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Effect of feeding different level of *Moringa oleifera* leaf meal on growth performance, lipid profile and meat fatty acid composition of Vanaraja chicken in tropics

ABHISHEK KUMAR[1], KAUSHALENDRA KUMAR[2], SANJAY KUMAR[3], CHANDRAMONI[4], R R K SINHA[5], J K PASWAN[6] and G P MANDAL[7]

Bihar Agricultural University, Patna, Bihar 800 014 India

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ABSTRACT

Present study was designed to investigate the dietary inclusion of *Moringa oleifera* leaf meal (MOLM) on growth performance, lipid profile and meat fatty acid composition of Vanaraja birds under tropical condition. The experiment was conducted for 56 days on 300 Vanaraja birds divided into 5 different treatment groups of 60 birds each. T_1 served as control group and fed only with basal ration whereas, other treatment groups such as T_2, T_3, T_4 and T_5 were supplemented with 5, 10, 15 and 20% *Moringa oleifera* leaf meal along with basal ration. Growth performance and feed conversion efficiency in Vanaraja chicken showed significant effect and good fluctuation was observed among the different treatment groups. The total cholesterol and triglyceride level decreased significantly as compared to control group. The fatty acid composition in chicken was significantly improved. However, the maximum profit per kg live weight was noted in T_2 group and least profit observed in 20% MOLM fed group. It was concluded that the overall performances improved significantly with 5% followed by 10% *Moringa oleifera* leaf meal supplemented birds with achieving maximum profit and healthy meat production for human consumption.

Key words: Growth performance, Lipid profile, Meat fatty acid, *Moringa oleifera,* Vanaraja

In present scenario, acute shortage of animal protein in developing countries justifies the research into the potentials of some locally available feed resources that could be included into the poultry diets to sustain the poultry enterprises and to improve the profit margin through reducing the use of conventional protein sources (Atawodi *et al.* 2008). *Moringa oleifera* leaf meal (MOLM) could be used as alternative feed resource in commercial livestock and poultry in the tropics. Moringa plant (miracle tree) has been reported to have many medicinal uses such as possessing of hypocholesterolemic properties, antioxidant activity (Worku 2016). This experiment was therefore conducted to study the dietary inclusion of *Moringa oleifera* leaf meal on growth performance, lipid profile and meat fatty acid composition of Vanaraja chicken.

Present address: [1]Veterinary Officer (kumarabhishek1808@gmail.com), COMFED, Patna, Bihar. [2,3]Assistant Professor (drkaushalivri@gmail.com, sanjayvet29@rediffmail.com), [4]Professor and Head (chandramoni108@rediffmail.com), Deaprtment of Animal Nutrition. [5]Assistant Professor (drsinhalpm@rediffmail.com), Department of LPM. [6]Ph.D. Scholar (jiten084@gmail.com), Dairy Cattle Nutrition Division, NDRI, Karnal. [7]Assistant Professor (gpmandal1@gmail.com), Department of Animal Nutrition, Faculty of Veterinary and Animal Science, WBUAFSc, Kolkata.

MATERIALS AND METHODS

Feeding, management, dietary treatment and laboratory analysis: The experiment was conducted for 56 days to investigate the dietary inclusion of *Moringa oleifera* leaf meal (MOLM) on growth performance, lipid profile and meat fatty acid composition of Vanaraja birds. Feed ingredients were procured in one lot for whole experiment and its proximate principles were determined as per AOAC (2005) along with calcium and phosphorus using the method modified by Talapatra *et al.* (1940) before compounding experimental rations and feed formulation was done as per BIS (1992). Different ingredients used in experiment were yellow maize, soya bean meal, wheat bran, de-oiled rice bran, soybean oil, common salt, calcite powder, mineral mixture and additives (Tables 1, 2).

Day-old chicks of Vanaraja strain (300) were procured from PDP, Hyderabad during early winter and temperature was approximate 32°C. The experimental birds were weighed and randomly divided into 5 experimental groups including control of 60 chicks in each group replicated with 20 chicks in each replicate and given only crushed maize on first day and then given standard ration. All the standard managemental practices were followed during experimental period including vaccination schedule.

