$ | 22.50$^{a}$ | 3.10 |
| Hind limb (g) | 19.42$^{d}$ | 21.92$^{c}$ | 21.92$^{c}$ | 24.73$^{b}$ | 24.96$^{a}$ | 2.00 |
| Fur (g) | 9.86$^{e}$ | 10.44$^{d}$ | 10.46$^{c}$ | 11.00$^{b}$ | 11.50$^{a}$ | 1.45 |
| Loin (g) | 10.87$^{e}$ | 10.91$^{d}$ | 12.60$^{c}$ | 13.56$^{d}$ | 13.75$^{a}$ | 2.00 |
| Stomach (g) | 4.56$^{c}$ | 3.82$^{e}$ | 4.19$^{d}$ | 4.63$^{b}$ | 5.26$^{a}$ | 2.00 |
| Empty stomach (g) | 1.69$^{e}$ | 1.75$^{d}$ | 1.76$^{c}$ | 1.86$^{b}$ | 2.36$^{a}$ | 2.16 |
| Caecum+ content (g) | 2.21$^{c}$ | 2.29$^{b}$ | 2.21$^{c}$ | 2.21$^{c}$ | 2.41$^{a}$ | 2.00 |
| Empty caecum (g) | 1.58$^{b}$ | 1.69$^{a}$ | 1.54$^{d}$ | 1.57$^{c}$ | 1.53$^{e}$ | 4.84 |

*a,b,c,d,e,-Means with different superscripts on the same row differ significantly (P<0.05); SEM = Standar d error of mean; NS = not significant*

The weight of some internal organs especially liver and kidneys are normally employed to determine the presence of anti-nutritional factors in the feed. The increase in internal organs weight above the normal physiological ranges is used as an index of feed toxicity (FAO, 1997). The significant (P<0.05) increase in the liver and kidney weights of the rabbits on the MOLM diets compared to the rabbits on control diet suggested that the MOLM diets increased physiological and metabolic activities of these animals/rabbits in a bid to detoxify some anti-nutritional factors contained in MOLM based diets. The values obtained in this study for the internal organs weights ranged between 5.00 and 10.91g for heart and 8.74 and 14.13g for lung, which is in agreement with report of Nuhu (2010) who reported the weight of heart (5.00 - 8.33g) and lung (9.00 – 13.10g).

**Table 6: Organs weight of weaner rabbits fed graded levels of *Moringa oleifera* leaf meal**

| | | Treatments | | | | |
|---|---|---|---|---|---|---|
| Parameters | A (0%) | B (5%) | C (10%) | D (15%) | E (20%) | SEM |
| Kidney (g) | 10.46 | 11.58 | 11.63 | 11.51 | 12.15 | 0.66$^{NS}$ |
| Heart (g) | 5.00 | 5.51 | 9.23 | 9.12 | 10.91 | 0.25$^{NS}$ |
| Lungs (g) | 8.74$^{bc}$ | 10.94$^{bc}$ | 10.91$^{c}$ | 11.21$^{b}$ | 14.13$^{a}$ | 0.74 |
| Liver (g) | 37.77$^{ab}$ | 39.49$^{ab}$ | 39.61$^{b}$ | 41.80$^{ab}$ | 46.81$^{a}$ | 1.71 |
| Spleen (g) | 0.91 | 1.00 | 1.34 | 1.47 | 1.84 | 0.11$^{NS}$ |
| Pancreas (g) | 0.60$^{c}$ | 0.72$^{ab}$ | 0.75$^{ab}$ | 0.91$^{a}$ | 0.94$^{a}$ | 0.11 |
| Large intestine weight (g) | 80.95$^{a}$ | 87.81$^{b}$ | 90.42$^{a}$ | 96.86$^{a}$ | 99.65$^{a}$ | 3.19 |
| Small intestine weight (g) | 100.41$^{b}$ | 105.36$^{b}$ | 102.89$^{b}$ | 116.10$^{b}$ | 112.25$^{a}$ | 0.2 |

*a,b,c=Means with different superscripts on the same row differ significantly (P<0.05); SEM =Standard error of mean; NS = not significant*

