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Effects of dietary *Moringa Oleifera* seed meal on obesity, liver and kidney functional parameters of local and exotic chickens

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ABSTRACT

The study aimed at determining the nutrigenetic effect of Moringa oleifera seed meal (MOSM) on obesity, liver and kidney functional parameter of broilers and local chicken. Moringa oleifera has been found to have anti-inflammatory and antipyretic properties. A total of 96 broiler chickens and 96 local chickens were randomly assigned to 4 dietary treatment groups. Each group contained 24 birds (8 birds per replicate in 3 replicates) each for both genotypes of chicken in a factorial layout within a completely randomized design such that birds in each genotype were randomly allocated to four diets (control diet contained 0% MOSM and 5%, 10% and 15% graded levels of MOSM as diets 2, 3 and 4 respectively). Obesity was determined through weekly measurement of body weight and body mass index (BMI). Serum total cholesterol, kidney and liver functioning parameters were determined at week 8 by analyzing for creatinine, ALT, AST and ALP. Broilers exhibited higher creatinine, total cholesterol, ALT, AST and ALP but no significant difference (P>0.05). Broilers exhibited significantly higher (p<0.05) BMI than YENLC. G Ed interactions were observed at age 8 weeks. MOSM resulted in significantly higher (P<0.05) BMI in birds fed 10% MOSM at week 8. Increasing levels of MOSM also yielded reduction in the level of total cholesterol for both genotypes. There was no significant (P>0.05) interaction between genotype and MOSM utilization by the chickens and BMI at week 8, cholesterol, creatinine, ALT, AST and ALP. Thus, dietary intervention through the inclusion of MOSM is effective in lowering heart disease risk through lowering of adiposity (BMI) and cholesterolaemia and it has little or no toxic effect as AST and ALP were not significantly affected.*

Introduction

Feeds account for 60 percent to 70 percent of the whole cost of production in the poultry sector (Nworgu *et al.*, 1999). As a result, there is a pressing need to find alternative feed components that can partially or completely replace some of the standard feedstuffs without sacrificing feed quality or output. (Gueye and Branckaert, 2002).

The use of Moringa (Moringa oleifera), commonly known as "Drumstick tree" or "Miracle tree," as a protein source for animals has received a lot of attention (Makker and Becker, 1997; Sarwatt *et al.*, 2002). Moringa is a simple plant to grow and has a lot of promise for feed production. The plant can be harvested multiple times during a growing season and has the potential to reduce feed costs.

Moringa oleifera is in the family Moringaceae. It is a tree that grows quickly. Moringa can reach a height of 3 meters in its first year. Moringa is a drought-tolerant plant that thrives in arid environments. It's a native of the Indian subcontinent, but it's also widely grown in tropical regions around the world. It's a fast-growing, drought-resistant deciduous tree or shrub with a mature height of 12 meters. Antibiotic, antitrypanosomal, hypotensive, antispasmodic, anti-ulcer, anti-inflammatory, hypocholesterolemic, and hypoglycaemic properties are all found in Moringa (Latif and Gilani, 2007).

Fahey *et al.* (2005) elucidated that the seeds of *Moringa oleifera* are highly useful because of their antibiotic and anti-inflammatory properties to treat

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arthritis, rheumatism, gout, cramp, sexually transmitted diseases and boils. The seeds contain the potent antibiotic and fungicide terygospermin.

Antimicrobial activity of leaves, roots, bark, and seeds against bacteria, yeast, dermatophytes, and helminths pathogenic to humans was examined. *Pseudomonas aeruginosa* and *Staphylococcus aureus* were suppressed by fresh leaf juice and aqueous seed extract. In experimental mice, the seed extract had substantial antibacterial action against the Pyodermia (skin infection) causing bacterium *S. Aureus* (Fahey *et al.,* 2005).

The poultry industry is faced with a lot of challenges as per the cost and availability of conventional feedstuff and the response of different genotypes to different feedstuffs differ. Hence, the need for search for alternative feed ingredients. There is limited study on the utilization of MOSM in chickens and paucity of information on its utilization as it relates to the health of Marshall broilers and Yoruba Ecotype Nigerian local chickens.