Group 1 served as control fed with basal ration, birds in

Table 1. Chemical composition of feed ingredients used in experiment (g/kg DM*)

Ingredient	DM	CP	EE	CF	TA	AIA	NFE	Ca	P	ME (kcal/kg)
Yellow maize	915	95.0	47.0	20.8	28.0	12.0	809	0.80	3.60	3330
Soybean meal	925	450	2.40	58.5	70.5	11.0	419	2.30	5.80	2450
Wheat bran	905	140	36.1	105	66.0	14.0	653	2.10	11.8	2000
De-oiled rice bran	935	130	18.0	133	64.0	47.0	656	0.70	9.80	1800
Moringa oleifera leaf meal	945	253	68.4	99.2	115	14.5	465	17.0	3.00	2852

* DM, dry matter; CP, crude protein; EE, ether extract; CF, crude fibre, TA, total ash; AIA, acid insoluble ash; NFE, nitrogen free extract; Ca, calcium; P, phosphorus; ME, metabolizable energy.

Table 2. Percentage composition of different experimental diets

Ingredient	T_1	T_2	T_3	T_4	T_5
Moringa oleifera leaf meal (MOLM)	0.00	5.00	10.0	15.0	20.0
Yellow maize	54.0	51.0	48.0	46.0	44.0
Soya bean meal	32.0	30.0	28.0	26.0	24.0
Wheat bran	5.00	5.00	5.00	4.00	4.00
De-oiled rice bran	5.00	5.00	5.00	5.00	4.00
Soya oil	0.50	0.50	0.50	0.50	0.50
Common salt	0.30	0.30	0.30	0.30	0.30
Calcite	1.00	1.00	1.00	1.00	1.00
Mineral mixture	1.50	1.50	1.50	1.50	1.50
Premix	0.70	0.70	0.70	0.70	0.70
Calculated value					
CP (g/kg)	208.8	209.6	210.4	210.8	211.2
ME (kcal/kg)	2810.7	2804.3	2797.9	2804.8	2813.7
Ca (g/kg)	7.00	7.40	7.70	8.00	8.30
Av. P (g/kg)	5.00	4.90	4.80	4.70	4.60
Av. Methionine (g/kg)	4.10	4.30	4.40	4.50	4.70
Av. Lysine (g/kg)	9.10	9.50	9.90	10.6	11.1

T_1, served as control fed with basal ration; T_2, basal ration mixed with 5% *Moringa oleifera* leaf meal (MOLM); T_3, basal ration mixed with 10% MOLM; T_4, basal ration mixed with 15% MOLM; T_5 basal ration mixed with 20% MOLM.

Composition of mineral mixture: Retinol (210 mg), cholecalciferol (1.75 mg), alpha-tocopherol (250 mg), nicotinamide (1,000 mg), cobalt (150 mg), copper (1,200 mg), zinc (9,600 mg), manganese (1,500 mg), iodine (325 mg), iron (1500 mg), potassium (100 mg), magnesium (6,000 mg), selenium (10 mg), sodium (5.9 mg), sulphur (72 g), calcium (255 g) and phosphorus (127 g).

group 2 basal ration mixed with 5% MOLM, group 3 basal ration mixed with 10% MOLM, group 4 basal ration mixed with 15% MOLM and group 5 were fed basal ration mixed with 20% MOLM. Feed consumption, live weight gain, feed conversion ratio and performance index were calculated based on the amount of feed consumed every week.

Preparation of leaf meal: Moringa oleifera leaves were harvested from Bihar Veterinary College Campus, Patna, India. Branches were cut from the mature *Moringa* trees over 12 months old. The dried leaves were milled to make a leaf meal stored in the airtight nylon bags during entire period of the study.

