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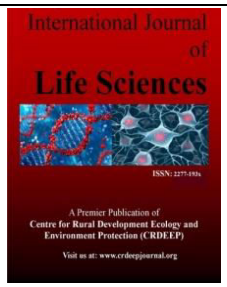

Full Length Research Paper

Effects of Graded levels of *Moringa oleifera* leaf meal on Growth performance, Semen Quality Indices, Blood Profile and Carcass characteristics of Rabbit Bucks

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ABSTRACT

This study was carried out to evaluate the effects of graded levels of *Moringa oleifera* leaf meal (MOLM) on growth performance, blood profile, semen quality indices and carcass characteristics of rabbit bucks. A total of 20 pre-pubertal mixed breed male rabbits with age ranging from 11-13 weeks were randomly allotted in a completely randomized design (CRD) into four treatments, with five replicate per treatment denoted as T1, T2, T3 and T4 respectively. Rabbits in T1 (control) were fed with standard compounded diet devoid of MOLM while rabbits in T2, T3 and T4 were fed with diets containing 5, 10 and 15% MOLM as replacements for groundnut cake. The experimental animals were fed ad libitum for 16 weeks. Data were collected on growth performance parameters, haematology, serum biochemistry semen quality indices and carcass characteristics of the rabbits. The data were subjected to analysis of variance (ANOVA) using SAS software. The results obtained revealed that growth performance indices were similar ($p>0.05$) among the treatments, serum biochemical parameters were not significantly influenced ($p>0.05$). However in haematological parameters only white blood cells and lymphocytes were significantly ($p<0.05$) reduced with increasing levels of MOLM. The results also revealed that semen quality indices were not significantly ($p>0.05$) affected by the treatments while the relative weights of some carcass cuts and organs statistically increased ($p<0.05$) across the treatments. These results suggest that *Moringa oleifera* leaf meal could effectively and safely replace groundnut cake without compromising the overall performance of rabbits.

Introduction

Consumers' preference for rabbit meat is on the rise as compared to other meat sources mainly because of its unique attributes of low cholesterol and sodium levels (Iyabode *et al*, 2014). Others attributes of its meat include high quality protein, finely grained, content of minerals superior to other meats, high meat yield and its general acceptability (Amaefule *et al.*, 2005). Also high prolificacy, as well as easiness and cheapness of maintaining its production cannot be dismissed as underlying factors for increasing production of rabbits.

Rabbits as livestock species possess the ability to thrive on plant materials based diet and are able to utilize them by efficiently converting them into useful animal protein for human consumption. This has been attributed to digestive anatomy and feeding habit of rabbits (Omole and Ajayi, 2006).

Feeding is one of the most important aspects of rabbit production and management which also depend largely on the use of conventional feedstuffs. However, reports have made it evident that the conventional sources of feed can no longer adequately meet the needs of the exponentially growing livestock industry (Abubakar, 2008). This has aroused the interest among the animal nutritionists in the search and use of unconventional feedstuffs as alternative ingredients to particularly replace those that are directly competed for by livestock with humans and *Moringa oleifera* had significantly gained wide acceptability in this respect.

Moringa oleifera leaf meal is obtained from *Moringa oleifera* plant which is widely cultivated in different regions of the world mainly because of its nutritional and pharmaceutical potential (Makkar and Bekker, 1996). *Moringa oleifera* leaf meal has

become one of the most popular unconventional feedstuffs of plant origin in animal nutrition. High contents of protein, vitamins and minerals found in *Moringa oleifera* leaf have indeed encouraged its use as an alternative feedstuff in animal feed formulation (Church World Service, 1994; Olugbemi *et al*., 2010; Odetola *et al*., 2012; Tijani *et al*., 2016).

The use and effects of *Moringa oleifera* leaf meal in diets have been reported for diverse livestock species (Olatunji *et al.*, 2015; Tijani*et al.*, 2016; Ahmad *et al*., 2017; Saswan *et al*., 2017; Damor *et al*., 2017). However, data on the implications of incorporating *Moringa oleifera* leaf meal in the diets of rabbit buck are still scanty. Therefore, this research aimed to study the effect of graded levels of *Moringa oleifera* leaf meal on growth performance, semen quality indices, carcass characteristics as well as haematology and serum biochemistry of rabbit bucks.

