Research Article

The Relationship between Feed Conversion Ratio, Feed Intake and Body Weight Gain of Broilers fed *Moringa oleifera* Leaf Supplemented Feed Following Challenged with Very Virulent Infectious Bursal Disease Virus

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Abstract | The relationship between weekly feed conversion ratios (WFCR), weekly feed intake (WFI) and weekly body weight gain (WBWG) of broilers fed *Moringa oleifera* leaf (MOL) supplemented feed and challenged with a very virulent infectious bursal disease virus was assessed. 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 raised in deep litter type 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. Broilers in groups A, B and C were challenged intraocularly at 35 days of age with 0.05 ml of a live vvIBDV while those in group D served as control. Weekly feed intake (WFI), weekly body weight gain (WBWG) and weekly feed conversion ratio (WFCR) were correlated for each group. Broilers in groups A, C and D showed a strong negative significant correlation (r = 0.9999, p = 0.0001) between WFCR and WFI, and between WBWG and WFCR, and a strong positive significant correlation (r = 1.0000, p = 0.0001) between WBWG and WFI from week 1 to 7. While broilers in group B only showed a strong negative significant correlation (r = 0.9999, p = 0.0001) between WFCR and WFI from week 1 to 7. *Moringa oleifera* leaf supplemented diet lowers the FCR of broilers in group B during infection with IBD virus which consequently increases their body weight gain.

Keywords | Broilers, *Moringa oleifera* leaf, Weekly feed conversion ratio, Weekly body weight gain, Correlation.

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INTRODUCTION

The inclusion of protein from leaf sources in diets for broilers is rapidly gaining ground due to its availability, abundance and relatively reduced cost (Onyemonyi et al., 2009). Leaf meal does not only serve as protein sources but also provide some essential vitamins, minerals and also oxycarotenoids which causes yellow colour of broiler skin, shank and egg yolk (Ravindra, 1986). With specific emphasis to protein substitutes, *Moringa oleifera* leaf (MOL) is among leaf plants that can be used as a cheap protein supplement that aids the digestion of other diets (Gadzira-

Table 1: Composition of Experimental Diets of broilers 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
Soyabean cake	11.695	8.4875	14.1925	10.18
Ground nut cake	11.69	13.9875	14.1925	17.295
MOLM	5	5	0	0
Fish meal	5	5	5	5
Salt	0.3	0.3	0.3	0.3
Lime stone	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 fiber	5.53	5.15	5.06	5.24
Ether extract	16.45	16.69	16.01	15.93

Key:
MOLM: *Moringa oleifera* leaf meal
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 6000mg, Vitamin B6 5,000mg, Vitamin B 40mg, Biotin 200mg, Niacah-40,000mg, Pantothenic 15,000mg,Folic acid 2,000mg, choline 300,000mg,Iron 60,000mg, manganese 80,000mg, copper 25,000mg, Zinc 80,000mg, cobalt 150mg, iodine 500mg, selenium 310mg, Antioxidant 20,000 mg

y et al., 2012). *Moringa oleifera* leaf was also claimed to be an immune system booster (Olugbemi et al., 2010; Jayavardhanan et al., 1994). *Moringa oleifera*is the most widely cultivated species of a monogeneric family, the Moringaceae that is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan (Mughal et al., 1999). It is widely cultivated and naturalized in tropical Africa, tropical America, Sri Lanka, India, Mexico, Malabar, Malaysia and the Philippine Islands where it's been advocated for traditional, medicinal and industrial uses (Morton, 1991).

Infectious bursal disease (IBD) is an immunosuppressive disease of poultry that is caused by Infectious bursal disease (IBDV) (Müller et al., 2003; Musa et al., 2010). Immunosuppression is usually due to the destruction of B cells and macrophages, and their functions (Sharma et al., 2000; Khatri et al., 2005), which leads to reduced antibody response to vaccinations, strong post vaccinal reactions and increased susceptibility to concurrent or secondary infections (Van-der-Berg 2000; Musa et al., 2012). Immunological stress, however, has a profound and significant effect on feed intake (Ferket and Gernat 2006).