The study was aimed to elucidate the comparative effect of the inclusion of MOSM on the obesity, heart, kidney and liver health of Marshall broilers and Yoruba Ecotype Nigerian local chickens in order to determine the comparative genetic response of this feed ingredients at graded levels.

Materials and Methods

Experimental animals, diets, design and management

Moringa oleifera seeds were sourced from markets in Kaduna metropolis. The seed was dried and thereafter crushed after purchase. The seeds were also ground at the feed mill into the chick starter mash and chick finisher mash at the feed mill before incorporating it into the diets of broiler and local chicks. Other feed ingredients were thoroughly mixed with MOSM at the feed mill.

Marshal® breed of broilers were obtained from Bronco Hatchery, Oluyole Extension, Ibadan. The eggs of the Nigerian Local Chickens (NLC) were sourced around Ayede rural community, Egbeda Local Government, Oyo State. The eggs were then taken to Bronco Farm Hatcheries for hatching.

A total of one hundred and ninety two birds comprising of ninety-six broiler chicks and ninety-six local chicks of both sexes were randomly allotted to four dietary treatments containing graded levels of MOSM: 0% (diet 1), 5% (diet 2), 10% (diet 3), 15% (diet 4) fed independently to the broiler chicks and local chickens such that each treatment comprised of three replicates of eight birds each in a completely randomized design. The experimental animals were weighed before feeding at the commencement of the feeding trial and on a weekly basis thereafter until the end of the study.

Bodyweight (BW): Bodyweight in grams (g) was determined on a weekly basis by the use of a sensitive scale.

Body Mass index (BMI): The body mass index was derived by dividing Bodyweight expressed in gram units by the square of body length expressed in cm units, and expressed in Kg/cm^2 units.

Collection of blood samples

Blood samples were collected from the wing web of the experimental birds at age 8 weeks into a set of sterilized dry glass tubes containing no traces of anticoagulant for serum separation within 45 minutes of blood collection. Alanine transaminase (ALT), aspartate transaminase (AST) and alkaline phosphatase (ALP) activities were determined using spectrophotometric methods as described by Rej and Hoder (1983); Hoder and Rej (1983); and McComb *et al.* (1983), respectively. While, the creatinine was determined by Folin-Wu filtrate methods as described by Toro and Ackermann (1975).

Organs' absolute and relative weight determination

After the experimental birds were sacrificed, the carcasses were then cut open and the liver, kidneys and heart were dissected out, blotted free of blood and adhering membranes and weighed. The organ weights were converted into relative weights by the simple formula:

$$\text{Relative organ weight (\%)} = \frac{\text{resh organ weight}}{\text{Live weight}} x\ 100$$

The General Linear Model technique in SPSS Version 22 was used to examine the data (IBM, SPSS). Significant differences were computed using New Duncan multiple range test (Gomez and Gomez, 1984) to determine the significance of specific classes. The appropriate statistical model used was:

$Y_{ijk} = \mu + G_i + M_j + (GM)_{ijk} + \varepsilon_{ijk}$;

Y_{ijk} = observation on kth population, of ith genotype and jth MOSM inclusion;

μ = common mean;

G_i = fixed effect of genotype (i=2);

M_j =fixed effect of MOSM inclusion (j=4);

$(GM)_{ijk}$ = interaction effect of genotype and MOSM;

ε_{ijk} = error term associated with each record (normally, independently and identically distributed with zero mean and constant variance)

Results

Genotype factor effect on Body Mass Index: The broiler had significantly higher body mass index than the YENLC throughout the experiment (Table 1). Diet (different levels of MOSM) factor impact on BMI: BMI was significantly affected ($p < 0.05$) by MOSM from week 5 through week 7, birds fed 5% and 10% MOSM had higher BMI relatively to the control. However, the values were not significantly different ($p > 0.05$) from that of the control (0% MOSM). Factor interaction effect of genotype X diet (graded levels of MOSM) on BMI: Genotype significantly interacted ($p<0.05$) with MOSM inclusion in chickens diets at week 5 to week 7.