Materials and methods

Description and preparation of the experimental site

The experiment was carried out in the Rabbitary Units of the Teaching and Research Farm, Ekiti State university, Ado Ekiti, Ekiti State, Nigeria. The location lies between latitude $7^0 3^1$and $7^0 54^1$ and longitude 5^0 and 27^1, with a tropical climate and distinct wet and dry seasons. The rainy season spans over seven months starting from March to October. Temperature in this area is fairly uniform throughout the year with very little deviation from mean annual of 27^0C. The topography is moderately sloppy.

The experimental site was thoroughly washed and fumigated with disinfectant prior to the arrival of the rabbits. The hutches, feeders and drinkers were thoroughly washed and sanitized.

Preparation of *Moringa oleifera* leaf meal (MOLM)

Fresh leaves of *Moringa oleifera* were harvested within and outside Ekiti State University Campus after which they were air-dried under the shade for some days to a suitable moisture content which allowed the dried leaves to be processed and milled into powdery form.

Experimental diets

The diets were formulated to meet the nutritional requirements of the rabbits as shown in table 1 containing 0, 5, 10 and 15g/100g of *Moringa oleifera* leaf meal in Treatments 1, 2, 3 and 4 respectively.

Table 1: Composition of the experimental diets g/100g

	Treatments			
Ingredients	T1 (0%MOLM)	T2 (5%MOLM)	T3 (10%MOLM)	T4 (15%MOLM)
Maize	35.00	35.00	35.00	35.00
Soybeans	6.00	6.00	6.00	6.00
GNC	20.50	20.50	20.50	20.50
Bone meal	3.00	3.00	3.00	3.00
Salt	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25
Wheat offal	15.00	15.00	15.00	15.00
PKC	20.00	20.00	20.00	20.00
MOLM	0.00	5.00	10.00	15.00
Total	100	100	100	100
Calculated Analysis				
Crude protein	21.43	20.34	19.30	18.25
Crude fiber	5.80	5.90	5.96	6.00

Experimental animals and management

A total of twenty male pre-pubertal mixed breed rabbitswith weight ranging from 0.54-1.74 kg were acquired from a reputable source and used for this study. They were allowed to acclimatize to the new environment prior to the commencement of the experiment. Adequate management such as feeding and housing were provided. Standard hygiene practices were also maintained. The feeding trial lasted for eight weeks.

Experimental design

The experimental design used for this study is completely randomized design (CRD). The bucks were randomly allotted into four experimental treatment groups and each treatment is further replicated five times with a rabbit per replicate.

Samples analysis and data collection

Growth performance

Data on weight gain were collected using weighing scale by subtracting the initial body weight from the final body weight. It was calculated and recorded averagely on g/day basis.

Data on feed intake was collected on weekly basis using the weighing scale to measure the quantity of feed offered and leftover. Differences between the feed offered and the feed leftover were calculated and recorded averagely on g/day basis.

The feed conversion ratio was calculated as ratio of feed consumed in kg to weight gain in kg.

$$\text{FCR} = \frac{\text{Weight of feed}}{\text{Weight gain}}$$

Sperm volume and colour

Ejaculate volume and colour were evaluated following the methods described by Ogunlade (2015).

Motility
This was determined by method described by Bearden and Fuquay (1997). 5µl of semen sample was directly placed on heated microscope slide and overlay with 22×22mm cover slip. Five microscope fields were viewed for each sample for observation of spermatozoa exhibiting motility, that is, movement. Averages of the five successive evaluations were recorded as the final motility scores.

Sperm Morphology
Evaluation of sperm abnormality was done according to the procedure described by Bearden and Fuquay (1997) with the use of eosin-nigrosin smear. A thin smear of a mixture of semen and eosin-nigrosin stain solution was drawn across the slide and dried. Two hundred and forty spermatozoa were counted and morphologically abnormal spermatozoa with defects in the head, midpiece and tail observed at 400× magnification under light microscope.

Livability
This was evaluated by standard eosin-nigrosin staining method procedure describe by Sidhu and Guaraya (1985). A drop of diluted semen mixed with eight drops of stain was incubated at 300C for 5mins. Smears were made on pre-warmed slide and allowed to dry at 30^0C. Excess stain was washed off in running tap water. The slide was briefly immersed in ethanol to remove water. The mounted smeared slide was observed under 400× objective lens of light microscope (Olympus). 100 sperm were counted on four different fields and means recorded as the final scores.

