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Evaluation of moringa (*Moringa oleifera*) leaf meal for broiler chicken performance and meat quality

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Abstract
The study evaluated dietary inclusion (0, 7, 14, and 21%) levels of Moringa oleifera leaf meal (MOL) on growth performance and meat quality of broiler chickens. A total of 240 broiler chicks (Chikun) were divided into four treatments with three replicates each (20 chicks per replicate) in a completely randomized design (CRD). The experiment lasted for 8 weeks. The results showed that live weight, dressed weight, dressing percentage, heart and liver weights differed (P<0.05) significantly across the four treatment groups. All other parameters did not differ significantly among the treatment groups. Growth traits of broiler chickens fed dietary inclusion levels of MOL revealed that only feed conversion ratio and mortality rates were significantly (P < 0.05) different across the treatments. Other traits such as final weight, weight gain, feed intake, average daily feed intake and average daily weight did not differ significantly among the treatment groups. Chemical compositional parameters of fresh broiler chicken meat revealed that per cent moisture, lipid, crude protein, ash and carbohydrate were significantly (P < 0.05) different across the treatments. However, chemical composition of meat floss ''dambun nama''from broiler chickens fed dietary inclusion levels of MOL showed that per cent moisture, lipid, crude protein, crude fibre and carbohydrate differed significantly (P<0.05) across the treatments. Furthermore, sensory attributes of meat floss from broiler chickens fed dietary inclusion levels of MOL showed that only juiciness differed significantly among the treatments. This study concludes that incorporation of MOL in the diet of broiler chickens at the inclusion levels of 0, 7, 14 and 21% had no deleterious effects on carcass and organ characteristics, chemical composition of both fresh meat and meat floss ''dambun nama''of broiler chickens. The processed meat floss was well-cherished by the sensory panelists and rated the product high for quality. It is suggested that other inclusion levels of MOL should be investigated in further studies using broiler chickens for growth and carcass performance re-evaluation for meat quality and its overall acceptance.

***Key words:** Broiler chicken, Moringa, meat quality*

Introduction

Innovations in food technology play a crucial role in translating nutritional information into consumer products to produce new healthy food ingredients and added specific nutrient or functional ingredients (Hsieh and Ofori, 2007). Meat preservation is more difficult than other kinds of food as it may result in oxidative rancidity, discolouration, mouldiness, off-flavour, sliminess etc (Gandi *et al*., 2014). FAO (1995) reported that meat processing enables the processor to convert low-priced meat cut into high-priced product. It has also been shown that processing of meat to products facilitates the packaging, handling, distribution and marketing of the product (Omojola *et al*., 2004).

The main objection to consumption of locally processed meat products lies with the

poor sanitary conditions that are associated with their production and handling processes (Balarabe *et al.*, 2016a). The methods of meat preservation are major challenges among meat consumers, handlers and entrepreneurs. Handling and storage methods are primarily concerned with minimizing microbial contamination and retarding microbial growth (Benjakul *et al.*, 1999). However, it is a common practice that after slaughtering the animals the meat product is consumed almost immediately without further processing (Steinhauster *et al.,* 1995). In Nigeria, meat processing is still in its technological infancy because the processing methods that have been in use for the past generations are yet to be standardized or modernized to cope with increasing consumer demand (Igene and Mohammed, 1983; Balarabe *et al*., 2016a). The major problem with traditional meat processing industries is lack of standardization requirements for the finished products (Bube, 2003). Therefore, processing method varies depending on the processor and the quality of the finished products (Farouk *et al*., 1992). In Nigeria, meat is processed traditionally into local products without recourse to quality control, into a variety of products such as *kilishi, balangu, tsire, tukunya, pomo, ganda, dambun nama,* among others. Balarabe *et al*. (2016b) reported that standardization of production processes of meat products improved shelf life and keeping quality.

Previous research works using leaf extracts of *Moringa oleifera* were mostly on the suppression of microbial (fungal and bacterial) activities and growths in meat products have been severally reported. For instance, Balarabe *et al.* (2016c) dissolved leaf powder of *Moringa oleifera* at 3.0g/100ml of water in cooking both red and white meat (beef, mutton, chevon, camel and broiler chicken meat) to process five different types of meat floss for their effects on shelf-life and storage quality over a 5-week period. Furthermore, Salisu (2017) investigated the inclusion levels of *Moringa oleifera* at 2.0, 3.0 and 4.0g/100 ml of water in cooking of beef to process meat floss and determined the shelf-life and storage quality up to 12 week period. Musa (2016) investigated the quality and shelf life of *dambun nama* processed using different types of white meat (turkey, duck, fish, guinea fowl and local chicken) for up to 5 week storage period.

