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Effect of dietary inclusions of *Moringa oleifera* leaf meal on the quality attributes of Japanese quail meat and eggs

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Abstract
The study was aimed to investigate the response of different levels of *Moringa oleifera* leaf meal on the quality attributes of Japanese quail meat and eggs. The study comprised of 300 day-old Japanese quail chicks reared up to 6 weeks for study on the quality attributes of broiler Japanese quail meat, and 360 adult Japanese quails reared from 7-22 weeks for study on the quality attributes of layer Japanese quail meat and eggs. The birds were allocated arbitrarily and uniformly in five different treatments: T_0 (Control), $T_{0.5}$, T_1, $T_{1.5}$, and T_2 based on 0, 0.5, 1, 1.5, and 2% inclusion levels of *M. oleifera* leaf meal, respectively. The study revealed improvements in the quality attributes of meat and eggs, claiming meat to be of good quality, and eggs to be slightly desirable to desirable in *M. oleifera* leaf meal based treatments. The best level of *M. oleifera* leaf meal inclusion in the diet was 1% in the study. A 1% level of inclusion of *M. oleifera* leaf meal can be recommended in the diets of broiler and layer Japanese quails for enhancement in quality and consumer acceptance of meat and eggs.

Keywords: Eggs, Japanese quail, meat, *Moringa oleifera* leaf meal, quality

Introduction
Meat and eggs from chickens' are an essential source of protein for human beings around the world, especially in developing nations like India. Meanwhile, malnourished chickens are inclined to produce less live weight and below par quality meat and eggs, which could be credited to substandard nutrition and genotype. Malnourished chickens will have lack of nutrients in their meat and eggs, resulting in variations in meat composition that could possibly modify the colour, flavour and texture of meat and eggs, and accordingly consumer preferences. Adding forage trees in diet of chickens has been associated with improvements in live weight, egg production and general health. Enhancement in chickens' live weights could deliver a beneficial effect on meat and egg quality characteristics. *Moringa oleifera* is one such forage tree. Almost all the parts of tree have medicinal, nutritional and therapeutic properties. The leaves of plant has been suggested as feedstuff for rabbits, goats, etc. as it possess high levels of crude protein and anti-oxidant compounds, that regulate meat quality (Siddhuraju and Becker, 2003) [1]. However, the literature in relation to the effect of *M. oleifera* leaves on the quality of chicken meat and eggs is scanty, and needs to be studied. The availability of such literatures is even scantier for Japanese quails, which leads to the present investigation on recording the response of *M. oleifera* leaf meal on the quality attributes of Japanese quail meat and eggs.

Materials and Methods
The present study was conducted at the Poultry Demonstration and Experimental Unit (PDEU) of College of Veterinary Science and Animal Husbandry, DSVCKV, Durg, Chhattisgarh, India. The study, based on completely randomised design, was carried on broiler and layer Japanese quails, for 1-6 and 7-22 weeks, respectively, for which, 300 day-old Japanese quail chicks and 360 adult Japanese quails (270 females + 90 males) were procured from PDEU, respectively. The quails with similar initial body weight were distributed randomly and equally in five different treatments of 3 replicates each based on five different inclusions of *Moringa oleifera* leaf meal. In addition to the basal diet, the treatments, T_0 (control), $T_{0.5}$, T_1, $T_{1.5}$ and T_2 were fed on 0, 0.5, 1, 1.5 and 2% inclusions of Moringa leaf meal.

The quails were fed is caloric and isonitrogenous diets based on ICAR (2013) [2], twice daily, provided ad libitum clean drinking water, and reared on floors under intensive system of housing. The experimental diets for broiler starter (1-3 weeks), broiler finisher (4-6 weeks), and layer (7-22 weeks) quails were formulated as in table 1. Besides, the proximate analysis of Moringa leaf meal used in the study is also indicated in table 1. The study was focussed on the quality evaluation of quail meat and eggs at the end of studies, for which a panel of 10 semi-trained judges were employed. The cooked meat and boiled eggs were presented to the judges for quality evaluation under identical conditions that include cooking and boiling of samples in the same volume and pressure of pressure cooker, and for the same time. The score card developed by Peryan and Pilgrim (1957) [3] and Paguia *et al*. (2014) [4] was used for the quality evaluation of meat and eggs, respectively. The quality attributes for meat was scored in the range of 1-10 and eggs was scored in the range of 1-6. The data were analysed though one-way ANOVA and Duncan's Multiple Range Test using IBM SPSS statistics software version 22.

