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Growth Performance of Broilers fed *Moringa oleifera* Supplemented Feed and Challenged with a very virulent Infectious Bursal Disease Virus

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ABSTRACT

A study was conducted to assess the growth performance of broiler chickens fed *Moringa oleifera* leaf (MOL) feed supplement and challenged with a very virulent infectious bursal disease virus (vvIBDV). Two hundred and forty day-old Ross 308 hybrid broiler chicks were randomly assigned into groups A, B, C and D of 60 chicks each and were raised in deep litter housing. Broiler starter (BS) and broiler finisher (BF) mash were formulated each with 5% MOL included as part of the feed ingredient for broilers in groups A and B while BS and BF for broilers in groups C and D were formulated without MOL. Broiler chickens in groups A, B and C were challenged at 35 days of age with 0.05 ml of a live vvIBDV, while those in group D served as control. Daily feed intake (DFI), feed conversion ratio (FCR) and average body weight gain (ABWG) was used to assess the growth performance. At 42 and 49 days of age, significant difference was observed in the feed intake of broilers in groups A, B and C when compared with group D ($p = 0.0001$). At 49 days of age, broilers in group A and D significantly ($p = 0.0001$) added more weight than those in groups B and C respectively. Broilers in group B had a significantly ($p = 0.0006$) lower FCR than those in group A, C and D at 28, 35 and 42 days of age. Despite the challenge with vvIBDV, MOL inclusion in the diet of broiler chickens resulted in reduced DFI, good FCR, increased ABWG and final body weight and carcass weight.

Keywords: Average Body Weight Gain; Broilers; Feed Conversion Ratio; *Moringa oleifera* leaf

INTRODUCTION

In Nigeria, commercial broiler chicken meat production is expanding daily and creates a great opportunity for the poultry industry to make profit (Onu and Aniebo, 2011). Broiler production can serve as a fast source of animal protein due to its rapid generational interval (Larry, 1993; Dipeolu *et al.,* 1996; Nworgu *et al.,* 2000; Smith, 2001; Essen *et al.,* 2005). Broilers are prolific, have high feed conversion ratio and are accepted by all irrespective of religion. Broilers have several nutritional qualities that are sought-after such as high protein, low lipid content and high polyunsaturated fatty acids; these make them more preferable health wise, when compared to red meat (Mothershaw *et al.,* 2009). However, highly infectious diseases such as infectious bursal disease (IBD) can cause losses that may be up to 30-40%, increase susceptibility to various bacterial and viral diseases, poor immune response to vaccines, a reduced antioxidant capacity, thereby making investment in the industry to be fearful and unrealistic (van den Berg, 2000; OIE, 2004; Min *et al.,* 2008).

Moringa oleifera tree belongs to the single genus monogeneric family *Moringaceae* which was formerly indigenous to Northwest India. *Moringa oleifera* tree is widely distributed throughout the Pacific region, Central America, the Caribbean, as well as West Africa (Lockett *et al.,* 2000; Aregheore, 2002). In Nigeria, this plant is commonly and widely cultivated in the Northern region and is known by most ethnic groups (Anjorin, *et al.,* 2010). Every part of the tree (roots, stem, bark, seeds and leaf) has been used for nutritional and medicinal purposes (Estrella *et al.,* 2000; Morimitsu *et al.,* 2000; Siddhuraju and Becker, 2003). *Moringa oleifera* leaf (MOL) contain bioactive ingredients agents that could substitute synthetic growth enhancers and supplements in poultry and other livestock due to the presence of vitamins and antimicrobial properties it possesses. Hence, MOL is among the leaf meals that could be used as source of proteins in commercial livestock production and poultry in the tropics (Makkar and Becker, 1997; Agbede, 2003). The inclusion of MOL in the feeds of chickens has been reported to be effective against intestinal parasites and enhances immune responses in broiler chickens (Shane, 1997; Moreeng, 2008). The aim of the study was to assess the growth performance of broilers fed with MOL supplemented feed and challenged with very virulent infectious bursal disease virus (vvIBDV).