The current tremendous changes of meat supply in Nigeria have made supermarket systems to organize the supply of pre-packed meat cuts in standard qualities especially for the elites in the society which makes the peasants and the have-nots finding ways of solving their own problems (Ojewola and Onwuka, 2001). However, the local meat industry in the country is still traditional and the production processes are usually done in an un-hygienic manner which results in product adulteration and contaminations. Local meat products processed in this manner are heavily infested with large number of microbes which results in poor quality storage and a good source of infection to consumers. There is the need to standardize the production processes of these local meat products in order to enhance their shelf-life and production of wholesome meat products. It is also imperative to devise other means or using local materials that have the potential to improve meat storage quality. Incorporation of herbal plant leaves and extracts as antioxidant have been reported to combat oxidative stress (Tanuj Tanwar *et al*., 2016). There is currently high consumer health concern in the use of synthetic antioxidants in food industry such as butylated hydroxyanisole (BHA) and the rest. Also, lipid oxidation is another concern for processed poultry products as it causes deterioration in quality and results in the development of rancid off-flavours and odours (Wang *et al.*, 2004).

This, therefore, triggers the current interest in the use of natural antioxidants in feed of

broiler chickens to delay lipid oxidative degradation, which deteriorates the quality of meat and reduces its shelf life. The natural plant leaf will also improve meat quality and its nutritional value. Natural antioxidants have been found in various substances with different chemical characteristics, which are widely present in plants. There have been limited reports on the bioactive constituents of *Moringa oleifera* leaves and its impact on broiler meat antioxidant status. Previous studies using *Moringa oleifera* were reported to have some positive effects on storage of meat floss (Balarabe *et al*, 2016c; Salisu, 2017). These earlier studies using *Moringa* leaf extracts were mostly on the suppression of microbial (fungal and bacterial) activities. For instance, Balarabe *et al.* (2016bc) dissolved powder leaf at 3.0g/100ml of water in cooking of beef, mutton, chevon, camel and broiler chicken meat to process meat floss and their effects on shelf-life and storage quality over a 5 - week period. Furthermore, Salisu (2017) investigated the inclusion levels of 2.0, 3.0 and 4.0g/100 ml of water in cooking of beef to process meat floss and determined the shelf-life and storage quality up to 12 week period.

Table 1: Composition of broiler starter diet containing varying levels of *Moringa oleifera* Leaf meal (0 – 4 weeks)

Ingredients	MOL 1	MOL 2	MOL 3	MOL 4
Maize	50.00	46.00	43.00	41.00
FSBM	15.00	15.00	15.00	15.00
MOL	**0.00**	**7.00**	**14.00**	**21.00**
Maize offal	3.50	3.50	3.50	3.50
GNC	27.00	24.00	20.00	15.00
Bone Meal	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.40	0.40
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.35	0.35
Salt	0.25	0.25	0.25	0.25
Vit. Premix	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis				
Crude Protein (%)	23.11	23.32	23.28	23.13
ME (Kcal/kg)	2911	2901	2902	2900
Calcium (%)	1.34	1.34	1.31	1.31
Phosphorus (%)	0.63	0.63	0.62	0.62
Ether Extract (%)	6.45	6.55	6.63	6.62
Crude Fibre (%)	4.61	4.81	4.91	5.00
Lysine (%)	1.21	1.18	1.20	1.17
Methionine (%)	0.56	0.54	0.52	0.51
Cost ₦/kg	120.4	116.0	112.0	107.3

MOL= *Moringa oleifera* Leaf Meal, GNC= Groundnut cake, FSBM= Full fat soya bez4wan meal. *Bio-mix broiler starter premix per 2.5kg of diet: Vit A, 10,000 I.U; Vit D_3, 2,000 I.U; Vit E, 23,000mg; Vit K_3, 2000mg; Vit B1,(thiamine) 1,800; Vit B_2(riboflavin), 5,500mg; Niacin, 27,500; Panthonenic acid, 7,500; Vit B6(pyridoxine),3000mg; Vit B_{12}, 15.00; Folic acid, 750.00mg; Biotin H_2, 60.00mg; Cholin Chloride, 300,000mg; Cobalt, 200mg; Copper,3000mg; Iodine, 3,000mg; Iron, 1,000mg; Manganese, 40,000.00mg; Selenium, 40,000mg; Zinc, 200mg; Antioxidant,1,250mg . M.E= Metabolisable energy