Sperm concentration
Evaluation of semen for spermatozoa concentration was done according to the method of Zaneveld and Polaski (1987).

Carcass characteristics and organs weight
At the termination of the feeding trial, two representative rabbits randomly selected from each experimental group were fasted overnight (12 hours), weighed and slaughtered by cervical dislocation followed by exsanguination. After complete bleeding, the collected drained blood was weighed and recorded. The slaughtered animals were eviscerated and dressed weights were recorded. Offals were also weighed and recorded separately. Both carcass cuts and organs weights were expressed relatively, that is their percentages of the animal's live body weight.

Blood collection and analysis
Three rabbits were randomly selected from each treatment for blood collection. The rabbits were bled through marginal auricular vein and blood samples were collected using 2ml syringe and emptied into vacutainer containing Ethylene Diamine Tetra Acetic Acid (EDTA) for haematology. The tubes were immediately capped and gently mixed by repeated inversion to ensure proper mixture of the blood with the anticoagulant (EDTA) to prevent clotting.

Blood samples for serum biochemical assay were however collected into vacutainer tubes devoid of anticoagulants. The tubes were kept in wooden rack and the blood samples were allowed to clot and the serum were separated by decanting which were kept deep frozen prior to analysis.

Red blood cell determination
The red blood cell was determined using improved Neubaeur haemocytometer method. 2ml of Grower's solution was added to 1ml of blood sample in test tubes. The Grower's solution helps to stain the cells and avoid clotting. The RBC was counted under the light microscope, using a steady counter and the calculation was done using the formula:

RBC (x^6/mm^3) = number of cell counted ×depth of cell × dilution factor × area of cells.

Haemoglobin determination
Haemoglobin concentration determination was done by cyanmethemoglobin method. The haemoglobin from a whole blood sample is released from erythrocyte and oxidized by ferricyanideto methemoglobin. The methemoglobin was further converted by cyanide to thestable cyanmethemoglobin. The absorbance of cyanmethemoglobin was measured at 540 nm wavelength and is directly proportional to the haemoglobin concentration in the sample.

Measurement of packed cell volume
PCV was determined by micro-method using plain capillary tubes of 75mm in length and 1mm internal diameter. The blood was allowed to enter the tube by capillary action, leaving at least 15mm unfilled. The tube was then sealed by heating the dry end of the tube in a fine flame of Bunsen burner, after which the sealed tubes were placed a special high-speed centrifuge. The tubes were centrifuged for 10 min at 3,000 rpm, then the packed cells read from a scale (haematocrit) held against the capillary tubes in a way the top of the plasma column coincides with the 100% line and the bottom of the packed red cells falls on the zero line.

Calculation of corpuscular constants
The mean corpuscular volume (MCV) was calculated using the formula:

$$\text{MCV (fl)} = \frac{\text{haematocrit (PCV)} \times 10}{\text{RBC in millions/mm}^3}$$

The mean corpuscular haemoglobin was calculated using the formula:

$$\text{MCH (pg)} = \frac{\text{Hb in/100mml blood} \times 100}{\text{RBC in millions/mm}^3}$$

The mean corpuscular haemoglobin concentration (MCHC) was calculated using the formula:

$$\text{MCHC} = \frac{\text{Hb in g/100mml blood} \times 100}{\text{Haematocrit (PCV)}}$$

White blood cell and differential leucocyte counts
The total leucocyte count was determined using the improved Neubaeur haemocytometer after appropriate dilution and differential leucocyte counts was performed using oil-immersion objective examination of blood films stained with modified Romanvosky's Giesma stain.

Determination of serum total protein
The total protein was determined using the biuret method. 4ml of biuret solution was used on 50µl of serum sample. The mixture was incubated at room temperature for 10 minutes and reading was done in spectrophotometer at 540nm wavelength.

Determination of Albumin value
The serum albumin was determined using the bromocresol green dye-binding (BCG) method. 300ml of bromocresol green reagent was added to 0.01ml of serum sample. The mixture was incubated at room temperature for 5 minutes and reading was done in spectrophotometer at 630nm wavelength.