MATERIALS AND METHODS

Study Location

The study was conducted at the Poultry Research Unit of the Faculty of Veterinary Medicine, Ahmadu Bello University Samaru, Zaria, Nigeria.

Ethical Statement

Approval for this research was sought from the Ethics committee of the Ahmadu Bello University, Zaria and guidelines for the care and humane handling of animals were strictly adhered to all through the study (FASS, 2010).

Collection and Processing of *Moringa oleifera* Leaf

Moringa oleifera leaf (MOL) was harvested (between the months of August and September) from an orchard at an early flowering stage. The stem and branches were cut from the moringa trees and spread out to dry under shade at room temperature for five days. The leaves were then removed manually by hand and ground into powder using a locally fabricated milling machine.

Mineral Analysis of *Moringa oleifera* Leaf

Mineral analysis of MOL was carried out according to the procedure of Association of Official Analytical Chemist (AOAC, 1990) to determine the calcium, phosphorus, magnesium, iron, sodium, zinc, copper, selenium, potassium, and manganese contents.

Phytochemical analysis of *Moringa oleifera* leaf

Qualitative and quantitative analysis of MOL was carried out, according to the method described by Sofowora (1993), to determine the presence of tannins, phytates, saponins, oxalates, cyanides, alkaloids, carbohydrates, flavonoids, steroids, terpenoids, phenols and phylobatanins.

Proximate analysis of *Moringa oleifera* Leaf

The standard methods of the Association of Official Analytical Chemists (1990) for proximate analysis of MOL was used to determine the percentage carbohydrates, crude protein, fat, fibre, ash, moisture and metabolizable energy.

Feed Formulation and Analyses

The dried MOL was milled with hammer mill and sieved with 3 mm mesh siever to obtain *Moringa oleifera* leaf meal. Broiler starter (22% crude protein) and broiler finisher (20% crude protein) were formulated with 5% MOL inclusion as described by the methods of Olugbemi *et al.* (2010a) using Pearson square method of balancing rations/nutrients. The feed was subjected to proximate and mineral analysis based on the method described by the AOAC (1990) in the Feed Analysis Laboratory of the Department of Animal Science, Ahmadu Bello University Zaria (ABU), to determine the level of metabolizable energy, crude protein, crude fibre, moisture, ash content, and dry matter (Table 1).

Experimental Animals and Housing

A total of 240 day-old Ross 308 hybrid broiler chicks were obtained from a commercial hatchery located in Yola, Nigeria. The chicks were brooded for 5 weeks (before they were experimentally challenged with vvIBDV) in a deep litter house which was properly cleaned and disinfected before the arrival of the chicks. Wood shavings were used as litter material, and feeders and drinkers were provided. The chicks were individually weighed and assigned in a complete randomised design into four different groups A, B, C and D of 60 chicks each. A 100 Watts bulb was provided in each of the compartment to supply light and heat during brooding.

Feeds and Feeding

All the broilers from all the groups were fed with broiler starter for 28 days (0 to 4 weeks of age) and broiler finisher for 21 days (5 to 7 weeks). Feed and water were provided *ad libitum* (using plastic drinkers and galvanised feeders).

Experimental Design

Groups A and B were fed with broiler starter and finisher diets each containing 5% MOL, while groups C and D were fed with broiler starter and finisher feed without MOL. Groups A, B and C were challenged at 35 days of age with a vvIBDV. All the groups were fed for 49 days (7 weeks).