However, the limitation of the earlier studies was in the manner of incorporation of these extracts (*Moringa oleifera*), which were only used during cooking processes of meat to process meat floss, as opposed to dietary inclusions of leaf meal (*Moringa oleifera*) in the diets of broiler chickens, and subsequent evaluation of the meat for processing into meat products, storage and preservation. Therefore, there is the need to investigate further the effects of dietary utilization of these leaf meals in broiler chickens and processing the meat into meat floss in order to determine its storability and shelf-life. The objective of this study was to evaluate the effects of dietary levels of *Moringa oliefera* leaf meal on broiler performance and meat quality.

Materials and Methods

The study was conducted at the Department of Animal Science, Faculty of Agriculture, and at the Department of Veterinary Microbiology, Faculty of Veterinary Medicine, Ahmadu Bello University, Samaru, Zaria.

Sourcing and Processing of *Moringa oleifera* Leaf Meal

Leaves from healthy plants of *Moringa oleifera* were sourced from Samaru and Sabon Gari markets in Zaria, Kaduna State, and shade-dried for ten days. The dried leaves were ground using mortar and pestle into powdered form to produce leaf meals of these respective plant materials.

Table 2: Composition of broiler finisher diet containing varying levels of *Moringa oleifera* leaf meal (5- 8 weeks)

Ingredients	MOL 1	MOL 2	MOL 3	MOL 4
Maize	55.00	51.00	48.00	44.00
FSBM	10.00	10.00	10.00	10.00
MOL	**0.00**	**7.00**	**14.00**	**21.00**
Maize offal	8.50	8.50	8.50	8.50
GNC	22.00	19.00	15.00	12.00
Bone Meal	3.00	3.00	3.00	3.00
Limestone	0.40	0.40	0.40	0.40
Methionine	0.25	0.25	0.25	0.25
Lysine	0.35	0.35	0.35	0.35
Salt	0.25	0.25	0.25	0.25
Vit. Premix	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis				
Crude Protein (%)	20.08	20.29	20.15	20.26
ME (Kcal/kg)	2972	2963	2963	2954
Calcium (%)	1.29	1.29	1.29	1.29
Phosphorus (%)	0.60	0.60	0.59	0.59
Ether Extract (%)	5.63	5.73	5.81	5.91
Crude Fibre (%)	4.63	4.83	4.93	5.13
Lysine (%)	1.13	1.10	1.05	1.01
Methionine (%)	0.53	0.51	0.49	0.48
Cost ₦/kg	116.6	112.2	107.5	103.1

MOL= *Moringa oleifera* Leaf Meal, GNC= Groundnut cake, FSBM= Full fat soya bean meal

*Bio-mix broiler starter premix per 2.5kg of diet: Vit A, 10,000 I.U; Vit D_3, 2,000 I.U; Vit E, 23,000mg; Vit K_3, 2000mg; Vit B1,(thiamine) 1,800; Vit B_2(riboflavin), 5,500mg; Niacin, 27,500; Panthonenic acid, 7,500; Vit B6(pyridoxine),3000mg; Vit B_{12}, 15.00; Folic acid, 750.00mg; Biotin H_2, 60.00mg; Cholin Chloride, 300,000mg; Cobalt, 200mg; Copper,3000mg; Iodine, 3,000mg; Iron, 1,000mg; Manganese, 40,000.00mg; Selenium, 40,000mg; Zinc, 200mg; Antioxidant,1,250mg . M.E= Metabolisable energy

Table 3: Growth performance of broiler chickens fed dietary inclusion levels of *Moringa oleifera* leaf meals (0-8weeks)

	Treatments					
Parameters	**MOL1 (0%)**	**MOL2 (7%)**	**MOL3 (14%)**	**MOL4 (21%)**	**SEM**	**LOS**
Initial total weight (g)	250.00	250.00	251.67	251.67	4.17	NS
Final weight (g)	2115.50	2124.40	2111.10	2383.30	18790	NS
Weight gain (g)	1865.50	1874.40	1859.40	2131.70	18683.06	NS
Feed intake (g)	4864.00	4761.50	4633.90	4571.70	67155.86	NS
Average daily feed intake (g)	86.86	85.03	82.75	81.64	21.42	NS
Average daily weight gain (g)	33.31	33.47	33.20	38.07	5.96	NS
Feed conversion ratio	2.97^{b}	2.88^{b}	2.83^{b}	2.43^{a}	0.011	**
Mortality (%)	10.00^{a}	6.67^{ab}	3.33^{ab}	0.00^{b}	22.92	*

a,b,c: Means having different superscripts across row are significantly different at P<0.05, MOL- *Moringa oleifera* leaf meal, SEM- Standard Error Mean, NS- Not significant at P<0.05