Determination of serum globulin
Serum globulin was evaluated using the following formula: Globulin = Total protein-Albumin.

Determination of Albumin/Globulin ratio
Albumin/globulin ratio was determined by dividing the albumin value by calculated globulin value.

Determination of Cholesterol
Cholesterol was determined by enzymatic hydrolysis and oxidation using CHOD-POD method (cholesterol liquicolour). This is an enzymatic calorimetric test for cholesterol with lipid clearing factor (LCF). The indicator quinoeinine is formed from hydrogen peroxide and 4-amino-phenazone in the presence of phenol and peroxide.

Determination of glucose
Fresh blood samples were collected in anticoagulant bottles containing flouride oxalate. The samples were spun in centrifuge at 3,000 rpm for 10 minutes to retract the plasma. The plasma was incubated for 10 minutes, 1000µl of distilled water was added to halt the reaction and reading was done in spectrophotometer at 500nm wavelength.

Determination of AST and ALT
Aspartate aminotransferase (ALT) and Alanine aminotransferase activities in serum were determined at 37^0C by colorimetric method described by Reitman and Frankel (1957).

Statistical analysis of data
All data collected were subjected to analysis of variance (ANOVA) using statistical analysis software (SAS, 1999) and means were separated using Duncan's procedure of the same software.

Results
Table 2 shows the growth performance of rabbits fed diets containing graded levels of MOLM. The various inclusion levels of MOLM did not significantly ($p>0.05$) affect the growth performance parameters which include feed intake, weight gain and feed conversion ratio across the treatments. However, feed intake range from 89.42g/day in treatment 1 to 92.08g/day in treatment 4, while weight gain range from 9.14g/day in treatment 2 to 11.43 g/day in treatments 1 and 4 respectively. Feed conversion ratio range from 7.83 in treatment 1 to 9.70 in treatment 2.

Table 2: Growth performance of rabbit bucks fed diets containing graded levels of MOLM

	Treatments				
Parameters	T1 (0%MOLM)	T2 (5%MOLM)	T3 (10%MOLM)	T4 (15%MOLM)	SEM
Initial weight (g)	990.00	990.00	990.00	990.00	0.00
Final weight (g)	1530.00	1360.00	1400.00	1510.00	-
Feed intake (g/day)	89.42	88.63	86.28	92.08	3.27
ADWG (g/day)	11.43	9.14	9.71	11.43	0.75
FCR	7.83	9.70	8.88	8.06	4.48

ADWG: Average daily weight gain, FCR: Feed conversion ratio, MOLM: Moringa oleifera leaf meal,SEM: Standard error of mean.

The haematology of rabbits fed diets with graded levels of MOLM supplemented diets is shown in table 3. The results indicated that the diets did not significantly ($p>0.05$) affect packed cell volume, red blood cell count, haemoglobin concentration, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, platelets, heterocytes, monocytes and eosinophils. However, the diets significantly ($p<0.05$) influenced white blood cell count and lymphocytes.

Table 3: Haematology of rabbits fed diets containing graded levels of MOLM.

	Treatments				
Parameters	T1 (0%MOLM)	T2 (5%MOLM)	T3 (10%MOLM)	T4 (15%MOLM)	SEM
PCV (%)	34.00	37.00	36.00	33.50	2.66
HbC (g/dL)	11.25	12.30	11.55	11.20	0.75
RBC ($\times10^6$µL)	5.57	5.99	6.15	5.93	0.57
WBC ($\times10^3$µL)	7025.00^a	7000.00^{ab}	5950.00^b	6475.00^{ab}	233.63
Platelets ($\times10^2$)	2595.00	1520.00	2130.00	2495.00	432.71
Lymphocytes (%)	65.00^a	64.00^a	66.50^a	57.50^b	0.65
Heterocytes (%)	35.50	31.00	29.50	37.50	3.20
Monocytes (%)	1.50	3.00	1.50	2.00	0.65
Eosinophils (%)	3.00	2.00	2.50	3.00	0.25
MCV (fL)	61.48	61.89	58.53	56.46	1.88

MCH (pg)	20.39	20.58	18.19	18.89	0.76
MCHC (g/dL)	33.14	33.24	32.08	33.48	0.45

Means with different superscripts in the same row are significantly different (p<0.05). PCV: Packed cell volume, HbC: Haemoglobin concentration, RBC: Red blood cell, WBC: White blood cell, MCV: Mean cell volume, MCH: Mean corpuscular haemoglobin, MCHC: Mean corpuscular haemoglobin concentration.MOLM: Moringa oleifera leaf meal, SEM: Standard error of mean.