Vaccines and Vaccination

Inactivated killed vaccine against IBD (inactivated intermediate strain, Virsin 122, oil emulsion, Biovac Limited, Isreal, Batch 1- 382222) and inactivated killed vaccine against Newcastle disease (ND) (oil emulsion Komorov strain, Biovac Limited, Isreal, Batch 1-422222) were obtained from a Veterinary Pharmaceutical store in Jos, Nigeria. Broilers in groups A and C were vaccinated intramuscularly through the thigh muscles with 0.5 ml of the killed IBD vaccine at 14 and 21 days of age, while vaccination against ND was done with the killed ND vaccine (0.5 ml) through the thigh muscles at 18 days of age.

Challenge with Infectious Bursal Disease Virus

At 35 days of age, broilers in groups A, B and C were challenged intraocularly with 0.05 ml of a live vvIBD virus. The IBD virus used for the challenge was a field strain of vvIBDV obtained from previously vaccinated layers that died of natural outbreak of IBD Sixty-five percent of commercial cockerels inoculated with the vvIBDV at 30 days of age with 50 µl of bursal suspension (v/w) in PBS (pH 7.4) died. One millilitre of bursal suspension (v/w) in PBS (pH 7.4) contained 10^{-976} CID_{50} of IBDV.

Assessment of Growth Performance Parameters

Growth performance of broiler chickens was assessed based on daily feed intake (DFI), average body weight gain (ABWG), feed conversion ratio (FCR) and dressing carcass (DC), and recorded for each group as used by Ayssiwede *et al.* (2011).

Where;

DFI (g/bird/week) = {(Quantity of feed offered – Quantity of feed left)/day ÷ Number of birds}

ABWG (g/day) = Weight Gain of the period (g) ÷ Length of the period (days)

FCR = Feed intake during a period (g) ÷ Weight gain of the period (g)

DC (%) = (Carcass weight of the bird ÷ Live body weight of the bird) × 100

At 49th day of age, 5 birds from each group were slaughtered, defeathered and eviscerated and then weighed carcass yield of broiler chickens fed with or without MOL supplemented diets. Before weighing the carcasses, the slaughtered birds per group were dipped in hot water, defeathered and eviscerated. The drumsticks, thighs, liver, heart, lungs and gall bladder were weighed and recorded for each bird. The colouration of the skin of the shanks and beaks of each of the carcasses for each group were measured using a scoring technique applied by Kaijage *et al.* (2003) and Onibi *et al.* (2008) in which the score varied from 1 to 4 according to the intensity of the yellowing. Thus 1) no yellow colour, 2) light to moderate yellow, 3) enough to well yellow and 4) intense to dark yellow colour observed.

Data Analysis

Data obtained were subjected to a one-way analysis of variance followed by Tukeys post-hoc test for multiple comparison. Values of $p < 0.05$ was considered significant using GraphPad Software Inc., San Diego CA, USA, version 4.0 for windows.

Table 1: Composition of Experimental Diets of Broiler Starter and Finisher Diets per 100 kg Feed

	Broiler starter (A and B) (%)	**Broiler finisher (A and B) (%)**	**Broiler starter (C and D) (%)**	**Broiler finisher (C and D) (%)**
Maize	50.14	52	50.14	52
Maize offal	9.2	10	9.2	10
Soybean cake	11.69	8.49	14.19	10.18
Groundnut cake	11.69	13.98	14.19	17.29
MOLM	5	5	0	0
Fish meal	5	5	5	5
Salt	0.3	0.3	0.3	0.3
Limestone	1.5	0.5	1.5	0.5
Bone meal	3.5	3.5	3.5	3.5
Lysine	0.85	0.5	0.85	0.5
Methionine	0.85	0.375	0.85	0.375
Premix (B/S, B/F)	0.25	0.25	0.25	0.25
Enzyme	0.025	0.1	0.025	0.1
Total:	100	100	100	100
Proximate analysis				
ME Kcal/Kg DM	2798.45	2752.55	2687.88	2664.83
Crude protein (%)	22.50	20.69	22.31	20.63
Crude fibre (%)	5.53	5.15	5.06	5.24
Ether extract (%)	16.45	16.69	16.01	15.93