Table 1: Feed composition (%) of broiler starter (1-3 weeks) and finisher (4-6 weeks), and layer (7-22 weeks) Japanese quail diets and proximate analysis of *Moringa oleifera* leaf meal

Ingredients	Broiler starter					Broiler Finisher					Layer				
	T_0	$T_{0.5}$	T_1	$T_{1.5}$	T_2	T_0	$T_{0.5}$	T_1	$T_{1.5}$	T_2	T_0	$T_{0.5}$	T_1	$T_{1.5}$	T_2
Maize	51.500	51.000	50.900	50.800	50.500	61.800	61.600	61.000	61.000	61.000	60.600	60.400	60.200	59.800	59.500
Soybean meal	42.600	42.500	42.200	41.800	41.600	33.400	33.100	32.900	32.600	32.200	27.400	27.100	26.800	26.600	26.400
Soybean oil	2.200	2.300	2.200	2.200	2.200	1.300	1.300	1.300	1.300	1.300	1.900	1.900	1.900	2.000	2.000
Limestone powder	0.850	0.850	0.850	0.850	0.850	1.200	1.200	1.200	1.200	1.200	7.800	7.800	7.800	7.800	7.800
Di-calcium phosphate	1.800	1.800	1.800	1.800	1.800	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300
Methionine	0.150	0.150	0.150	0.150	0.150	0.140	0.140	0.140	0.140	0.140	0.100	0.100	0.100	0.100	0.100
Salt	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
TM. Premix	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Vitamin Premix	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Vitamin B complex	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Choline Chloride	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Toxin binder	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Vitamin C	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Moringa oleifera leaf meal	0.000	0.500	1.000	1.500	2.000	0.000	0.500	1.000	1.500	2.000	0.000	0.500	1.000	1.500	2.000
Coccidiostat	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	-	-	-	-	-
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Crude protein	24.99	25.01	25.02	24.99	25.00	21.50	21.50	21.50	21.50	21.50	18.60	18.59	18.59	18.60	18.60
Metabolizable energy (kcal/kg)	2898	2900	2899	2899	2900	2950	2950	2950	2950	2950	2850	2850	2850	2850	2850
Calcium	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	3.00	3.00	3.00	3.00	3.00
Phosphorus	0.45	0.45	0.45	0.45	0.45	0.35	0.35	0.35	0.35	0.35	0.32	0.32	0.32	0.32	0.32
Lysine	1.45	1.45	1.45	1.45	1.45	1.20	1.20	1.20	1.20	1.20	1.00	1.00	1.00	1.00	1.00
Methionine	0.55	0.55	0.55	0.55	0.55	0.50	0.50	0.50	0.50	0.50	0.40	0.40	0.40	0.40	0.40
Proximate analysis (%) of *Moringa oleifera* leaf meal															
Dry matter	90.19														
Crude protein	30.21														
Crude fibre	8.12														
Ether extract	8.56														
Total ash	11.86														
Nitrogen free extract	41.25														

Preparation of *Moringa oleifera* Leaf Meal

The leaves and soft twigs of *Moringa oleifera* tree were harvested every 30-45 days from trees planted at the college farm and adjoining areas, and dried on plastic sheets for 4-5 days under shady and aerated conditions. After meticulous removal of soft twigs, the dry leaves were grounded in a mill to make leaf meal, and enclosed in airtight bags to get rid of humidity and contamination from the environment.

Results and Discussion

Quality evaluation of meat

The details of quality evaluation of broiler and layer Japanese quail meat is presented in table 2.

The quality evaluation of broiler meat revealed significant ($P \leq 0.05$) improvements in T_1 and $T_{1.5}$ for meat flavour and acceptability, and in T_1 for meat colour, juiciness, tenderness and texture as compared to T_0. Rest of the Moringa leaf meal based treatments showed insignificant ($P \geq 0.05$) improvements in comparison to T_0. The scores improved in the range of 1.53-10.77%, 5.00-18.33%, 1.61-16.13%, 1.58-12.7%, 1.58-11.11% and 1.66-18.33% for meat colour, flavour, juiciness, tenderness, texture and acceptability, respectively in comparison to T_0. However, the score for meat acceptability across the treatments was in the range of 6.00-7.10, which according to the score card suggests good quality meat.

Besides, insignificant ($P \geq 0.05$) improvements were noted in the sensory attributes (colour, flavour, juiciness, tenderness, texture and acceptability) of layer meat in Moringa leaf meal based diets than control. The scores were insignificantly higher in T_1 followed by $T_{1.5}$, T_2, $T_{0.5}$ and T_0. Though insignificant, the per cent improvement in meat colour, flavour, juiciness, tenderness, texture and acceptability was 3.22-12.9, 3.33-18.33, 4.61-13.85, 4.61-10.77, 3.27-22.95 and 4.47-10.45, respectively in comparison to T_0. The meat acceptability score among the treatments was in the range of 6.70-7.40, which suggests meat to be of good quality.

The present results are in agreement with the outcomes of Rahman *et al*. (2020) [5] who observed improvement in scores for meat colour, flavour, tenderness, and juiciness at 0.1-0.3% inclusions of Moringa leaf extract. The score for overall