Table 7, showed the results of nutrients digestibility study of weaner rabbits fed MOLM-based diet. The apparent digestibility values recorded for rabbits on the various dietary treatments revealed lower apparent digestibility values for rabbits fed 0% MOLM diet. This is somehow unexpected due to the relatively lower crude fibre content as compared to those containing 5, 10, 15 and 20%MOLM. This may suggest that the CF contents in all the dietary treatments did not affect the

digestion of the various nutrients evaluated. The increase in the apparent digestibility of dry matter, crude protein and crude fibre in the diets containing *Moringa oleifera* leaf meal could be attributed to the easy digestibility which increased quality of Moringa leaves activities of degrading bacteria in the caecum**.** These results are in line with those obtained by El-Badawi *et al*. (2014) who reported that feeding rabbits on rations supplemented with MOLM up to 0.30% was associated with significant (P<0.05) increase in nutrient digestibility.

**Table 7: Nutrient digestibility of weaner rabbits fed graded levels of *Moringa oleifera* leaf meal**

| | Treatments | | | | | |
|---|---|---|---|---|---|---|
| Parameters | A (0%) | B (5%) | C (10%) | D (15%) | E (20%) | SEM |
| Dry matter | 67.05$^{e}$ | 73.35$^{d}$ | 77.30$^{c}$ | 78.65$^{b}$ | 79.45$^{a}$ | 0.66 |
| Crude Protein | 67.79$^{e}$ | 77.34$^{d}$ | 80.51$^{c}$ | 82.75$^{b}$ | 87.80$^{a}$ | 1.23 |
| Crude fibre | 42.35$^{e}$ | 44.70$^{d}$ | 46.21$^{c}$ | 52.86$^{b}$ | 59.84$^{a}$ | 0.01 |
| Ether Extract | 70.87$^{e}$ | 75.00$^{d}$ | 77.42$^{c}$ | 80.55$^{b}$ | 86.82$^{a}$ | 0.9 |
| Ash | 58.30$^{a}$ | 57.20$^{b}$ | 46.40$^{c}$ | 46.00$^{d}$ | 48.71$^{e}$ | 0.00 |
| Nitrogen Free Extract | 70.87$^{e}$ | 76.05$^{d}$ | 77.96$^{c}$ | 82.34$^{d}$ | 86.67$^{a}$ | 0.00 |
| Metabolizable energy (kcal/kg) | 2766.00$^{e}$ | 2856.25$^{d}$ | 2861.11$^{c}$ | 2867.33$^{b}$ | 2880.78$^{a}$ | 0.00 |

*a,b,c=Means with different superscripts on the same row differ significantly (P<0.05);*
*SEM =Standard error of mean; NS = not significant*

**Blood is an important index of physiological and nutritional status in an organism (**Olorode *et al*., 2007**).** The PCV (%) values of 35.01-36.59% recorded in the present study for the treatment groups fall within the normal physiological range of 30.0-50.0% reported by Onifade and Tewe (1993) for healthy rabbits. The present study showed the Hb range of 9.45-14.23 g/dl and red blood cells (4.78 – 7.07 × 106/µl) which are generally higher compared to the haemoglobin values of 5.53 – 10.20g/dl and red blood cells (5.30 – 6.23 × 106/µl) values reported by Ahamefule *et al*. (2005) and Yakubu *et al.* (2008). The lower haemoglobin concentration in the blood may result to poor efficiency of oxygen transportation and hence poor respiration (Solomon *et al.*, 1998). The range for WBC count obtained in this study ranged between (5.55 – 10.66x16/$m^3$) and fall within the normal range for white blood cells (4.5 – 11 (10g/l) reported by Research Animal Resource (RAR) (2009). The increased levels of WBC with the increasing levels of MOLM in the diet agreed with the reports of Onifade and Tewe (1993). The MCHC values of 29.56 – 30.10g/dl fall within the normal range (27-37) reported by RAR (2009). The significantly (P<0.05) higher mean values recorded for mean corpuscular volume (MCV) (74.91fl), mean corpuscular haemoglobin (MCH) (22.81x109/fl) and mean corpuscular haemoglobin concentration (31.76Pg) among rabbits placed on the control diets could be due to the lower haemoglobin values and this may probably predispose the rabbits on these diets to develop microcytic anaemia (Choladda, 2012).