BMI effect of graded levels of MOSM within genotype (breed). In the YENLC, from week 5, birds fed 5% MOSM had higher BMI compared to the control while at week 8, birds fed 10% MOSM also had higher BMI than the control group as was presented in Table 2. For broilers, from week 5 to week 8, birds fed 10% MOSM had the highest BMI compared to the control (Table 2).

Table 1. Effects of genotype, dietary *Moringa oleifera* seed meal (MOSM) level (0, 5, 10 and 15 %) from 0 to 8 weeks of age as well as their interaction on BMI.

Age	Genotype		Diet				Breed × Diet
	YENLC ALL	Marshall ALL	0% MOSM	5% MOSM	10% MOSM	15% MOSM	
Week 1	0.38 ± 0.01	0.54 ± 0.01	0.45 ± 0.01 ^{a}	0.45 ± 0.02 ^{a}	0.43 ± 0.02^{a}	0.51 ± 0.02^{b}	NS
Week 2	0.46 ± 0.01	0.62 ± 0.01	0.58 ± 0.02 ^{b}	0.56 ± 0.02 ^{b}	0.55 ± 0.02 ^{b}	0.49 ± 0.02 ^{a}	NS
Week 3	0.55 ± 0.01	0.67 ± 0.01	0.67 ± 0.02 ^{c}	0.68 ± 0.03 ^{c}	0.6 ± 0.02 ^{b}	0.53 ± 0.02 ^{a}	NS
Week 4	0.52 ± 0.02	0.65 ± 0.02	0.64 ± 0.02 ^{b}	0.63 ± 0.03^{b}	0.59 ± 0.03 ^{b}	0.5 ± 0.02 ^{a}	NS
Week 5	0.55 ± 0.01	0.71 ± 0.02	0.67 ± 0.03^{b}	0.71 ± 0.03 ^{b}	0.67 ± 0.03^{b}	0.51 ± 0.02 ^{a}	*
Week 6	0.64 ± 0.02	0.78 ± 0.03	0.69 ± 0.02 b	0.77 ± 0.03 ^{bc}	0.81 ± 0.04^{c}	0.61 ± 0.03^{a}	*
Week 7	0.57 ± 0.02	0.81 ± 0.02	0.69 ± 0.03^{ab}	0.74 ± 0.03^{b}	0.76 ± 0.04^{b}	0.63 ± 0.03^{a}	*
Week 8	0.55 ± 0.02	0.81 ± 0.02	0.7 ± 0.03^{b}	0.73 ± 0.04 ^{b}	0.78 ± 0.04^{b}	0.58 ± 0.03^{a}	NS

Note: $^{a, b, c}$ Means with different superscripts within a row are significantly different; Group mean, standard error and number count of samples (x±sem(n)) shown; *(p<0.05), NS – non-significance, G – Genotype, MOSM – Moringa oleifera Seed meal; Breed X Diet – Interaction between breed and diet.

Table 2. Means (±SEM) BMI of yoruba nigerian local chicken and marshall broiler chickens fed *Moringa oleifera* seed meal (MOSM) at different levels from hatch to 8 weeks age.