Feed intake (FI) is the most important factor that influences both the body weight gain (BWG) and feeds conversion ratio (FCR) in broilers. Broilers may not grow to their full potentialunless they consume their full nutritional requirement each and every day. Besides satisfactory feed formulations, maintaining utmost feed intake is the most vital factor that determines the rate of growth and efficiency of nutrient utilization (Ferket and Gernat, 2006). Feed conversion ratio is the feed intake that is needed by a broiler to add in body weight over a stipulated time interval (Reyer et al., 2015). Therefore, this study was conducted to assess the relationship between WFI, WFCR and WBWG of broilers fed MOL supplemented diet and challenged with a very virulent infectious bursal disease virus.

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.

Collection and Processing of *Moringa oleifera* Leaf

Moringa oleifera leaf 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 MOL wasthen removed manually by hand and grounded into powder using a locally manufactured 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 components.

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 (AOAC, 1990) for the proximate analysis of the MOL was used to determine the percentage carbohydrates, crude protein, fats, fibre, ash, moisture and metabolizable energy.

Feed Formulation and Analyses

The dried MOL was milled with a hammer mill and sieved with 3 mm mesh sieve to obtain *Moringa oleifera* leaf meal. Broiler starter (22% crude protein) and broiler finisher (20% crude protein) were formulated base on the recommended levels for broilers as reported by McDonald et al. (1995) who put the protein requirements for broilers raised in the tropics at 20-22%for starter and 18-20% for finisher. Five percent MOL was included in the feed as described by the methods of Olugbemi et al. (2010) using Pearson square. 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, to determine the level of metabolizable energy, crude protein, crude fibre, moisture, ash content, and dry matter (Table 1).

Experimental Chicks 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 in a deep litter house which was properly cleaned and disinfected before the arrival of the chicks with wood shavings 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-watt bulb was provided in each of the compartment to supply light and heat during brooding.

Feeds and Feeding

All the broilers were fed with broiler starter for 28 days (from 0 to 4 weeks of age) and broiler finisher for 21 days (from 5 weeks 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 through the thigh muscles intramuscularly 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 intramuscularly at 18 days of age.

Challenge with Infectious Bursal Disease Virus

At 35 days of age, all the broilers in groups A, B and C were challenged intra ocularly 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 ofIBD. Sixtyfive per cent of commercial cockerels inoculated 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 Weekly Feed Conversion Ratio, Weekly Feed Intake and Weekly Body Weight Gain of Broilers

Weekly feed conversion ratio (WFCR), Weekly feed intake (WFI) and weekly body weights gain (WBWG) were assessed and recorded for each group according to the

modified formula by Ayssiwede et al. (2011). Where;
WFI (g/bird/week) = {(Quantity of feed offered – Quantity of feed left)/week ÷ Number of birds}
WBWG (g/day) = Weight Gain of the period (g) ÷ Length of the period (days)
WFCR = Feed intake during a period (g) ÷ Weight gain of the period (g)

Data Analysis

The data obtained were analysed using multivariate method (Correlation) with JMP version 11 (SAS Inst. Cary NY). The analysis is considered significant at $p<0.05$.

Table 2: Correlation between WFCR, WFI and WBWG of broilers of Group A fed 5% *Moringa oleifera* leaf supplemented feed, vaccinated against IBD and challenged with vvIBDV

Age (Weeks)	Variable by variable	Correlation coefficient (r)	p-value
	WFCR and WFI	-0.9087	0.0001
1	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9084	0.0001
	WFCR and WFI	-0.9836	0.0001
2	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9838	0.0001
	WFCR and WFI	-0.9920	0.0001
3	WBWG and WFI	0.9998	0.0001
	WBWG and WFCR	-0.9905	0.0001
	WFCR and WFI	-0.9921	0.0001
4	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9921	0.0001
	WFCR and WFI	-0.9876	0.0001
5	WBWG and WFI	0.9999	0.0001
	WBWG and WFCR	-0.9877	0.0001
	WFCR and WFI	-0.9966	0.0001
6	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9966	0.0001
	WFCR and WFI	-0.9884	0.0001
7	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9885	0.0001