Lipid profile and meat fatty acid estimation: In serum samples lipid profile includes total cholesterol, triglyceride and HDL were estimated by using test kit at 505nm wavelength in spectrophotometer 106. However, extraction of muscle lipid for cholesterol and meat fatty acid estimation was performed as per Folch *et al.* (1957) method and determination of muscles total cholesterol by Zlatkis *et al.* (1953) method.

Statistical analyses: All the data were analysed statistically using Statistical Packages for Social Sciences (SPSS) Software, version 20.00. One-way analysis of variance with the post hoc Duncan's multiple comparison test, means were separated using LSD to evaluate statistical significance of differences among the control and experimental groups according to Snedecor, and Cochran (1994).

RESULTS AND DISCUSSION

In this study different parameter like feed intake, body weight gain, feed conversion ratio, performance index, lipid profile, fatty acid composition and production economics were observed, respectively.

Growth performance and feed efficiency: The effect of dietary inclusion of *Moringa oleifera* leaf meal (MOLM) on growth performance and feed conversion efficiency in Vanaraja chicken showed significant ($P<0.05$) effect and remarkable change was observed among the different treatment groups (Table 3). As a whole after the end of eighth week it was observed that inclusion of MOLM had significant effect on feed intake in comparison to control. With the increased supplement beyond 5% of MOLM significantly higher feed intake was observed. The present result agreed well with the findings of Gadzirayi *et al.* (2012) and Tesfaye *et al.* (2013), who reported that feed intake increased as MOLM inclusion increased probably due to increased bulk concentration. However, Divya *et al.* (2014) found that the addition of MOL powder at any level slightly decreased feed intake on 21 and 42 d of age as compared to control, although the decrease was not significant ($P>0.05$). The result of our study was in agreement with the above study conducted by various researchers on poultry. The increased feed intake with increased level of MOLM level in treatment groups might be due to faster passage rate of excreta due to increasing level of fibre content in the diet.

The average body weight gain of T_2 group was

Table 3. Effect of different level of *Moringa oleifera* leaf meal on average feed intake, growth performance and production efficiency of Vanaraja birds

Attributes	T_1	T_2	T_3	T_4	T_5	SEM	P-value
Feed intake (g)	3042.6 [a]	3110.4 [b]	3191.3 [c]	3249.8 [c]	3218.1 [c]	25.5	<0.001
BWG (g)	1396.9 [c]	1468.3 [d]	1398.2 [c]	1305.4 [b]	1154.9 [a]	17.4	<0.001
FCR	2.18 [b]	2.12 [a]	2.28 [c]	2.49 [d]	2.79 [e]	0.019	<0.001
PI	45.9 [d]	47.2 [e]	43.8 [c]	40.2 [b]	35.9 [a]	0.373	<0.001
Serum and meat lipid profile							
Cholesterol (mg/dl)	166.9 [d]	160.1 [cd]	148.8 [bc]	139.6 [ab]	132.6 [a]	6.59	<0.001
Triglyceride (mg/dl)	185.8 [d]	181.9 [cd]	171.3 [bc]	164.9 [b]	151.2 [a]	6.27	<0.001
HDL (mg/dl)	57.9	61.9	62.6	61.0	60.7	2.62	0.468
LDL (mg/dl)	71.7 [c]	61.8 [bc]	51.9 [ab]	45.6 [a]	41.6 [a]	6.37	<0.001
VLDL (mg/dl)	37.2 [d]	36.4 [cd]	34.3 [bc]	32.9 [b]	30.2 [a]	1.25	<0.001
Thigh meat cholesterol (mg/g)	71.5 [b]	70.6 [b]	66.1 [ab]	63.7 [ab]	60.4 [a]	3.26	0.032
Breast meat cholesterol (mg/g)	66.6 [c]	64.4 [bc]	62.5 [abc]	58.7 [ab]	57.2 [a]	2.80	0.038

[abcde]Values with different superscripts in a row differ significantly ($P < 0.05$; $P < 0.01$). BWG, body weight gain; FCR, feed conversion ratio; PI, performance index; HDL, high density lipoprotein; LDL, low density lipoprotein; VLDL, very low density lipoprotein.