Key: MOLM: Moringa oleifera leaf meal. ME: Metabolizable energy, B/S: Broiler starter, B/F: Broiler finisher

Premix used contained: vitamin A – 15,000.00 iu Vitamin D3 - 3, 000,000 iu, Vitamin E- 30,000 iu Vitamin K- 3,000 mg Vitamin B1 3000 mg, Vitamin B2 6000 mg, Vitamin B6 5,000 mg, Vitamin B 40 mg, Biotin 200 mg, Niacah-40,000 mg, Pantothenic 15,000 mg, Folic acid 2,000 mg, choline 300,000 mg, Iron 60,000 mg, manganese 80,000 mg, copper 25,000 mg, Zinc 80,000 mg, cobalt 150 mg, iodine 500 mg, selenium 310 mg, Antioxidant 20,000 mg

RESULTS

There was no significant difference observed in the feed intake of broilers in groups A and B when compared with groups C and D during the first 35 days of age. At 42 and 49 days of age, significant difference was observed in the feed intake of broilers in groups A, B and C when compared with group D (P = 0.0001) (Table 2).

There was increase in weekly body weight of broilers in all the groups throughout the study period (49 days). At 21 days of age, there was a significant reduction in the body weight of broilers in group B when compared to those of group C and D respectively. At 28 days of age, broilers in group D significantly added more weight than those in group A and B. Broilers in group C added significant weight than those in group B, but there was no significant weight difference between broilers in group A and C. At 35 days of age, birds in group C added significant weight than those of group A and B respectively, and birds in group D added significant weight than those of group B. By day 42 of age, birds in group A added significant weight than those of group B and C respectively. Birds in group D added significant weight than those in group B and C. At 49 days of age, birds in group A and D significantly added more weight than those in group B and C respectively (Table 3).

There was no significant difference in the FCR of broilers in the different groups during the first 21 days of age. At 28, 35 and 42 days of age, birds in group B had a significantly lower FCR than those in group A, C and D (P = 0.0006) (Table 4).

At 49 days of age, the live and carcass weight of birds in group D were not significantly different (Table 5). There were no significant differences (p = 0.06) in the weights of the crop and gizzard between groups. The proventriculus, abdominal fat and liver were significantly (p = 0.001) heavier in group A when compared with those of group C. The weight of the gall bladder, heart, lungs and drumstick did not show any significant difference (p = 0.06) between groups. The thigh was significantly heavier (p = 0.01) in group D than in C. The MOL in the diet of broilers in groups A and B gave a significant (p = 0.0001) yellowish colouration of shank and beak when compared to those of groups C and D.

DISCUSSION

The significant reduction observed in the daily feed intake (DFI) of broilers in the challenged groups when compared to the non-challenged on day 42 (7 days post infection) may be due to the challenge with the vvIBDV. Reduced feed intake observed in groups A and B (in addition to the vvIBDV virus) may be associated with reduced palatability of the MOL in the diets as was reported by Kakengi *et al.* (2003). This was further exacerbated in this present study by the challenge with vvIBDV, as IBD is known to be associated with anorexia (Tsukamoto *et al.,* 1995; Islam *et al.,* 2001).

Table 2: Feed Intake of Broilers Fed 5% *Moringa oleifera* Leaf Supplemented Feed

	Groups			
Age (days)	***M. oleifera* + Vaccine + Challenge (g)**	***M. oleifera* + No Vaccine + Challenge (g)**	**Control Feed + Vaccine + Challenge (g)**	**Control Feed + No Vaccine + No Challenge (g)**
7	15.63±2.82	13.39±3.08	16.29±2.77	16.19±2.50
14	37.91±1.93	37.00±2.21	39.56±2.15	39.01±1.96
21	62.90±2.17	61.71±2.34	65.23±2.24	65.33±2.27
28	96.39±4.66	95.74±5.09	95.09±4.59	96.41±4.57
35	118.2±2.08	118.6±1.31	126.2±4.65	137.2±12.88
42	112.4^{a}±5.58	102.2^{a}±5.49	135.9^{b}±5.22	225.2^{c}±5.05
49	99.77^{a}±6.43	108.1^{a}±7.43	102.6^{a}±6.29	205.8^{b}±21.27