WFCR: Weekly Feed Conversion Ratio, WFI: Weekly Feed Intake, WBWG: Weekly Body Weight Gain

RESULTS

Group wise correlation shows that broilers in group A showed a strong negative significant correlation (r = 0.9999, p = 0.0001) between WFCR and WFI, and between WBWG and WFCR, and a strong positive significant correlation (r = 1.0000, p = 0.0001) between WBWG and WFI from week 1 to 7 (Table 2). Broilers in group B

Table 3: Correlation between WFCR, WFI and WBWG of broilers of Group B fed 5% *Moringa oleifera* leaf supplemented feed, not vaccinated against IBD but challenged with vvIBDV

Age (Weeks)	Variable by variable	Correlation coefficient (r)	p-value
	WFCR and WFI	-0.9976	0.0001
1	WBWG and WFI	0.1923	0.4923
	WBWG and WFCR	-0.1859	0.5070
	WFCR and WFI	-0.9706	0.0001
2	WBWG and WFI	0.1402	0.6181
	WBWG and WFCR	-0.1536	0.5847
	WFCR and WFI	-0.9402	0.0001
3	WBWG and WFI	-0.1577	0.5745
	WBWG and WFCR	0.0551	0.8452
	WFCR and WFI	-0.9495	0.0001
4	WBWG and WFI	0.2951	0.2856
	WBWG and WFCR	-0.2722	0.3263
	WFCR and WFI	-0.9734	0.0001
5	WBWG and WFI	0.2080	0.4569
	WBWG and WFCR	-0.2471	0.3746
	WFCR and WFI	-0.9665	0.0001
6	WBWG and WFI	-0.1323	0.6383
	WBWG and WFCR	0.1385	0.6226
	WFCR and WFI	-0.9704	0.0001
7	WBWG and WFI	-0.2281	0.4136
	WBWG and WFCR	0.2137	0.4445

WFCR: Weekly Feed Conversion Ratio, WFI: Weekly Feed Intake, WBWG: Weekly Body Weight Gain

showed a strong negative significant correlation (r = 0.9999, p = 0.0001) between WFCR and WFI from week 1 to 7. However, a week negative, not significant correlation (r = 0.18, p = 0.5) was observed between WBWG and WFCR from week 1 to 5, and a positive not significant correlation was also observed between WBWG and WFCR from week 6 and 7. Still, a week positive, not significant correlation was observed between WBWG and WFI in week 1, 2, 4 and 5, while a week negative, not significant correlation was observed in week 3, 6 and 7 (Table 3).A strong negative significant correlation (r = 0.9999, p = 0.0001) was observed between WFCR and WFI and between AWBWG and WFCR from week 1 to 7 among broilers of group C. Still, a strong positive significant correlation (r = 1.0000, p = 0.0001) was observed between AWBWG and WFI from week 1 to 7 (Table 4). Similarly, a strong negative significant correlation (r = 0.9999, p = 0.0001) was observed between WFCR and WFI, and between WBWG and WFCR, and a strong positive significant correlation (r = 1.0000, p = 0.0001) between WBWG and WFI from week 1 to 7 among broilers of group D (Table 5).

Table 4: Correlation between WFCR, WFI and WBWG of broilers of Group C vaccinated against IBD and challenged with vvIBDV

Age (Weeks)	Variable by variable	Correlation coefficient (r)	p-value
	WFCR and WFI	-0.9638	0.0001
1	WBWG and WFI	1.0000	0.0001
	WBWG and FCR	-0.9644	0.0001
	WFCR and WFI	-0.9722	0.0001
2	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9727	0.0001
	WFCR and WFI	-0.9782	0.0001
3	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9783	0.0001
	WFCR and WFI	-0.9709	0.0001
4	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9709	0.0001
	WFCR and WFI	-0.9716	0.0001
5	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9716	0.0001
	WFCR and WFI	-0.9641	0.0001
6	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9641	0.0001
	WFCR and WFI	-0.9681	0.0001
7	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9681	0.0001

WFCR: Weekly Feed Conversion Ratio, WFI: Weekly Feed Intake, WBWG: Weekly Body Weight Gain