Trait/Age	Yoruba Ecotype Nigerian local chicken				Marshall Broiler			
	0% MOSM	5% MOSM	10% MOSM	15% MOSM	0% MOSM	5% MOSM	10% MOSM	15% MOSM
Week 1	0.40±0.02^{a}	0.36±0.03^{a}	0.36±0.02^{a}	0.39±0.02^{a}	0.50±0.01^{b}	0.53±0.01^{b}	0.51±0.02^{b}	0.62±0.03^{c}
Week 2	0.50±0.02^{bc}	0.47±0.02^{b}	0.46±0.02^{b}	0.39±0.02^{a}	0.66±0.03^{e}	0.64±0.02^{e}	0.61± 0.02^{de}	0.56±0.03^{cd}
Week 3	0.62±0.02 ^{cd}	0.58±0.02^{bc}	0.52±0.03^{ab}	0.48±0.02^{a}	0.73±0.03^{e}	0.77±0.04^{e}	0.65±0.01^{d}	0.56±0.02^{bc}
Week 4	0.58±0.03^{b}	0.57±0.03^{b}	0.48±0.02^{a}	0.46±0.02^{a}	0.70±0.03^{c}	0.69±0.03^{c}	0.68±0.03^{c}	0.53±0.02^{ab}
Week 5	0.57±0.03^{a}	0.60±0.03^{a}	0.51±0.03^{a}	0.51±0.02^{a}	0.76±0.03^{b}	0.80±0.04^{b}	0.80±0.04^{b}	0.51±0.02^{a}
Week 6	0.63±0.03^{ab}	0.72±0.03^{bcd}	0.58±0.04^{a}	0.65±0.05^{abc}	0.75±0.03^{cd}	0.82±0.05^{d}	0.98±0.05^{e}	0.58±0.04^{a}
Week 7	0.57±0.03^{ab}	0.64±0.04^{bc}	0.52±0.03^{a}	0.55±0.03^{ab}	0.80±0.03^{d}	0.83±0.03^{d}	0.94±0.04^{e}	0.68±0.05^{c}
Week 8	0.55±0.03^{ab}	0.61±0.03^{b}	0.59±0.04^{b}	0.47±0.03^{a}	0.84±0.04^{c}	0.83±0.05^{c}	0.92±0.05^{c}	0.66±0.05^{b}

Note: $^{a, b, c}$ Means with different superscripts within a row are significantly different; Group mean, standard error and number count of samples (x±sem(n)) shown; *(p<0.05), NS – non-significance, G – Genotype, MOSM – Moringa oleifera Seed meal.

Genotype factor effect on Serum cholesterol: The Marshall broilers (63.32 MG/DL) have higher valuing of total cholesterol than the YENLC. However, the values are relatively the same.

Dietary factor influence (graded amounts of MOSM) on Serum Cholesterol: When the birds were considered irrespective of the genotype, serum total cholesterol exhibited a trend of decreasing as dietary MOSM levels increased (inverse relationship) to 10% MOSM; 0% MOSM> 5% MOSM> 10% MOSM. The value for 15% MOSM (60.23mg/d/) was higher than those of 5% and 10% (58.41) but significantly lower ($p<0.05$) than the control (76.2 mg/dl)

Genotypes - Diet (graded levels of MOSM) factor interaction effect on Serum cholesterol – Genotype did not significantly interact with MOSM to determine total cholesterol.

Serum cholesterol effects of Graded level of MOSM within genotype (breed): In the Marshall broilers and YENLC, an inverse relationship was observed between dietary MOSM level and serum total cholesterol up to 10% (0% MOSM> 5% MOSM > 10% MOSM) as shown in Table 3.

Genotype Effect: There was no significant difference ($p>0.05$) between the genotype for relative kidney weight however there was significant difference ($p<0.05$) between the relative weights of liver and the heart. However, the relative weights of the liver and heart of the Marshall broilers was significantly higher than that of the YENLC. The relative kidney weight of Marshall broilers was higher than that of YENLC.

Interaction Effect: There was significant interaction ($p<0.05$) between genotype and diet for the relative weight of heart.

Effect on chickens irrespective of Graded levels of MOSM: the values for the relative kidney weights were not significantly different however birds fed 15% level of MOSM had the relative weight that was comparably lower to the control (0% MOSM). Birds fed 15% MOSM had the least relative liver and heart weights while birds fed 5% MOSM level had the highest relative weight however diet significantly influenced only the relative heart weight ($P<0.05$) but the relative heart weight of diets 1, 2 and 3 were similar.