Analysis for Anti-nutritional Factors

The leaf powder of *Zogale* (*Moringa oleifera*) was analysed for anti-nutritional factors; tannin (1.45), saponin (1.22), phytate (2.84), alkaloid (9.36) and flavonoid (0.66), as per the procedures of AOAC (2005).

Experimental Design and Management of Birds

Two hundred and fifty (250) chikun day old broiler chicks were used into four different dietary treatments comprising of a control (MOL1; 0) and different proportions of *Moringa oleifera* (7.0, 14.0 and 21.0kg of diet to serve as treatments MOL2, MOL3 and MOL4, respectively) and were replicated three (3) times of 20 chicks per replicate in a completely randomized design (CRD). The trials lasted for 8 weeks (0 – 4 weeks starter phase and 5 – 8 weeks finisher phase) (Tables 1 and 2).

Feed and clean water were given *ad libitum* to the birds throughout the experimental period. Vaccinations against Newcastle and Gumboro diseases were done at appropriate time, as recommended by the Veterinary Teaching Hospital (VTH) of Ahmadu Bello University, Zaria. Other standard methods such as fumigation, sanitation and prophylactic medications were given to ensure good health of the birds.

Performance Traits Evaluation

The initial body weights of the birds were measured at the beginning of the experiment, while final body weights were recorded at the end of the experiment. Feed consumption and body weight of the birds were taken weekly. Body weight was then computed as the difference between the final body weight and the initial body weight. The feed conversion ratio was computed as the ratio between feed intake and body weight gain.

Table 4: Carcass and Organ Characteristics of Broiler Chickens fed dietary levels of *Moringa oleifera* Leaf meal

	Treatments					
Parameters	**MOL1 (0%)**	**MOL2 (7%)**	**MOL3 (14%)**	**MOL4 (21%)**	**SEM**	**LOS**
Live Weight(g)	1850.0^{b}	2191.7^{a}	2033.3^{ab}	2191.7^{a}	15000	*
Dressed Weight(g)	1695.00^{b}	1900.00^{a}	1816.67^{ab}	1963.33^{a}	8985.41	*
Dressing Percentage(%)	66.31^{ab}	64.08^{ab}	62.92^{b}	67.71^{a}	3.559	*
Oragans Weight (expressed as percentages of live weight)						
Heart	0.532^{a}	0.452^{b}	0.436^{b}	0.472^{b}	0.001	**
Gizzard	2.506	2.248	2.601	2.313	0.034	NS
Liver	2.504^{a}	2.061^{b}	2.698^{a}	2.048^{b}	0.021	**
Abdominal Fat	1.711	2.116	2.429	1.684	0.272	NS
Prime Cuts Weight(expressed as percentages of dressed weight)						
Drumstick	15.797	16.114	15.949	16.122	0.149	NS
Breast	27.476	23.913	26.589	26.339	6.497	NS
Thigh	17.897	17.562	17.911	16.919	0.872	NS
Back	18.219	18.459	18.275	18.259	0.304	NS

a,b,c: means having different superscripts across row are significantly different at P<0.05, MOL- *Moringa oleifera* leaf meal, SEM- Standard Error Mean, NS- Not significant at P<0.05

Table 5: Chemical composition (%) of fresh broiler chicken meat fed dietary inclusion levels of *Moringa oleifera* leaf meals

Parameters	**MOL1 (0%)**	**MOL2 (7%)**	**MOL3 (14%)**	**MOL4 (21%)**	**SEM**
Dry Matter	23.97^{a}	23.06^{b}	23.02^{b}	22.11^{c}	0.044**
Lipid	15.60^{b}	18.75^{a}	13.06^{c}	9.59^{d}	0.167*
Protein	55.98^{c}	53.29^{d}	58.79^{b}	63.65^{a}	0.115*
Fibre	3.60	3.45	3.20	3.04	0.278NS
Ash	2.46^{a}	2.80^{b}	3.71^{a}	2.66^{b}	0.018**
Carbohydrate	1.99^{ab}	2.11^{a}	1.44^{b}	2.00^{a}	0.099*

a,b,c: Means across row having different superscript are significantly different at P< 0.05, NS= Not significant .MOL= *Moringa oleifera,* SEM= Standard error mean.