Table 4 reveals the effect of diets containing graded levels of MOLM on serum biochemistry of rabbit bucks. None of the serum biochemical parameters which include aspartate amino transferase, alanine amino transferase, total cholesterol, albumin, total protein, globulin and albumin-globulin ratio were significantly (p>0.05) affected by the experimental diets.

Table 4: Effect of diets containing graded levels of MOLM on serum biochemistry of rabbit bucks.

	Treatments				
Parameters	T1 (0%MOLM)	T2 (5%MOLM)	T3 (10%MOLM)	T4 (15%MOLM)	SEM
Total protein (g/dL)	6.13	5.26	5.47	4.39	0.39
Albumin (g/dL)	2.83	2.64	2.67	2.34	0.31
Globulin (g/dL)	3.32	2.62	2.80	1.96	0.60
Albumin/globulin	0.85	1.40	1.39	1.25	0.43
Cholesterol (g/dL)	91.31	59.98	58.20	46.20	18.72
AST (g/dL)	19.63	16.83	16.62	16.18	1.43
ALT (g/dL)	4.88	7.22	7.76	8.24	2.17

AST: Aspartate amino transferase; ALT: Alanine amino transferase; MOLM: Moringa oleifera leaf meal; SEM: Standard error of mean.

Table 5 shows the effect of diets containing graded levels of MOLM on semen characteristics of rabbit bucks. The results indicated that fertility indices of bucks spermatozoa such as motility, viability, concentration, morphology (normal and abnormal), volume and colour were not significantly (p<0.05) affected by the experimental diets.

Table 5: Effect of diets containing graded levels of MOLM on semen characteristics of rabbit bucks.

	Treatments				
Parameters	T1 (0%MOLM)	T2 (5%MOLM)	T3 (10%MOLM)	T4 (15%MOLM)	SEM
Motility (%)	62.50	65.00	72.50	75.00	5.40
Viability (%)	72.50	70.00	70.00	70.00	3.15
Concentration (10^6)	140.50	242.60	250.45	245.00	113.23
Normal (%)	77.50	77.50	82.50	82.50	2.50
Abnormal (%)	22.50	22.50	17.50	17.50	2.50
Volume (ml)	0.50	0.60	0.40	0.45	0.19
Colour	Milky	Milky	Milky	Milky	

MOLM: Moringa oleifera leaf meal, SEM: Standard error of mean.

Relative carcass weight of rabbit bucks fed diets containing varied levels of MOLM is shown in table 6. Bled weight, dressed weight, head and hind quarter weights were significantly (p<0.05) affected whereas, eviscerated weight, hind feet weight, rib weight, fore quarter weight, back weight, fore feet weight and tail weight were not significantly (p>0.05) influenced.

Table 6: Effect of diets containing graded levels of MOLM on relative carcass cuts weight (%) of rabbit bucks.

	Treatments				
Parameters	T1 (0%MOLM)	T2 (5%MOLM)	T3 (10%MOLM)	T4 (15%MOLM)	SEM
Bled weight	97.39^{ab}	98.06^{a}	98.51^{a}	95.47^{b}	0.98
Dressed weight	92.03^{ab}	91.89^{ab}	94.60^{a}	89.84^{b}	0.79
Eviscerated weight	59.47	58.47	54.33	57.92	2.91
Head weight	10.77^{b}	10.49^{b}	12.03^{a}	10.94^{ab}	0.27
Hind feet weight	1.44	1.62	1.81	1.43	0.14
Rib weight	10.53	10.70	9.69	11.92	1.13
Fore quarter weight	11.26	10.34	9.22	10.37	0.83
Hind quarter weight	17.98^{b}	22.09^{a}	17.41^{b}	19.11^{b}	0.49

Back weight	16.51	11.53	13.94	12.21	2.25
Fore feet weight	0.71	0.66	0.85	0.64	0.16
Tail weight	5.91	0.74	0.88	0.83	2.47

Means with different superscripts in the same row are significantly different (p<0.05). MOLM: Moringa oleifera leaf meal, SEM: Standard error of mean.