Table 3. Effects of genotype, dietary *Moringa oleifera* seed meal (MOSM) level (0, 5, 10 and 15 %) from 0-8 weeks age, and their interaction on cholesterol, creatinine, serum enzyme activities.

Parameter	Genotype		Diet				Breed × Diet
	YENLC	Marshall	0% MOSM	5% MOSM	10% MOSM	15% MOSM	
Cholesterol (mg/dl)	63.27±1.57	63.32±1.56	76.20±0.05^{c}	58.35±0.17^{a}	58.41±0.28^{a}	60.23±0.15^{b}	NS
Creatinine (mg/dl)	2.72±0.04	2.69±0.05	2.44±0.05^{a}	2.73±0.05^{b}	2.82±0.03^{b}	2.83±0.02^{b}	NS
ALT (U/L)	17.13±0.19	16.80±0.18	16.28±0.22^{a}	16.64±0.19^{ab}	17.08±0.25^{b}	17.86±0.14^{c}	NS
AST (U/L)	22.65±0.12	22.36±0.12	22.49±0.21^{ab}	22.17±0.18^{a}	22.55±0.15^{ab}	22.81±0.12^{b}	NS

Note: [a, b, c] Means with different superscripts within a row are significantly different; Group mean, standard error and number count of samples (x±sem(n)) shown; *($p<0.05$), NS – non-significance, G – Genotype, MOSM – Moringa oleifera Seed meal; Breed X Diet – Interaction between breed and diet; ALT – Alanine transaminase; AST - Aspartate transaminase.

Table 4. Serum cholesterol, creatinine and serum enzymes of yoruba nigerian local chicken and marshall broiler chickens fed graded levels of *Moringa oleifera* seed meal (MOSM) from hatch to 8 weeks age.

Trait	Yoruba Ecotype Nigerian Local Chickens				Marshall Broilers			
	0% MOSM	5% MOSM	10% MOSM	15% MOSM	0% MOSM	5% MOSM	10% MOSM	15% MOSM
Cholesterol (mg/dl)	76.19±0.06^{c}	58.24±0.22^{a}	58.43±0.46^{a}	60.23±0.30^{b}	76.20±0.07^{c}	58.46±0.27^{a}	58.39±0.37^{a}	60.24±0.09^{b}
Creatinine (mg/dl)	2.50±0.07^{a}	2.75±0.05^{b}	2.85±0.05^{b}	2.80±0.03^{b}	2.39±0.07^{a}	2.72±0.08^{b}	2.79±0.04^{b}	2.86±0.02^{b}
ALT (U/L)	16.18±0.37^{a}	17.00±0.27^{abc}	17.35±0.29^{bcd}	17.98±0.20^{d}	16.37±0.27^{a}	16.29±0.21^{a}	16.81±0.39^{ab}	17.73±0.21^{cd}
AST (U/L)	22.90±0.30^{b}	22.12±0.26^{a}	22.67±0.17^{ab}	22.90±0.12^{b}	22.08±0.20^{a}	22.21±0.27^{ab}	22.43±0.27^{ab}	22.72±0.20^{ab}
ALP	23.32±0.22^{a}	23.63±0.34^{ab}	23.90±0.15^{ab}	24.17±0.21^{b}	23.60±0.29^{ab}	23.37±0.27^{a}	23.48±0.22^{ab}	24.00±0.19^{ab}

Note:[a, b, c] Means with different superscripts within a row are significantly different; Group mean, standard error and number count of samples (x±sem(n)) shown; *($p<0.05$), NS – non-significance, G – Genotype, MOSM – Moringa oleifera Seed meal; ALT – Alanine transaminase; AST – Aspartate transaminase; ALP - Alkaline phosphatase.

Table 5. Effects of genotype (yoruba nigerian local chickens and marshall broilers), dietary *Moringa oleifera* seed meal (MOSM) level (0, 5, 10 and 15 %) from 0-8 weeks age, and their interaction on relative kidney, liver and heart weights.