All values are expressed as mean ± SEM, values with different superscript ^{a,b,c} within rows differ at p<0.05.
#Birds were vaccinated at 14 and 21 days old *Challenge was done with very virulent infectious bursal disease virus

Table 3: Average Body Weight Gain of Broilers Fed 5% *Moringa oleifera* Leaf Supplemented Feed

	Groups			
Age (days)	***M. oleifera* + Vaccine + Challenge (g)**	***M. oleifera* + No Vaccine + Challenge (g)**	**Control Feed +Vaccine + Challenge (g)**	**Control Feed + No Vaccine + No Challenge (g)**
0	44.60±1.25	42.07±1.33	43.40±1.14	43.20±0.99
7	15.85±0.96	16.59±0.33	16.68±0.99	15.76±0.84
14	38.33±1.59	35.94±1.46	37.90±1.87	38.01±2.00
21	68.71^{a}±1.99	62.49^{a}±3.09	76.87^{b}±3.21	73.53^{b}±2.40
28	106.6^{a}±3.61	99.25^{a}±4.87	123.2^{b}±5.84	125.7^{b}±3.21
35	138.7^{a}±4.25	122.2^{a}±5.42	180.8^{b}±9.19	157.9^{b}±4.38
42	159.2^{a}±5.34	139.8^{b}±5.94	141.0^{b}±8.26	179.5^{a}±4.19
49	193.0^{a}±9.99	177.8^{b}±7.84	172.8^{b}±12.30	246.3^{a}±7.34

All values are expressed as mean ± SEM, values with different superscript^{a,b,} within rows differ at p<0.05.
#Birds were vaccinated at 14 and 21 days old *Challenge was done with very virulent infectious bursal disease virus

Table 4: Feed Conversion Ratio of Broilers Fed 5% *Moringa oleifera* Leaf Supplemented Feed.

	Groups			
Age (days)	***M. oleifera* + Vaccine + Challenge (g)**	***M. oleifera* + No Vaccine + Challenge (g)**	**Control Feed +Vaccine + Challenge (g)**	**Control Feed + No Vaccine + No Challenge (g)**
7	1.08±0.13	0.81±0.02	1.04±0.08	1.08±0.07
14	1.01±0.04	1.06±0.06	1.09±0.07	1.09±0.11
21	0.93±0.03	0.73±0.06	0.88±0.05	0.90±0.03
28	0.92^{a}±0.03	0.63^{b}±0.05	0.80^{a}±0.05	0.77^{a}±0.02
35	0.86^{a}±0.03	0.62^{b}±0.05	0.73^{a}±0.04	0.88^{a}±0.02
42	0.72^{a}±0.02	0.59^{b}±0.03	1.02^{c}±0.07	1.27^{a}±0.03
49	0.53^{a}±0.03	0.50^{a}±0.03	0.52^{a}±0.04	0.85^{a}±0.02

All values are expressed as mean ± SEM, values with different superscript^{a,b} within rows differ at p<0.05.
#Birds were vaccinated at 14 and 21 days old *Challenge was done with very virulent infectious bursal disease virus

Table 5: Carcass and Organ Weights of Broilers (at 49 days of age) Fed 5% *Moringa oleifera* Leaf Supplemented Feed