Carcass evaluation traits

At the end of the 8th week of the experimental trial, three (3) birds of representative weights were randomly selected from each replicate making 12 birds per treatment. The birds were fasted overnight and provided with water, then weighed, slaughtered, and eviscerated. Carcass indices such as live weight, carcass weight, dressing weight, dressing percentage, organs weight and weight of the prime cuts were taken. Prime cuts and organ weights were expressed as percentages of dressed weight and live weight, respectively.

Processing of meat floss

Fresh broiler chicken meat was cut into pieces of approximately 4 cm by 2.5 cm dimensions and washed with water, mixed with spices (ginger, pepper, onion, cloves, garlic, Maggi, thyme, salt, curry etc.), boiled for about 90 minutes and pounded into shreds using a mortar and pestle. This was then shallow-fried using groundnut oil in a stainless steel pot to obtain meat floss, which is usually brownish in colour (Kalla *et al.*, 2005).

Proximate analysis

Fresh raw broiler chicken meat from the various treatment groups of MOL1, MOL2, MOL3 and MOL4) were immediately taken to laboratory for analysis of proximate composition (dry matter, crude protein, crude fibre, lipid and ash) as per the procedures laid down by AOAC (2005).

Freshly processed meat floss from broiler chickens fed dietary inclusion levels of *Moringa oleifera* (MOL1, MOL2, MOL3 and MOL4) were immediately taken to laboratory for analysis of proximate composition (moisture, crude protein, crude fibre, lipid, ash and carbohydrate) as per the procedures laid down by AOAC (2005). .

Sensory evaluation of meat floss

Meat floss ‘‘*dambun nama*’’ processed from broiler chickens fed dietary inclusion levels of *Moringa oleifera* (MOL1, MOL2, MOL3 and MOL4) leaf meal were subjected to sensory evaluation for their acceptance. Forty (40) sensory judges (staff and postgraduate students only) of the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria; familiar with quality attributes of meat products were constituted for evaluation, using the 5 - point hedonic scale: 1 - like very much, 2 - like moderately, 3 - neither like nor dislike, 4 - dislike moderately and 5 - dislike very much (Bube, 2003). The sensory attributes considered were tenderness, juiciness, texture, colour, aroma and acceptability.

Statistical Analysis

Data obtained from the experiments were subjected to the analysis of variance (ANOVA) using the general linear model procedure of Statistical Analysis System (SAS, 2008). Significant means were used to separate using Duncan’s Multiple Range Test (DMRT) in the SAS version 9.0 Package.

Results and Discussion

Table 3 shows growth performance of broiler chickens fed dietary inclusion levels of *Moringa oleifera* leaf meals. The results revealed that growth performance such as initial weight, final weight gain, feed intake, average daily feed intake and average daily weight gain did not differ significantly among the four treatments (MOL1, MOL2, MOL3, and MOL4). However, feed conversion ratio was significantly ($P<0.01$) different among the treatments. Treatment MOL1, MOL2 and MOL3 were similar, but differed significantly ($P<0.01$) with treatment MOL4; values being 2.97, 2.88, 2.83, 2.43, respectively. There was significant ($P<0.05$) difference in mortality rates among the treatments; with MOL1, MOL2 and MOL3 did not differ significantly as shown in Table 3.

Table 4 depicts results on carcass characteristics of broiler chickens fed dietary inclusion levels of MOL. The results showed significant ($P<0.05$) differences in respect of live weight, dressed weight, dressing percentage, heart weight and liver weight ($P<0.05$). Live weight was better ($P<0.05$) in MOL2, MOL3 and MOL4 than MOL1. Dressed weight was also significantly ($P<0.05$) better in MOL2, MOL3 and MOL4 than MOL1. The dressing percentage was better in MOL1, MOL2 and MOL4 than MOL3. Other growth traits such as gizzard weight, abdominal fat, drumstick, breast, thigh and

back weights were not significantly across the treatment groups, as presented in Table 4.