Table 7 displays the effect of feeding diets supplemented with different levels of MOLM on relative organs weight of rabbit bucks. Liver, lung, filled gut and kidney weights were not significantly (p>0.05) affected by the treatments. However, heart weight was significantly affected. The pattern of influence did not follow a particular sequence.

Table 7: Effect of diets containing graded levels of MOLM on relative (%) organ weight of rabbit bucks.

	Treatments				
Parameters	T1 (0%MOLM)	T2 (5%MOLM)	T3 (10%MOLM)	T4 (15%MOLM)	SEM
Liver weight (%)	2.01	2.20	2.10	2.26	0.19
Lung weight (%)	0.60	0.69	0.61	0.60	0.09
Heart weight (%)	0.19^{b}	0.31^{a}	0.19^{b}	0.23^{b}	0.01
Filled gut weight (%)	13.14	12.03	16.58	14.59	1.19
Kidney weight (%)	0.75	0.65	0.62	0.61	0.13

Means with different superscripts in the same row are significantly different (p<0.05). MOLM: Moringa oleifera leaf meal, SEM: Standard error of mean.

Discussion

As revealed by the results, none of the growth performance index of rabbits was significantly affected by the experimental diets. Similar reports have been made by previous findings. Olatunji *et al*. (2016) did not observe significance influence of feeding ration supplemented with graded levels of MOLM on final weight of growing rabbits. Similarly, Odetola *et al*. (2012) did not observe influence of feeding grade level of MOLM as replacement for soybeans meal on both weight gain and feed intake of rabbits but however reported significant effect on feed conversion ratio. Significance influence in FCR has been attributed to superior growth rate and weight gain of rabbits (Okorie, 2003; Odetola *et al*., 2012).

Growth performance of other animal species fed MOLM have also been documented. Onukwo *et al*. (2015) reported no significant of using MOLM at 5, 7.5 and 10% in boiler diets on growth performance. The non-significant differences may be suggesting that MOLM supplemented diets are utilized in a similar manner as the standard (control) diet by the rabbits.

Haematological characteristics are used to assess the physiological disposition of livestock to the plane of nutrition (Maduike and Ekenyem, 2006). Merck (2012) stated that red blood cells, white blood cells and platelets are used in the diagnosis and monitoring of disease. Decrease in Haemoglobin concentration and packed cell volume below 30% may result to anaemia (Jenkin, 2008). In the present study, haematology parameters observed were within the normal physiological ranges reported for rabbits (RAR, 2009). PCV values obtained in this study falls within the normal physiological range documented by Burn and Lannoy (1966). Normal PCV value is an indication of adequate nutritional status of the rabbits (Adejumo, 2004). This implies that MOLM provides the adequate nutrients to support the normal process of erythropoiesis. This findings corroborates that of Okeke *et al*. (2009) who also reported that feeding MOLM to rabbits did not detrimentally affect the PCV.

Normal physiological range of Red blood cells for rabbits documented by Mitruka and Rawnsley (1977) was 5.46-7.94×$10^{6}$$mm^{3}$. The values of RBC obtained in this study conformed to this range. As obtained in this study, Ewuola*et al*., (2012) reported that there was no significant effect of feeding MOLM on RBC of growing rabbits.

Haemoglobin concentration among the treatments were not significantly influenced in this present study, contrary observation was made by Terzungwe *et al*. (2013) who reported significant increase in Haemoglobin concentration in rabbits fed graded levels of MOLM. However, Hbvalues obtained in this study fall within the normal physiological range (10.4-17.4g/dL) for rabbits (Mitruka and Rawnsley, 1977). Correlation has been established between Haemoglobin concentration and protein quality as low quality protein diets has been implicated to induce low haemoglobin concentration in rabbits (Abu *et al*., 1988). Therefore, the result obtained for haemoglobin in this study further validate that protein of MOLM is of high quality.

The values obtained for RBC indices, that is, mean cell volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were within the normal physiological range for rabbits (Mitruka and Rawnsley, 1977). RBC indices are important in differential diagnosis of different anaemic conditions (Campbell, 1988). Therefore it could be inferred that the experimental diets in this study did not induce anaemia.