Table 5: Correlation between WFCR, WFI and WBWG of broilers of Group D, not vaccinated against IBD and not challenged with vvIBDV (control group)

Age (Weeks)	Variable by variable	Correlation coefficient (r)	p-value
	WFCR and WFI	-0.9783	0.0001
1	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9777	0.0001
	WFCR and WFI	-0.9389	0.0001
2	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9388	0.0001
	WFCR and WFI	-0.9895	0.0001
3	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9892	0.0001
	WFCR and WFI	-0.9945	0.0001
4	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9944	0.0001
	WFCR and WFI	-0.9907	0.0001
5	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9911	0.0001
	WFCR and WFI	-0.9923	0.0001
6	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9923	0.0001
	WFCR and WFI	-0.9884	0.0001
7	WBWG and WFI	1.0000	0.0001
	WBWG and WFCR	-0.9884	0.0001

WFCR: Weekly Feed Conversion Ratio, WFI: Weekly Feed Intake, WBWG: Weekly Body Weight Gain

DISCUSSION

The relationship between WFCR, WBWG and WFI was not affected in groups A and C when compared with those of group D even after the challenge with vvIBDV. This is seen in the strong negative and strong positive significant correlation between these parameters in these groups. Vaccination against IBDV that was earlier given to these groups prevented the IBD virus from severing the strong relationship that was observed between these parameters, as vaccination plays an important role in preventing diseases such as IBD (Abdu, 1986). The strong significant correlation that was observed between these groups (A and B) could also indicate that both formulations of the feeds (MOL supplemented and non MOL supplemented) are adequate in nutritional value.

The challenge with vvIBDV seems to affect the relationship between WFI, WFCR and WBWG of broilers in group B. The week negative not significant correlation observed between WBWG and WFI in weeks 3,6, and 7 shows that there was a decrease in WFI and hence WBWG during the experimental period. Generally, the quantity of feed consumed contributes immensely to weight gain in broilers. The decrease in feed intake observed in broilers of the this group could either be as a result of the change in feed from broilers finisher to broilers starter or as a result of the unpalatable nature of leaf meals due to the presence of tannins as tannins have been associated with bitter taste that will prevent chicks from consuming adequate quantity of the feed (Omekam 1994; Kakenge et al., 2003). This was further aggravated by the challenge with vvIBDV, as IBD has been known to be associated with anorexia (Tsukamoto et al., 1995; Islam et al., 2001). This is to say, MOL supplemented feed alone without vaccination against IBD, could not prevent the devastating effect of the IBD after with the IBD virus. However, despite the challenged with vvIBDV, the correlation between WFCR and WFI was not affected. This is shown in the strong negative significant correlation observed between these parameters. Thus, as the WFCR decreases, WFI increases. A low FCR is an excellent characteristic of high quality feed (Hascik et al., 2010). The present study implies that broilers fed MOL supplemented diets adequately utilize the nutrients in the feed they consume even when infected with IBD virus. This agrees with the work of Onunkwo and George (2015), Ebenebi et al. (2012) and Safa and El Tazi (2012) who also reported a lower FCR in broilers fed MOL supplemented diet. This could probably be the reason for the not significant reduction in WBWG as observed in the week positive correlation between WFCR and WBWG of broilers in group B after challenge with vvIBDV. The not significant reduction in the WBWG of broilers in group B despite the challenge with vvIBDV could be attributed to the presence of amino acids, vitamins, minerals, antioxidants, immunostimulants and antibacterial that are present in the MOL (Makkar and Becker, 1997; Fahey, 2005; Anwar et al., 2007).

CONCLUSION

Moringa oleifera leaf supplemented diet lowers the FCR of broilers during infection with IBD virus which consequently increase their body weight gain.

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CONFLICT OF INTEREST

The authors wish to declare no conflict of interest.

AUTHORS CONTRIBUTION

A.G Balami, P.A Abdu, A.M Wakawa and T. Aluwong designed the research, A.G Balami, S.J Enam and M.N Patrobas conducted the research, while all the authors participated in writing and proof reading of the manuscript.

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