	Groups			
Parameter (g)	***M. oleifera* + Vaccine + Challenge (g)**	***M. oleifera* + No Vaccine + Challenge (g)**	**Control Feed +Vaccine + Challenge (g)**	**Control Feed + No Vaccine + No Challenge (g)**
Live weight	1739.0 ± 198.95	1493.2 ± 250.3	1453.0 ± 231.1	1844.0 ± 291.9
Carcass weight	1681.0 ± 186.1	1439.8 ± 243.0	1397.4 ± 220.1	1771.4 ± 284.9
DC (%)	96.72 ± 0.74	96.42 ± 0.61	96.22 ± 0.73	96.04 ± 0.53
Crop	22.00 ± 4.39	28.60 ± 6.38	12.80 ± 2.13	27.80 ± 8.754
Proventriculus	10.40^{a} ± 0.55	9.80^{a} ± 1.30	7.00^{c} ± 2.00	8.20^{c} ± 1.92
Gizzard	48.80 ± 2.54	49.00 ± 3.05	46.40 ± 5.34	50.60 ± 4.67
Abdominal fat	26.00^{a} ± 9.85	17.40^{a} ± 5.37	8.40^{b} ± 5.68	15.60^{a} ± 6.94
Liver	45.20^{a} ± 8.20	34.20^{a} ± 8.07	29.20^{b} ± 5.26	41.00^{a} ± 7.87
Gall bladder	2.00 ± 0.0	1.40 ± 0.24	2.20 ± 0.20	1.70 ± 0.44
Heart	9.00 ± 0.89	7.20 ± 1.32	6.80 ± 0.80	8.00 ± 0.55
Lung	9.60 ± 0.68	8.00 ± 0.89	7.20 ± 0.58	9.20 ± 0.80
Thigh	181.20^{a} ± 37.08	166.00^{a} ± 35.93	137.60^{b} ± 25.03	204.00^{a} ± 28.12
Drum stick	159.8 ± 8.63	132.0 ± 13.22	135.2 ± 11.68	171.0 ± 11.61
Yellow legs	3.00^{a} ± 0.00	3.40^{a} ± 0.55	1.00^{b} ± 0.00	1.00^{b} ± 0.00
Yellow skin	2.60^{a} ± 0.55	1.80^{a}± 0.45	1.00^{b} ± 0.00	1.00^{b} ± 0.00

All values are expressed as mean ± SEM, values with different superscript ^{a,b,c} within rows differ at $p<0.05$.
DC= Dressed carcass. #Birds were vaccinated at 14 and 21 days old *Challenge was done with very virulent infectious bursal disease virus

This was further exacerbated in this present study by the challenge with vvIBDV, as IBD is known to be associated with anorexia (Tsukamoto *et al.,* 1995; Islam *et al.,* 2001). In addition, the DFI didn't had any effect on the weekly body weight gain (WBWG) of birds in groups A and B, which could be due to the rich nutrient contents (Kakengi *et al.,* 2003; Sarwatt *et al*., 2004) and antimicrobial properties of MOL (Fahey *et al.,* 2001; Ratshilivha *et al.,* 2014). This is in agreement with the findings of Portugaliza and Fernandes (2012) who also reported a similar trend. The result of this study also indicated that, even after challenge with vvIBDV, there was considerable increase in the WBWG of birds in groups A and B, while those in group C experienced a significant decrease in their WBWG. This increase could be attributed to the presence of amino acids, vitamins, minerals, antioxidants contents, and immunostimulants and antibacterial properties of MOL which enhanced increase in the live body weight (Fahey, 2005; Anwar *et al.,* 2007).

It was also observed that the FCR of broilers in groups A and B was lower than those in groups C and D. This implies that birds fed MOL supplemented diets will adequately utilize the nutrients in the feeds they consume. This could probably be the reason for increase in WBWG of birds in groups A and B when compared with those in group C. Ebenebi *et al.* (2012) and Safa and El Tazi (2014) also recorded lower FCR in broilers fed MOL supplemented diet when compared with the control group. The lower FCR and increase in WBWG of birds observed in group A and B may also be attributed to the rich nutrient contents (Kakengi *et al.,* 2003; Sarwatt *et al.,* 2004) and antimicrobial properties of MOL (Fahey *et al.,* 2001; Ratshilivha *et al.,* 2014).