Table 5 shows data on per cent proximate composition of fresh broiler chicken meat fed dietary inclusion levels of MOL. The results revealed that all the compositional parameters (moisture, lipid, crude protein, ash and carbohydrate contents) were significantly (P<0.05) different, except the fibre content of the meat. For instance, the per cent moisture content was significantly (P<0.05) highest in MOL1 (23.97%) followed by MOL2 (23.06%) and MOL3 (23.02%) and lowest in MOL4 (22.11%). The per cent lipid was highest in MOL2 (18.75%) followed by MOL1 (15.60%) and lowest in MOL4 (9.59%). However, the per cent crude protein content among the treatment groups was highest (P<0.05) in MOL4 (63.65%) followed by MOL3 (58.79%) and lowest in MOL2 (53.29%). The per cent ash content was highest (P<0.05) in MOL3 (3.71%) followed by MOL2 (2.80%) and MOL4 (2.66%) and lowest in MOL1 (0.46%). The per cent carbohydrate content of fresh broiler meat follows similar trend with the per cent ash content, as presented in Table 5.

Table 6 shows data on chemical composition of meat floss from broiler chicken meat fed dietary inclusion levels of MOL. The results showed that all the parameters except per cent ash content were significantly (P<0.05) different across the treatments. The per cent moisture content of meat floss was significantly (P<0.05) highest in MOL1 (4.17%) and MOL4 (4.32%) followed by MOL4 (3.61%) and lowest in MOL3 (2.83%). The per cent lipid content differed (P<0.05) significantly among the treatments; values being 38.80, 43.85, 41.60 and 42.05% for MOL1, MOL2, MOL3 and MOL4, respectively. However, the per cent crude protein content of meat floss processed from broiler chicken meat fed dietary inclusion levels of MOL revealed that MOL3 (49.86%) was highest (P<0.05) followed by MOL4 (47.86%) and lowest in MOL1 (36.41%). The per cent carbohydrate contents were 17.97, 3.44, 5.77 and 3.64 (P<0.05) for MOL1, MOL2, MOL3 and MOL4, respectively, as shown in Table 6.

Table 7 presents data on sensory attributes of meat floss from broiler chickens fed dietary inclusion levels of MOL. The sensory attributes considered were colour, texture, aroma, tenderness, juiciness and acceptability. The results showed that colour, texture, aroma, tenderness and acceptability did not differ significantly across the treatment groups. However, juiciness was the only attribute that differed (P<0.05) significantly among the treatments; values being 1.59, 1.41, 2.04 and 1.56 for MOL1, MOL2, MOL3 and MOL4, respectively. However, MOL2 and MOL4 were most preferred (like very much) followed by MOL1 and least preferred was MOL3; with scoring of 2.04 (which was liked moderately), as depicted in Table 7.

Table 6: Chemical composition (%) of meat floss from broiler chicken meat fed dietary inclusion levels of *Moringa oleifera* leaf meal

Treatments	MOL1 (0%)	MOL2 (7%)	MOL3 (14%)	MOL 4(21%)	SEM	LOS
Moisture	4.17^{a}	3.61^{b}	2.88^{c}	4.32^{a}	0.038	**
Lipid	38.80^{c}	43.85^{a}	41.60^{b}	42.05^{b}	0.343	*
Protein	36.41^{d}	46.44^{c}	49.86^{a}	47.86^{b}	0.083	*
Fibre	2.80^{ab}	2.99^{a}	2.23^{bc}	2.07^{c}	0.043	**
Ash	2.66	2.66	2.20	2.14	0.044	NS
Carbohydrate	7.97^{a}	3.44^{b}	5.77^{b}	3.64^{b}	2.240	*

a,b,c: Means across row having different superscript are significantly different at P< 0.05, NS= Not significant ,MOL= *Moringa oleifera,* SEM= Standard error mean.

Table 7: Sensory evaluation of meat floss processed from broiler chicken meat fed dietary inclusion levels of *Moringa oleifera* leaf meal

Sensory attributes	MOL1 (0%)	MOL2 (7%)	MOL3 (14%)	MOL4 (21%)	SEM	LOS
Colour	1.52	1.63	1.56	1.29	0.571	NS
Texture	1.85	1.63	1.89	1.89	0.606	NS
Aroma	1.63	1.67	1.89	1.93	0.681	NS
Tenderness	1.74	1.89	2.04	1.85	0.656	NS
Juiciness	1.59^{ab}	1.41^{b}	2.04^{a}	1.56^{b}	0.718	*
Acceptability	1.59	1.56	2.04	1.82	0.771	NS

a,b,c : Means across row having different superscript are significantly different at P< 0.05, NS= Not significant, Like very much = 1, Like moderately = 2, Neither like nor dislike = 3, Dislike moderately = 4, Dislike very much = 5