**Table 8: Haematological parameters of weaner rabbits fed graded levels of *Moringa oleifera* leaf meal**

| | Treatments | | | | | |
|---|---|---|---|---|---|---|
| Parameters | A (0%) | B (5%) | C (10%) | D (15%) | E (20%) | SEM |
| PCV (%) | $35.01^{a}$ | $32.57^{b}$ | $33.59^{a}$ | $31.62^{b}$ | $36.59^{a}$ | 0.5 |
| RBC (x $10^{6}$/µl) | $4.78^{e}$ | $6.05^{b}$ | $5.18^{c}$ | $6.94^{b}$ | $7.07^{a}$ | 3.23 |
| HB (g/dl) | $9.45^{a}$ | $10.49^{ab}$ | $10.61^{ab}$ | $11.60^{b}$ | $14.23^{a}$ | 0.51 |
| WBC (x $10^{3}$/µl) | $5.55^{a}$ | $7.16^{c}$ | $8.66^{a}$ | $9.66^{ab}$ | $10.66^{ab}$ | 6.90 |
| MCV (fl) | $74.91^{a}$ | $68.78^{b}$ | $68.02^{a}$ | $70.02^{d}$ | $74.67^{c}$ | 8.00 |
| MCH (x109/L) | 22.81 | 21.69 | 20.61 | 20.69 | 21.67 | $0.00^{NS}$ |
| MCHC (Pg) | $31.76^{a}$ | $30.76^{a}$ | $30.90^{ab}$ | $29.65^{a}$ | $29.10^{a}$ | 5.10 |
| Platelet (103/mm3) | $125.00^{ab}$ | $170.23^{a}$ | $173.34^{b}$ | $158.56^{b}$ | $167.54^{ab}$ | 91.32 |

a,*b,c=Means with different superscripts on the same row differ significantly (P<0.05);*
*SEM =Standard error of mean; NS = not significant, PCV= Packed cell volume; RBC=Red blood cell; Hb=Haemoglobin; WBC=White Blood Cell; MCHC=Mean cell haemoglobin concentration;MCV= Mean Corpuscular Volume; Mean Corpuscular Hemoglobin (MCH)*

## Conclusion

Based on the results of this study, it was concluded that weaner rabbits can utilize varying levels of *Moringa oleifera* leaf meal up to 20% inclusion in their diets without any adverse effects on growth performance, carcass yield, organ and gut characteristics. From physiological point of view, also, blood profile of rabbits in all treatment groups was within normal range for rabbits which is an indication of safety of the test ingredient and inadvertently adequate nutritional and good health status of the rabbits.

## References

**Abdullah, A. Y., Purchas, R. W. and D. A. S. 1998**. Patterns of Change with Growth for Muscularity and other Composition Characteristics of Southdown Rams Selected for High and Low Back Depth. *New Zealand Journal of Agricultural Research,* 41: 367– 376.

**Adeniji, A. A. and Lawal, M. 2012.** Effect of Replacing Groundnut Cake with *Moringa oleifera* Leaf Meal (MOLM) in the Diets of Grower Rabbits. *International Journal of Molecular Veterinary Research*, 2(3): 8-13

**Aduku, A. O. 2005.** Tropical Feedstuffs Analysis Table, Department of Animal Science, **Ahmadu Bello University Zaria, Nigeria** pp. 2-4.

**Aduku, A. O. and J. O. Olukosi. 1990**. Rabbit Management in the Tropics: Production, Processing, Utilization, Marketing, Economics, Practical Training, Research and Future Prospects. G.U. Publications, Abuja Nigeria, pp 33-44.

**Aduku, A.O. 1992.** Rabbit Management in the Tropics. Living book series. Abuja FCT.

**Ahamefuel, F. O., Edouk, G. A, Usman, A., Amaefule, K. U and Oguike, 2006**. Blood Biochemistry and Haematology of Weaner Rabbits fed Sun-dried, Ensiled and Fermented Cassava Peel based Diet. *Pakistan Journal of Nutrition*. 5 (3): 248-253

**Akinmutimi, A. H, and Osuagwu, C. C. 2008.** Response of Weaner Rabbits Fed Graded Levels of Sweet Potato Meal in Place of Maize-Based Diet. *Pakistan Journal of Nutrition* 7: 705-709

**Akinmutimi, A. H. 2006**. Determination of Optimal Dietary Level of Inclusion of Cooked Sword Bean Meal in Broiler Starter Diet. *Journal of Animal and Veterinary Advances* 5: 689–694.