This study also showed an increase in the WBWG of broilers in group A and B even after challenge with vvIBDV. This was in contrast to the birds in group C that experienced a decrease in WBWG after challenge with vvIBDV which negatively affected their final WBWG.

The final live and carcass weight, and percentage carcass dressed weight were insignificantly higher in group D followed by groups A, B, and C, respectively. The increase in these variables may be associated with the rich phytonutrients contents of MOL, which minimized the vvIBDV challenged systemic effects. Furthermore, birds from groups A and B may have recovered much earlier from the IBD challenge than those in group C owing to individual differences in feed metabolism. Although, no literature had reported final live and carcass weight of broilers fed MOL and challenged with vvIBDV, however, Maroufyan *et al.* (2010) had earlier reported a decrease in the live weight and carcass weight of broiler chickens after a challenge with vvIBDV. The increase in these variables may be associated with the rich phytonutrients reported in MOL, which in part minimized the vvIBDV challenged systemic effects. Another reason for the increase (though not significant) observed in the live and carcass weight of broilers in group A and B when compared with those from group C may be associated with the phytonutrients and immune boosting properties reported in MOL (Fuglie, 1999) which reduces the systemic effect of the challenged vvIBDV thereby resulting in the early recovery of the birds from IBD challenged and also help them to resume eating faster, as MOL have been reported to aid digestibility, absorption and performance (Aregheore, 2001). *Moringa oleifera* leaf supplemented diets is known to contain high protein which the birds efficiently metabolized for their growth. The result of this study is in conformity with the work of Kakengi *et al.* (2003), Olugbemi *et al.* (2010b) and Banjo (2012) who in their separate studies reported that inclusion of MOL in the diet of broilers enhances their weight gain when compared to controls.

Ologhobo *et al.* (2014) also reported that, higher mean values of slaughter weight were obtained in birds fed diet containing 5% MOL as compared to those fed with control diet. The result of this study is also in agreement with the work of Onu and Aneibo (2011) who reported that broilers fed with 5% MOL in feed recorded a significantly higher body weight which could be attributed to the higher protein content of the diet.

Inclusion of the MOL in the diet of birds in group A and B increased the weight of organs in them when compared to the birds in group C. This is evidenced in the weight of the proventiculus, gizzard, liver, heart and lungs. The increase in the weight of these organs is proportional to the WBWG in the various groups. This result is in agreement with that of Safa and El Tazi (2014) who reported that broilers fed MOL in their diet had a higher organ (proventiculus, gizzard, liver, spleen, heart, lungs) weight when compared with controls. Similar results have also been reported by Preston and William (1973) who indicated that heavier broilers at slaughter would have higher dressing percentage as well as organ weight.

A yellowish colouration of the shank, skin and beak of broilers observed in groups A and B may be due to the high content of beta-carotene and xanthophylls in the MOL which the birds efficiently absorbed and utilize. Diets rich in xanthophylls pigmentation influence the yellowing of skin, abdominal fats and egg yolk (Surai *et al.,* 2001; Agbede and Aletor, 2003). The yellow colouration observed in this study is in agreement with the report of Etalem *et al.*(2013), Olugbemi *et al*. (2010a,b) who also observed that, intense yellow colouration of the beak, legs, abdominal fat, skin and egg york of broilers increased when MOL was included in their diets.

Conclusion

Despite the challenge with vvIBDV, broilers that were fed with 5% MOL inclusion in their diet were observed to have a reduced feed intake, good feed conversion ratio, increased average weekly body gain and final body and carcass weight.

Conflict of Interest

The authors declare that they do not have any conflict of interest.

Author's Contribution

BAG, APA, WAM and AT did the experimental design. B AG. wrote the manuscript. BAG and ESJ did the laboratory work. NJJ and GJJ proof read the manuscript.

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