Trait	Genotype		Diet				Breed X Diet
	YENLC	Marshall	0% MOSM	5% MOSM	10% MOSM	15% MOSM	
Kidney	0.00	0.07±0.01	0.07±0.01^{a}	0.08±0.03^{a}	0.08±0.01^{a}	0.05±0.01^{a}	NS
Liver	0.36±0.01*	0.75±0.06	0.52±0.07^{a}	0.69±0.12^{b}	0.54±0.06^{a}	0.47±0.05^{a}	NS
Heart	0.08±0.01*	0.16±0.01	0.12±0.01^{b}	0.14±0.02^{b}	0.13±0.01^{b}	0.09±0.01^{a}	*

Note: [a, b, c] Means with different superscripts within a row are significantly different; Group mean, standard error and number count of samples (x±sem(n)) shown; *($p<0.05$), NS – non-significance, G – Genotype, MOSM – Moringa oleifera Seed meal; Breed X Diet – Interaction between breed and diet.

Table 6. Relative kidney, liver and heart weights of yoruba nigerian local chicken and marshall broiler chickens fed graded levels of *Moringa oleifera* seed meal (MOSM) from hatch to 8 weeks age.

Trait	Yoruba Ecotype Nigerian Local Chickens				Marshall Broilers			
	0% MOSM	5% MOSM	10% MOSM	15% MOSM	0% MOSM	5% MOSM	10% MOSM	15% MOSM
Kidney	0.00	0.00	0.00	0.00	0.07±0.01	0.08±0.03	0.08±0.01	0.06± 0.02
Liver	0.33±0.02^{a}	0.39±0.05^{ab}	0.36±0.02^{a}	0.35±0.02^{a}	0.70±0.07^{c}	1.00±0.16^{d}	0.72±0.07^{c}	0.59±0.06^{bc}
Heart	0.09±0.01^{ab}	0.07±0.01^{a}	0.10±0.00^{ab}	0.06±0.01^{a}	0.16±0.01^{d}	0.20±0.02^{e}	0.15±0.02^{cd}	0.12±0.01^{bc}

There was no significant difference for the relative kidney weight for the broilers however, broilers fed 5% and 10% levels of MOSM had values higher than the control for broilers, the values obtained for the relative weight of the liver was significantly higher (P<0.05) in diet 2 (5%MOSM) than the control. The relative liver weight of diets 1, 3 and 4 were similar. The relative heart weight of birds in diet 2 was significantly higher (P<0.05) than the values obtained for other diets however the relative heart weight of the control was higher than that of diets 3 and 4.

For the YENLC, the relative liver and heart weights were similar however the relative liver weights of birds fed the MOSM included diets were higher than that of the control while only birds fed 10% MOSM had a higher relative heart weight than the control.

Discussion

Blood cholesterol was considerably higher in broilers than in the local chickens. This higher cholesterol is indicative of, and associated with, the tendency for broilers to accumulate more body fat than the YENLC. Broilers have been genetically modified for fat growth (Hartcher and Lum, 2020) and this has increased their tendency for increased fat deposition which is substantially related to increased blood cholesterol.

Dietary MOSM significantly reduced the total cholesterol. MOSM appears to act principally through a lowering of total cholesterol. Serum Cholesterol effects of graded levels of MOSM within genotype (breed) in the present study showed that cholesterol declined in response to dietary MOSM.

This agreed with the report of Yang *et al.* (2006) that Moringa leaf meal decreased blood triglycerides and improved immunological response in mice by increasing peripheral and splenocyte T-cell proliferation.

Genotype factor effect on creatinine, ALT, AST and ALP: YENLC have higher values of creatinine, ALT, AST and ALP than the Marshall broilers.

Diet (graded levels of MOSM) factor effect on creatinine, ALT, AST and ALP: there were significant differences for all the parameters. The values of creatinie, ALT, and ALP increased as the levels of MOSM was increasing, however, there was no significant difference among 5%, 10% and 15% treatment groups.

For AST, the values of birds fed 10% and 15% MOSM were higher than the control (0%MOSM) while birds fed 5% MOSM had the least value of AST.