**Amao, E. A., Jimoh, R. A. and Adeoli, T. M. 2014.** Reproductive

Performance of Rabbit Does Fed Graded Levels of *Moringa oleifera* Leaf Meal-Based Diet. *International Journal of Sciences,* 3. 61-67.

**AOAC. 2005.** Association of Official Analytical Chemists, *Official methods of Analysis.* 15th edition, Washington, D. C.

**Biya, A. J., Kannan, A., Murugan, M., and Anil, K. S. 2008**. Effect of Different Feeding Systems on the Carcass Characteristics of New Zealand White rabbit. Department of Livestock Production Mgt., College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala. *Journal of Animal Science* 67: 57-60.

**Blasco, A., Ouhayoun, J., Mansoero, G. 1992**. Status of Rabbit Meat: Criteria and Terminology. Options Med: Terranean's – *Series Seminaries*; 17; 105-120.

**Booth, F. E. M. and Wickens, G. E. 1988.** Non-Timber Uses of Selected Arid Zone Trees and Shrubs in Africa. FAO conservation guide, Rome, pp 92-101.

**Cheeke, P. R., M. A. Grobener and N. M. Patton. 1986**: Fibre Digestion and Utilization in Rabbits. *Journal of Applied Rabbit Research*. 9: 25-30.

**Choladda, V. C. 2012**. Mean Corpuscular Volume (MCV). Practical Haematology 8th Edition Longman Group Limited. pp 22-28.

**El-Badawi, A. Y., Omer, H. A. A., Abedo, A. A. and Yacout, M. H. M. 2014**. Response of Growing New Zealand White Rabbits to Rations Supplemented with Different Level of *Moringa oleifera* Dry Leaves. *Global Veterinarian*, 12(4): 573-582.

**Ewuola, E. O, and Egbunike, G. N. 2008**. Haematological and Serum Biochemical Response of Growing Rabbits Bucks Fed Different Levels of Dietary Fumonisin V1. *African Journal of Biotechnology.*, 7; 4304-4309.

**Fadiyimu, A. A, Alokan, J. A, and Fajemisin, A. N. 2010**. Digestibility, Nitrogen Balance and Haematological Profile of West African Dwarf Sheep Fed Dietary Levels of *Moringa oleifera* as Supplement to *Panicum maximum*. *Journal of American Science*; 6(10):634-643.

**Foidl, N. and Paul, R. 2008.** *Moringa oleifera*. In: The Encyclopedia of Fruit and Nutrition, Foidl, N. and R. Paul (Eds.). ABI, Oxfordshire, UK., pp: 509-512.

**Food Agriculture Organization, 1997**. The Rabbit Husbandry, Health and Production. FAO Animal Production and Health Series No. 21, Food and Agriculture Organization of the United Nations, Rome, Italy.

**Iyayi, E. A., Oluwakemi, O. and Odueso, M. 2003**. Response of Some Metabolic and Biochemical Indices in Rabbits Fed Varying Levels of Dietary MOL. *African Journal of Biomedical Research,* 6(1): 43-47.

**Jiwuba, P. C, Okechukwu, S. O, Onyekwere, M. U, Olabode, A. D, Ugwu D. O, Ogbuewu P. I, Ahamefule, F. O. 2016.** Performance of West African Dwarf (WAD) Goats Fed *Moringa oleifera* Leaf Meal; *in Proceeding of 41st Annual Conference for Nigeria Society for Animal Production (NSAP)*. 2016;711-714.

**Kpodékon, T. M, Youssao A. K, Tossou C. M, Djago A.Y and Coudert P. 2008**. Effects of Molasses Incorporation in Rabbit Fattening Diet on Growth Performances. 9th

World Rabbit Congress, June 10-13, Verona-Italy, pp: 123-125.

**Lebas, F. 1987.** Reflection on Rabbit Nutrition with a Special Emphasis on Feed Ingredients Utilization. Cuniculture, *Chemin de Lassére*, 31450 France.