significantly (P<0.05) higher while T_3 group was comparable with control (Table 3). Ebenebe *et al.* (2012) reported that chicks fed on moringa based diets performed significantly (P<0.05) better than the birds of control group in term of higher weight gain. This improvement in body weight gain and feed conversion ratio may be attributed to rich content of nutrients in MOLM and anti-microbial properties of moringa. Safa (2014) found that birds fed on MOLM gained significantly (P<0.05) higher weight and more feed intake than birds fed the control diet. However, birds fed on (5% MOLM) diet showed heaviest body weight. The addition of *Moringa oleifera* leaf meal in the diet of the broilers significantly (P<0.05) enhanced their weight gain as compared to the control group (Khan *et al.* 2015, AbouSekken 2015). The decreased body weight gain might be due to high level of interleukin1. An increased level of MOLM in the diet results in increase in level of linolenic acid, and this causes decreased level of prostaglandin E_2. This increased level of interleukin causes degradation of muscles protein. Hence there is decrease in body weight gain on inclusion of certain level of MOLM. The body weight changes increased up to a certain level of MOLM feeding and after increasing the level then a decreasing trend of body weight is noticed. This might have happened due to increasing level of fibre content in the diet and less adipose tissue deposition in body. Another reason might be less efficient utilization of fibre by birds. The increasing fibre content of diets may have impaired nutrient digestibility and absorption.

However, feed conversion ratio for T_2 group was found to be significantly (P<0.05) lower than all other treatment group, while none of the group was comparable with each other (Table 3). Overall performance index for T_2 group was the highest which was significantly (P<0.05) higher than all other treatment group. Juniar *et al.* (2008) worked on the effect of *Moringa oleifera* leaf meal in feed on broiler production performance and reported that the inclusion of *Moringa oleifera* leaf meal at amounts up to 10% did not produce significant effects on feed conversion ratio and production efficiency. Safa (2014) found that treatment effect on feed conversion ratio was significantly (P<0.05) superior than birds fed the control diet. However, birds fed on 5% MOLM diet showed best feed conversion ratio. This might be due to the fact that birds fed MOLM based diet had lesser utilization potential of the nutrients probably because of the increased bulkiness with increased inclusion level.

Serum and meat lipid profile: During experiment total cholesterol and triglyceride level decreased significantly (P<0.05) as compared to control group (Table 3). With increasing level of MOLM in the diet, decreasing trend of serum cholesterol was noted. However, numerical value of HDL for T_3 group was the highest and for T_1 group lowest but no significant difference (P<0.05) was found among various treatment groups. It might be due to presence of β-sitosterol, a bioactive compound in MOLM, which lowers plasma concentration of LDL. Another important reason may be the presence of fibre in MOLM. During digestion in intestine, bile acids are secreted and we know that cholesterol is the main component of bile acid. Now, fibre of MOLM coats the bile acids in the intestine and is excreted in the body. Subsequently, body needs to draw cholesterol from the blood to form bile acids and thus lowering blood cholesterol level. During experiment total LDL and VLDL level decreased significantly (P<0.05) as compared to control group. With increasing level of MOLM in the experimental diet, decreasing trend of serum LDL and VLDL was noted. Divya *et al.* (2014) reported that on dietary inclusion of different levels of MOL powder in broilers' ration significantly (P<0.05) decreased the triglycerides, cholesterol and uric acid. Increase in fibre may also be responsible for less absorption of triglycerides and cholesterol from the intestinal tract of the birds (Kumar *et al.* 2016).