Growth performance such as initial weight, final weight, weight gain, feed intake, average daily feed intake, average daily weight gain did not differ significantly among the four treatments of *Moringa oleifera* leaf meal (MOL1, MOL2, MOL3 and MOL4), respectively. Treatment four (MOL4) had the highest body weight gain (2131.70g), followed by MOL2 (1874.40g). This shows that *Moringa oleifera* leaf meal does not have any deleterious effect in the diet of broiler chickens; this might have been due to low content of tannins and alkaloids which were efficiently metabolised for growth. This is in line with the reports of Cariaso (1988) and Olugbemi *et al.* (2010), that growth rate, body weight gain, feed consumption, final body weight gain and feed cost were not adversely affected when broiler chickens were fed 5% level of *Moringa oleifera* leaf. *Moringa oleifera* leaf incorporated in broiler chicken diet led to better growth performance of the birds compared to maize meal feed alone (Nihad *et al*., 2016). The authors reported that effect of supplementation of *Moringa oleifera* leaf attribution at 15 and 20% in diet of poultry chickens increased body weight and blood biochemical of broiler chickens.

Feed conversion ratio was significantly different among the treatment groups, with treatment four (MOL4) having the least value of 2.43. This was in contrast with the reports of Akhouri *et al.* (2013) and Abou Sekken (2015) that *Moringa oleifera* significantly ($P < 0.05$) increased feed conversion ratio in broiler chickens.

The present stuudy showed that broiler chickens fed *Moringa oleifera* leaf meal at 21% had the highest values in live weight, dressed weight and dressing percentage (2191.7g, 1963.33g and 67.71%) respectively as compared to the other treatment groups. This might be due to the presence of phytochemicals in *Moringa oleifera* leaf which improves physical and chemical properties of meat. Mukumbo *et al.* (2014) reported that inclusion of *Moringa oleifera* leaf (2.5, 5.0 and 7.5%) in finisher pig diet had no detrimental effect on carcass characteristics of physico-chemical meat quality and it significantly improved the acceptability of the meat colour, odour, and lipid profile.

Chemical composition of meat is influenced by different factors such as species, breed, age, sex, anatomical location of muscle and nutrition (Lawrie, 1998). All the compositional parameters (dry matter, lipid, protein, ash and carbohydrate contents) in this study were significantly different with the exception of fibre content. The dry matter of fresh broiler meat obtained in this study is less than the result of Bube (2003) who reported dry matter content of raw beef, goat, mutton, local chicken and duck meat as 28.8%, 28.5%, 27.9%, 31.5% and 26.0%, respectively. Salisu (2017) reported the dry matter content of raw

beef as 37.91%. This was in contrast with the reports of Balarabe *et al.* (2016b) who showed the dry matter content of fresh meat of beef, mutton, chevon, camel and broiler chicken as; 29.73%, 27.49%, 31.6%, 41.75% and 54.96%, respectively. The dry matter observed in this study might be due to the different inclusion of *Moringa oleifera* leaf meal in the diets of broilers. Plane of nutrition, breed and age of an animal can influence its compositional status (Balarabe *et al.* (2016b). The protein content of fresh broiler meat was at variant with the reports of Bube (2003) and Balarabe *et al.* (2016b) who showed the protein content of fresh broiler and local chicken meat as 26.13% and 19.8% respectively. The per cent ash (2.4%-3.1%) content in this study is similar to the report of Balarabe *et al.* (2016b). The significant differences observed in the composition of fresh meat of the experimental birds as compared to other reports is probably due to the inclusion of the plant leaf meal in the diets of broiler chickens which has the ability to improve/increase the crude protein, reduce fat content and nutritional value of meat. Qwele *et al.* (2013) reported that with higher crude protein level in *moringa* enriched products, a small quantity will be required by consumers to meet their nutrient requirement, and hence reduce expenditure on meat and meat products.