Even though the white blood cells (WBC) obtained in this study differs statistically among treatments, they were however within the acceptable range documented for physiologically normal rabbits (Mitruka and Rawnsley, 1977). Abnormal decrease in WBCs below the normal physiological range for rabbits is

suggestive of certain parasitism and allergic conditions while abnormally higher values indicate recent infection in animals (Ahamefule *et al*., 2008). Therefore in this study, the experimental diets did not compromise the health of the rabbits. White blood cells differential counts of rabbits were not significantly influenced by graded levels of MOLM in diets. Terzungwe *et al*. (2013) made a similar report from his study where he reported no significant influence of graded levels of MOLM on WBCs differential counts of rabbits. Normal differential counts is indicative of normal immune system functioning.

Total serum protein, albumin and globulin values obtained in this study were similar to those reported Terzungwe *et al*. (2013) who also observed no significance influence of graded levels of MOLM on rabbits. However, Omara *et al*. (2017) observed a contrast result who reported significant increase in serum protein with increasing MOLM in rabbit buck diets which was attributed to higher protein content in the feed. Quality and quantity of protein intake have been reported to influence total protein, albumin and globulin of serum (Onifade and Tewe, 1993). Therefore, the results obtained in this study indicated that the experimental diets were not deficient with respect to protein quality and quantity.

In this study, serum cholesterol decreased linearly across the treatments. *Moringa oleifera* have been reported to exert hypocholesterolemic effect in several species (Gashi *et al*., 2000; Jiwuba *et al.*, 2016; Omara *et al*., 2017).

Serum enzymes particularly AST and ALT are vital markers of various organs and tissue disorders arising from toxicity or disease conditions and are therefore used to assess or monitor the health status of different organs and tissues with the animal's body. Similar to what is observed in this study, using up to 15% MOLM by Ewuola (2012) and up to 20% MOLM by Olatunji *et al*. (2013) respectively did not significantly affect rabbit serum AST and ALT levels. Therefore it could be inferred that using up to 15% MOLM in rabbits' diets did not pose any significant risk of organ and tissue damage.

Sperm motility and concentration has been described as the most vital indices of fertility (Brun *et al*., 2002). Even though in this present study, significant differences were not observed across the treatment groups, however the values tend to increase with increasing level of MOLM. Similar reports have been made by previous researchers. Abu and Ikpechukwu (2003) reported an improvement in semen quality of rabbit bucks when diet was supplemented with up to 15% MOLM. ELDeeb *et al*. (2015) documented that rabbits fed diet supplemented with 4% MOLM produced sperms that are more superior in motility compared to those in control without MOLM in the diet. Livability and abnormality describe viability and morphological or structural defect of sperm respectively. Both parameters are very important indices of fertilization and were not adversely affected in cock fed diets containing MOLM in comparison to those in control in this study. This is suggesting that MOLM did not exert any residual cytotoxic effect on sperm cells.

Some carcass characteristics (bled weight, dressed weight, head weight and hind quarter weight) and kidney weight relative to the live body weight were significantly affected by treatment diets. Effects of MOLM on carcass characteristics of rabbits have been documented by previous researchers. Odetola *et al*. (2012) reported significant influence of replacing soybean meal with MOLM at 0, 5, 10 and 15% in rabbits' diets on carcass and organ weight particularly on loin, hind limb, fore limb, spleen, lung and heart. Similar result was also obtained by Omara *et al*. (2017) who reported significance influenceon carcass and organs weights of New Zealand white rabbits when graded level of MOLM (5.48, 10.97 and 16.45%) was used to replace 10, 20 and 30% respectively of protein content in commercial rabbit diet. Omara *et al*. (2017) did provide additional information on abdominal fat content which was not observed in this study. They reported a significant decreased with increasing level of MOLM in comparison to control diet, which was attributed to lower energy value of MOLM containing diets.

Conclusion and recommendation

Growth performance of rabbit bucks were not significantly influenced by the various inclusion levels of MOLM. Inclusion of MOLM up to 15% in diets is safe for feeding rabbit bucks as revealed by haematology and serum biochemistry and neither were the reproductive potentials of rabbit bucks fed MOLM compromised as determined by the ejaculate quality analysis.

Therefore, *Moringa oleifera* leaf meal could be used to replace groundnut cake up to 15 % without any adverse effect on the health status and overall performance of rabbit bucks.

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