**Lebas, F. 2002.** Role of Dietary Fibre in Rabbit Nutrition and in Digestive Troubles Prevention. 2nd *Rabbit Congress of the Americas*, Habana City, Cuba, June 19-22.

**Lukefahr, S. and Goldman, M. 1990.** A Technical Assessment of Production and Economic Aspect of Small-Scale Rabbit Farming in Cameroon. *Journal of Applied Rabbit Research*., 8: 126-135.

**Makkar, H. P. S. and Becker, K. 1997.** Nutritional value and nutritional components of whole and extracted *Moringa oleifera* Leaves. Animal Feed Science and Technology 63: 211 – 228.

**National Research Council. 1995.** Nutrient Requirement of livestock. 8th Revised Edition. National Academy press-Washington D.C.

**Nuhu, F. 2010.** Effect of *Moringa oleifera* Leaf Meal (MOLM) on Nutrient Digestibility, Growth, Carcass and Blood Indices of Weaner Rabbits. M.Sc. Thesis, Faculty of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. pp 75-82.

**Olofin, E. A Nabegu, A. B. and Dambazau, A. M. 2008**, Wudil within Kano zone Geographical synthesis, 1st edition, Adamu Joji Publisher. Department of Geography Kano State University of Science and Technology, Wudil.

**Olorode, B. R., Adeniran, R. A. and Abiola, J. O. 2007.** Effect of Graded levels of *Moringa oleifera* Seed Meal on Haematological Values and Organ Weight of Broiler Chicken. Tropical *Journal of Animal Science*; 10: 63-67.

**Onifade A. A. and Tewe, O. O. 1993**. Alternative Tropical Energy Feed Performance in Rabbit Diets: Growth Performance, Diets Digestibility and Blood Composition. *World Rabbits Science*; 1:17–24.

**Research Animal Resource (RAR) 2009**. Reference values for laboratory animals: Normal haemotological values. RAR websites, RAR, University of Minnesota; pp 187.

**Sabayo, J. C., Okunbanjo, O. A., Adeyemi, A. O. and Usman, J. M. 2007**. Nutritional Evaluation of Graded Levels of Maize Gluten in Rabbits diets. *Proceedings Annual Conference of the 32nd Nigeria Society of Animal Production proceeding*. University of Calabar 18th-21th March, pp: 268-269.

**SAS, 2002.** User's Guide Statistic Version 6th Edition, SAS Statistical Package Inc, Cary, North Carolina, U.S.A.

**Silva, F. and Azevedo, C. A. V. 2009.** Principal Components Analysis in the Software Assistant Statistical Attendance. In: *World Congress on Computers in Agriculture. American Society of Agricultural and Biological Engineers* pp-77.

**Solomon, I. P., Monsi, A. and Zitte, F. I. 1998.** Physiological haematological and biochemical evaluation of Grass cutter and rabbit. In: *Proceedings of Nigeria Society for Animal Production*. Abeokuta, pp 405.

**Spreadburg, D. and Davidson, J. 1978.** A study of Fibre Utilization by the Growing New Zealand White Rabbits. *Journal of Science and Food Agriculture*. 29:640 – 648.

**Tesfaye A, Pornsri C, Pravee V, and**

**Sayan T. 2005.** The Potential of Urea Treated Maize Stover and *Moringa oleifera* Fodder for Growth Performance of Weaned Crossbred Calves. Kasetsart. *Journal of National Science*. 2005;39638- 646.

**Ufele, A. N., Ebenebe, C. I., Igwe, I. I., Mojbo,T. C., Akeinne, F. C. and Aziagba, B. O. 2013.** Drumstick Tree (*Moringa oleifera*) leaf meal on the average weight gain of domestic rabbits (*Oryctolagus cuniculus*). *The Bio-Scientist*, 1(1): 106-112.

**Yahaya, M. B., Kibon, A. 2013.** Effect of Supplementation and Voluntary Feed Intake in Red Sokoto Goats Offered a Basal Diet of Treated Maize Stover. *International Journal of Agriculture and Bioscience*.; 2 (1): 30-34

**Yakubu, A., Adua, M. M. and Adamude, H. 2008.** Welfare and Haematological Indices of Weaner Rabbits as Affected by Stocking Density. *9thWorld Rabbit Congress*- June 10-13, Verona, Italy.

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