Per cent moisture was highest in MOL4 (4.32%) followed by MOL1 (4.17%), MOL2 (3.61%) and MOL3 having the lowest value of 2.88%. This was similar to the reports of Balarabe *et al.* (2016b) who reported the moisture content of meat floss processed from different meat types (beef, mutton, chevon, camel and broiler chicken meat) using *Moringa oleifera* leaf extract in cooking of the meat as 3.9, 9.9, 6.4, 2.8 and 10.6, respectively. Salisu (2017) reports the moisture content of meat floss processed from beef meat cooked using different levels of *Moringa oleifera* leaf extract (2.0, 3.0 and 4.0) as 6.32, 4.42 and 8.09 respectively. This was also similar to the report of Bube (2003) who showed the moisture content of meat floss of broiler chicken as 6.2. The lesser the moisture content of a meat product, the higher the shelf life of meat product. This shows that *Moringa oleifera* leaf has the potential of increasing and improving the quality of meat and meat product. The per cent lipid content was highest in MOL2 (43.85) and least in MOL1 (38.41). This was in contrast with the reports of Bube (2003) and Balarabe *et al.* (2016b). Treatment 1(MOL1) had the least per cent crude protein of 36.41 and MOL3 had the highest value of 49.86. Bube (2003), Balarabe *et al.* (2016b), and Salisu (2017) reported per cent crude protein of meat floss of broiler chicken meat as 52.9, 51.9 and 45.56 respectively. The per cent ash contents in this result among the experimental groups (2.66, 2.66, 2.20 and 2.14) for MOL1, MOL2, MOL3 and MOL4 were lower than the reports of previous researchers (Bube ,2003; Balarabe *et al.*, 2016b). The leaf meals of *Moringa oleifera* included in the diet of broiler feed and further processing into meat floss did not show any deleterious effect to the birds and it improved the quality characteristics of the meat. This might be as a result of the antioxidant, phytochemical and bioactive properties of the plant leaf.

Sensory attributes such as palatability, juiciness, tenderness, colour, aroma and acceptability are important components of consumer preferences and consumption which may vary from product to product and also the locality of the meat product (Balarabe *et al*., 2016b). The results in this study showed that sensory parameters like colour, texture, aroma, tenderness and acceptability did not differ significantly with the exception of juiciness among the treatment groups. The mean panel rating for colour across the treatment groups showed high score of likeness based on the 5-point hedonic scale used in the sensory rating

(1- like very much, 2- like moderately, 3- neither like nor dislike, 4- dislike moderately, 5- dislike very much) with MOL2 (1.63) having the highest value, followed by MOL3 (1.56), MOL1 (1.52) and MOL (1.29), respectively. The high colour scoring in this study is similar to the high colour scoring of broiler meat floss from the reports of Bube (2003) and Balarabe *et al.* (2016b). Appearance of meat influences the acceptance of meat since colour is the first criterion consumers' use to judge meat quality and acceptability (Comfort, 1994). The mean panel for tenderness, texture, aroma and acceptability did not show any difference across the treatment groups, which was similar to the reports of Bube (2003) who showed high sensory scores of meat floss among ruminant and non-ruminant species in terms of tenderness, juiciness, acceptability and flavour. Balarabe *et al.* (2016b) reported high score of tenderness of meat floss in broiler chicken and indicated it might be due to marbling effect of muscle fat which agrees with the report of Miller *et al.* (1995) that mode of marbling had a significant effect on meat tenderness. However, the sensory properties of meat like tenderness, texture and aroma may have significant impact on meat quality acceptability. Leora (1994) reported that aroma is made up of varieties of different classes of chemicals that are either present in the food ingredients or are formed during processing. The author also stated that flavour which is linked to aroma is defined as the combined perception of taste; smell and mouth feel. Therefore, aroma of meat is considered as a major factor that improves meat palatability and consumption. The acceptability of all the meat floss across the treatment groups in this study could be due to familiarity of broiler chicken meat among the panelists. This was similarly reported by Kalla *et al.* (2005) that familiarity of a product has positive influence on its acceptability. Bube (2003) reported highest acceptability scores among panelists assessing varieties of meat floss processed from both red and white meat. However, the slight difference observed in juiciness among the treatments in the present study might be due to the impact of the *moringa* in the meat. Therefore, from the results obtained on sensory attributes in this study shows that meat floss from broiler meat of *Moringa oleifera* leaf meal among the treatment groups had meat of good characteristics in terms of colour, texture, aroma, tenderness and acceptability.

Conclusions and Recommendations

This study concludes that the incorporation of MOL in the diet of broiler chickens at the inclusion levels of 0, 7, 14 and 21% had no deleterious effects on carcass and organ characteristics, chemical composition of both fresh meat and processed meat floss of broiler chickens. The processed meat floss was well - cherished by the sensory panelists and rated the product high for quality. The other inclusion levels of MOL should be investigated in further studies using broiler chickens for growth and carcass re-evaluation for meat quality.

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