Table 4. Effect of different level of *Moringa oleifera* leaf meal on meat fatty acid (mg/g) profile of Vanaraja birds

Attributes	T_1	T_2	T_3	T_4	T_5	SEM	P-value
C14:0 (Myristic acid)	0.33	0.34	0.39	0.36	0.28	0.045	0.275
C16:0 (Palmitic acid)	24.3	26.0	24.4	22.6	22.9	3.08	0.803
C16:1 (Palmitoleic acid)	2.04 ^{a}	2.20 ^{a}	3.74 ^{b}	1.83 ^{a}	1.21 ^{a}	0.571	0.046
C18:0 (Stearic acid)	9.42 ^{a}	10.8 ^{ab}	10.0 ^{ab}	11.2 ^{ab}	11.4 ^{b}	0.707	0.146
C18:1 (Oleic acid)	19.5	20.5	19.2	18.4	17.3	1.60	0.435
C18:2 (Linoleic acid)	17.2	17.9	17.5	17.9	18.9	1.54	0.823
C18:3n3 (Lenolenic acid)	0.28 ^{a}	0.33 ^{b}	0.35 ^{bc}	0.39 ^{c}	0.32 ^{b}	0.014	0.004
C20:1 (Erucic acid)	0.13 ^{a}	0.18 ^{ab}	0.18 ^{ab}	0.20 ^{b}	0.22 ^{b}	0.024	0.090
C20:2 (Eicosadienoic acid)	0.41	0.41	0.47	0.67	0.60	0.165	0.496
C20:4 (Arachidonic acid)	6.76 ^{ab}	7.01^{ab}	6.05 ^{a}	8.52 ^{ab}	9.18 ^{b}	1.09	0.143
C22:0 (Behenic acid)	0.72 ^{a}	0.71 ^{a}	1.02 ^{ab}	1.17 ^{b}	1.19 ^{b}	0.143	0.046
C22:6 (Docosahexaenoic acid)	0.37 ^{a}	0.60 ^{b}	0.66 ^{bc}	0.80 ^{c}	0.85 ^{c}	0.072	0.006
C23:0 (Tricosanoic acid)	2.94	3.11	3.54	2.82	3.15	0.614	0.804
C24:1 (Nervonic acid)	1.40	1.48	1.47	1.55	1.37	0.214	0.915

^{abc} Values with different superscripts in a row differ significantly ($P < 0.05$; $P < 0.01$).

The total cholesterol in thigh and breast muscle of Vanaraja birds differed significantly (P<0.05). The average meat cholesterol level was highest in T_1 group while lowest in T_5 group. It may be due to hypo-cholesterolemic properties of MOLM. According to Brogna *et al.* (2011) dietary saponins bound to cholesterol, thus hampering its absorption in the intestine which could reduce the accumulation of cholesterol in meat.

Meat fatty acid composition: The effect of dietary inclusion of *Moringa oleifera* leaf meal (MOLM) on meat fatty acid profile of Vanaraja chicken is presented in Table 4. The effect of treatment on myristic acid, palmitic acid, oleic acid, linoleic acid, eicosadienoic acid, tricosanoic acid and nervonic acid level in the breast meat of Vanaraja bird did not change significantly (P>0.05). However, palmitoleic acid, stearic acid, lenolenic acid, erucic acid, arachidonic acid, behenic acid, docosahexaenoic acid level in birds were found to be significantly different (P<0.05). The highest DHA level was estimated in T_5 group where maximum level of MOLM supplemented and lowest in control group. Tannins contained in *Moringa oleifera* leaf meal could also be the reason hence they are reported to have a positive effect on meat fatty acid composition (Vasta *et al.* 2009). Moreover, work on an assessment of the antioxidant potential of selected plant extracts *in vitro* and *in vivo* experiment on pork and found that antioxidant such as vitamin E, selenium, phenols, flavonoids and vitamin C is present in moringa leaves. However, Wapi *et al*. (2013) reported that the treatment had significant effect (P<0.05) on C16:0, C18n6, C18n9, and C20:1n11 fatty acids with TRT1 (1000g/ton MOLM) having the highest proportions. The treatments had an effect (P<0.05) on PUFA with chicken breast from treatment 4 having the highest proportions of PUFA. Chicken meat is sensitive to oxidative deterioration due to high content of PUFA and rate of meat discoloration is believed to be related to the effectiveness of the oxidation processes.