Genotypes X Diet (graded levels of MOSM) factor interaction effect on creatinine, ALT, AST and ALP – Genotype did not significantly interact with MOSM to determine creatinine, ALT, AST and ALP.

Creatinine, ALT, AST and ALP effect s of Graded level of MOSM within genotype (breed): There were significant differences for all the parameters. In YENLC, creatinine, ALT and ALP increased as the levels of MOSM increased while the values of AST increased from 5%MOSM level to 15%MOSM level but the value obtained for 15% was the same with that of the control.

In Marshall broilers, the values for creatinine and AST increased as the levels of MOSM increased while for ALT, the values increased from 5% MOSM treatment group to 15% MOSM treatment group however, the values obtained for 10% and 15% were higher than that of the control. The values obtained for ALP were significantly not different but birds fed 10% MOSM had the highest values (5%<0%<15%<10%).

The result was in agreement with the report of Jimoh *et al.* (2012) when the birds fed garlic-supplemented meals had their serum examined, they found a linear decrease in total cholesterol, low-density lipoprotein (HDL), and triacylglycerol, but a progressive increase in high-density lipoprotein (HDL). This demonstrated that the MOSM can elicit hypocholesterolemic effects via modulating cholesterol and lipid metabolism. In all of the treatments, the levels of cholesterol in the birds' sera were lower than the threshold considered dangerous to human health. According to Helen (1989), hypercholesterolemia (>240 mg/dl) is linked to an increased risk of coronary heart disease, especially when LDL cholesterol levels in the blood are higher than HDL cholesterol levels. Heart disease is more likely in this situation. The liver is responsible for almost half of total cholesterol production. (Murray *et al.*, 1988). *Moringa oleifera* and its different extracts have been found to have hypocholesterolemic effects on chickens, mostly by inhibition of major liver enzymes involved in cholesterol and lipid synthesis.

Effect of Genotype (irrespective of diet) on relative organ weight. The parameters were considerably higher in broilers than in local chickens and this may be due to the higher sizes of the broilers than the local chickens.

Effect of diet (irrespective of genotype) on relative organ weights. MOSM inclusion did not significantly influence the relative weight of the kidney and this is an indication that the feed was not toxic and the relative heart weights of birds fed MOSM at 5% and 10% levels were similar to the control whereas the relative weight at 15% was significantly lower than the control and this implied that the inclusion of MOSM up to 15% was safe. The relative weights of liver at 10% and 15% levels of MOSM were similar to the control which implied that the feed was not toxic even at 15%.

Relative organ weights effects of graded levels of MOSM within genotype (breed); all the parameters were similar in Y_NLC for the graded levels of MOSM. In broilers, birds fed 10% and 15% MOSM had significantly similar relative liver weight when compared to the control and the relative heart weight of birds fed 10% MOSM was similar to the control however the graded level of MOSM did not significantly influence the relative kidney weights.

The numerical difference in relative organ weights of kidney, liver and heart of broilers and those fed MOSM may probably be due to the their differences in live weight, since the surface area and the live weight determine the amount of feathers and visceral organs required. (Broadbent *et al.*, 1981). Esonu *et al.* (2008) reported that organ weights are an index of nutrients retained by the birds. According to Butcher *et al.* (1983), external and internal offal percentages tend to increase as slaughter weight of the animal increase. The non significant influence of MOSM among treatments on the kidney and the similarities of birds fed MOSM up to 10% level of broilers when compared with the control and 15% level for Y_NLC when compared with the control on the liver and heart is an indication of absence of toxin up to that levels of MOSM since hypertrophy or hypotrophy of these organs has been associated with the presence of toxins. (Voss *et al.,* 1990; Ewuola *et al.,* 2003).

Conclusions

The findings revealed that feeding chickens up to 15% has no toxic effects on the liver and fall within the safety margin of broilers considering the lower serum cholesterol level, relative organ weights of the heart, kidney and liver as well as the creatinine, ALT, ASP and ALP levels.

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