However, most studies on fatty acids have been conducted on the ability of a lipid rich plant extract to enhance levels of PUFA in meat and increased degree of unsaturated fatty acids in the diets has been reported to be a positive feature with respect to human health; however it may have a negative effect on shelf life of poultry meat (Skrivan *et al.* 2012). Therefore, manipulation of fatty acid composition by introducing higher tissue concentrations of n-3 PUFA (optimum ratio of n-6/n–3) can be advantageous to human health and its supplementation can be successfully implemented in broiler poultry diets through scientifically managed programmes.

The supplementation of MOLM in the diet decreased the cost of experimental ration. However, the profit per kg live weight was maximum in T_2 group followed by T_3, T_1 and T_4 groups, respectively whereas, least profit was observed in 20% MOLM fed group. Onibi *et al.* (2008) reported that a reduction in the cost of feed consumed at higher inclusion of leaf meals. However, the net revenue from birds dropped as the level of MOLM in the diets increased. This could be attributed to the depressed weight gain recorded for birds fed these diets. The results of economic analysis indicated that the cost of feed reduced with increasing levels of MOLM in the diet. Talha (2013) worked on the use of *Moringa oleifera* in poultry diets and reached on conclusion that regarding economic benefits, the levels of inclusion of *Moringa* leaf meal can be expected to be cost effective are –10% to replace fish meal in broiler diet and 8% and 16% introduction in the diet of indigenous chickens. Onunkwo and George (2015) suggest that up to 10% MOLM in broiler diets could marginally reduce feed cost in broiler production. The present study finding was in agreement with the observation of different researchers' view.

Therefore, the results of present study can be concluded that the growth performance and feed conversion ratio improved significantly with 5% followed by 10% *Moringa*

oleifera leaf meal supplemented birds with achieving maximum profit. The serum and meat cholesterol level was significantly decreased and good quality fatty acids at tissues level were noted with higher level of MOLM fed groups. Considering the nutritional importance of *Moringa oleifera* leaf meal and overall performance of Vanaraja birds to achieve the desirable market weight economically, inclusion of 10% MOLM in ration is suggested to the backyard poultry producer.

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REFERENCES

AbouSekken M S M. 2015. Performance, immune response and carcass quality of broilers fed low protein diets contained either *Moringa oleifera* leaves meal or its extract. *Journal of American Science* **11**(6): 153–64.

AOAC. 2005. Association of Official Analytical Chemists. *Official Methods of Analysis*. 18th edn. Washington DC.

Atawodi S E, Mari D, Atawodi J C and Yahaya Y. 2008. Assessment of *Leucaena leucocephala* leaves as feed supplement in laying hens. *African Journal of Biotechnology* **7**: 317–21.

BIS. 1992. Indian standard, poultry feeds specifications. *Bureau of Indian Standards*. 4th Review. Manak Bhawan, 9, Bahadur Shah Zafar Marg, New Delhi, India.

Brogna D M R, Nasri S, Ben Salem N, Mele M, Serra A, Bella M, Priolo A, Makkar H P S and Vasta V. 2011. Effect of dietary saponins from *Quilaja saponaria* L. on fatty acid composition and cholesterol content in muscle *Longissimus dorsi* of lambs. *Animal* **7**: 1124–30.

Divya, Mandal A B, Biswas A, Yadav A S and Biswas A K. 2014. Effect of dietry *Moringa oleifera* leaves powder on growth performance, blood chemistry, meat quality and gut microflora of broiler chicks. *Animal Nutrition and Feed Technology* **14**: 349–57.

Ebenebe C L, Aniebo U C and Nweze B O. 2012. Comparison of haematological parameters and weight changes of broiler chicks fed different levels of *Moringa oleifera* diet. *International Journal of Agriculture and Biological Science* **1**: 23–25.

Floch J, Lees M and Sloane Staniey G H. 1957. A simple method for the isolation and purification of total lipids from animal tissue. *Journal of Biological Chemistry* **226**: 497–509.

Gadzirayi C T, Masamha B, Mupangwa J F, and Washaya S. 2012. Performance of broiler chickens fed on mature *Moringa oleifera* leaf meal as a protein supplement to soyabean meal. *International Journal of Poultry Science* **11**: 5–10.

Juniar I, Widodo E and Sjofjan O. 2008. Effect of *Moringa oleifera* leaf meal in feed on broiler production performance. *Jurnal Ilmuilmu Peternakan Brawijaya* **18**: 238–42.

Khan I, Zaneb H, Masood S, Faseeh H and Rehman U. 2015. Affect of *Moringa oleifera* leaf supplementation on intestine morphology and growth performance in broiler chickens. *Scholar's Advances in Animal and Veterinary Research* **2**: 25–31.

Kumar A, Kumar K, Kumar S, Chandramoni and Paswan J K. 2016. Effect of feeding *Moringa oleifera* leaf meal on cholesterol level in Vanaraja chicken. *Proceeding of XVI Biennial Conference of Animal Nutrition Society of India,* pp. 269. 6–8 February. Karnal, India.

Onibi G E, Folorunso O R and Elumelu C. 2008. Assessment of partial equi-protein replacement of soyabean meal with cassava and *Leucaena* leaf meals in the diets of broiler chicken finishers. *International Journal of Poultry Science* **7**: 408–13.

Onunkwo D N and George O S. 2015. Effects of *Moringa oleifera* leaf meal on the growth performance and carcass characteristics of broiler birds. *IOSR Journal of Agriculture and Veterinary Science* **8**(3): 63–66.

Safa M A E L T. 2014. Effect of feeding different levels of *Moringa oleifera* leaf meal on the performance and carcass quality of broiler chicks. *International Journal of Science and Research* **3**: 147–51.

Skirivan M, Marounek M, Englmaierova M and Skirivanova E. 2012. Influence of dietary vitamin C and selenium, alone and in combination on the composition and oxidative stability of meat of broilers. *Food Chemistry* **130**: 660–64.

Snedecor G W and Cochran W G. 1994. *Statistical Methods*. 9th edn. The Iowa, State University Press, Ames, Iowa.

SPSS. 2011. Statistics Version 20.0. IBM SPSS Inc., USA.

Talapatra S K, Roy S C and Sen K C. 1940. The analysis of mineral constituents in biological materials. I. Estimation of phosphorus, calcium, magnesium, sodium and potassium in food stuffs. *Indian Journal of Veterinary Science and Animal Husbandry* **10**: 243–58.

Talha E A. 2013. The use of *Moringa oleifera* in poultry diets. *Turkish Journal of Veterinary and Animal Sciences* **37**: 492–96.

Tesfaye E, Animut G, Urge M and Dessie T. 2013. *Moringa olifera* leaf meal as an alternative protein feed ingredient in broiler ration. *International Journal of Poultry Science* **12**: 289–97.

Vasta V, Mele M, Serra A, Scerra M, Luciano G, Lanza M and Priolo A. 2009. Metabolic fate of fatty acids involved in ruminal biohydrogenenation in sheep fed concentrate or herbage with or without tannins. *Journal of Animal Science* **87**: 2674–84.

Wapi C, Nkukwana T T, Hoffman L C, Dzama K, Pieterse E, Mabusela T and Muchenje V. 2013. Physico-chemical shelf-life indicators of meat from broilers given *Moringa oleifera* leaf meal. *South African Journal of Animal Science* **43**: 43–47.

Worku A. 2016. *Moringa oleifera* as a potential feed for livestock and aquaculture industry. *African Journal of Agricultural Science and Technology* **4**(4): 666–76.

Zlatkis A, Zak B and Boyle A J. 1953. A new method for the direct determination of serum cholesterol. *Journal of Laboratory and Clinical Medicine* **41**: 486–92.