acceptability of meat improved in the range of 4.31-4.59 which according to the hedonic scale can be said of very good to excellent quality. Another study by Kumar *et al*. (2018) [6] revealed improvement in scores for meat appearance, flavour, tenderness, juiciness and palatability at 5, 10, 15 and 20% inclusion levels of Moringa leaf meal. In this context, El-Tazi (2014) [7] further conveyed improvement in tenderness and juiciness of breast and thigh meat at 3, 5 and 7% inclusion levels of Moringa leaf meal. In addition, improvement in scores for goat meat aroma intensity, juiciness, tenderness, flavour and atypical flavour was discussed by Moyo *et al*. (2014) [8] in *Moringa oleifera* leaf meal supplemented group (200g/day). The improvement in meat colour was attributed to the anti-oxidant capacity of Moringa leaves which is due to good levels of β-carotene, proteins, calcium and potassium in Moringa leaves. Colour stability is related to antioxidant levels in meat samples. While, the enhancement in meat flavour was explained by the presence of flavonoids, polyphenols, carotenoids and other bioactive compounds in Moringa leaves. Also, the improvement in tenderness was attributed to increased loss of moisture from the meat products which might have led to hardening of texture, breakdown of fat and degradation of muscle fibre proteins by bacterial action resulting into decreased water binding. Moreover, the improvement in juiciness scores was brought by gradual loss of moisture from the meat products. The improvement in overall meat acceptability was due to improvement in scores of colour, flavour, tenderness and juiciness due to high anti-oxidant properties of Moringa leaf extract (Rahman *et al*., 2020) [5]. The high aroma intensity scores of meat were credited to the higher intramuscular fat content in meat supplemented with Moringa leaf meal (Moyo *et al*., 2014) [8].

Contrastingly, no change in sensory attributes of cooked pork patties due to incorporation of *Moringa oleifera* leaf extract was observed by Mutthukumar *et al*. (2014) [9]. The addition of Moringa leaf extract did not produce appreciable colour, odour, flavour or texture changes and all the products were equally acceptable as evidenced by the overall acceptability scores falling in the range of 6.4-6.5.

In the present study, the acceptability of meat has increased in the Moringa leaf meal included treatments than control due to improvement in colour, flavour, juiciness, tenderness, and texture scores. This could be due to high anti-oxidant properties of Moringa leaves.

Table 2: Average scores in quality evaluation of broiler and layer Japanese quail meat (Mean ± SE) under different dietary treatments

Properties	T_0	$T_{0.5}$	T_1	$T_{1.5}$	T_2
Average scores in quality evaluation of broiler Japanese quail meat (Mean ± SE) under different dietary treatments					
Colour	6.50^{a}±0.16	6.60^{a}±0.16	7.20^{b}±0.20	6.90^{ab}±0.17	6.80^{ab}±0.13
Flavour	6.00^{a}±0.21	6.30^{ab}±0.21	7.10^{c}±0.23	6.80^{bc}±0.20	6.50^{abc}±0.16
Juiciness	6.20^{a}±0.20	6.30^{a}±0.26	7.20^{b}±0.20	6.80^{ab}±0.29	6.60^{ab}±0.16
Tenderness	6.30^{a}±0.15	6.40^{a}±0.16	7.10^{b}±0.23	6.80^{ab}±0.32	6.50^{ab}±0.16
Texture	6.30^{a}±0.15	6.40^{a}±0.16	7.00^{b}±0.25	6.70^{ab}±0.21	6.30^{a}±0.15
Acceptability	6.00^{a}±0.14	6.10^{ab}±0.17	7.10^{c}±0.23	6.60^{bc}±0.16	6.40^{ab}±0.16
Average scores in quality evaluation of layer Japanese quail meat (Mean ± SE) under different dietary treatments					
Colour	6.20±0.71	6.40±0.66	7.00±0.25	6.50±0.52	6.50±0.16
Flavour	6.00±0.63	6.20±0.62	7.10±0.37	6.80±0.51	6.60±0.22
Juiciness	6.50±0.40	6.50±0.56	7.40±0.54	6.80±0.55	6.50±0.58
Tenderness	6.50±0.50	6.50±0.63	7.20±0.59	6.80±0.69	6.40±0.54
Texture	6.10±0.40	6.60±0.66	7.50±0.58	6.50±0.77	6.30±0.65
Acceptability	6.70±0.36	7.00±0.53	7.40±0.47	7.30±0.57	7.10±0.52

[a, b and c] Mean with different superscript differ significantly within rows ($P \leq 0.05$)

Quality evaluation of eggs

The details of quality evaluation of layer Japanese quail eggs are descripted in table 3.

The quality evaluation of eggs revealed significant ($P \leq 0.05$) improvements in T_1 and $T_{1.5}$, and insignificant improvements in $T_{0.5}$ and T_2 for egg flavour in comparison to T_0. Besides, there were insignificant ($P \geq 0.05$) improvements in Moringa leaf meal based treatments than control for egg off-flavour and acceptability. The per cent improvement in scores for egg flavour, off-flavour and acceptability was 12.19-19.51, 3.84-7.69 and 4.44-13.33, respectively in comparison to T_0. Meanwhile, the acceptability scores in Moringa leaf meal based treatments falling in the range of 4.70-5.10 reported eggs to be slightly desirable to desirable, while in control having score of 4.50, eggs were claimed to be slightly desirable.

The present result on organoleptic evaluation of egg corroborates with the investigation of Olugbemi *et al.* (2010) [10] where taste, colour, aroma and general acceptability of boiled chicken eggs improved at 5 and 10% inclusions of Moringa leaf meal. The general acceptability of eggs in Moringa leaf meal included groups increased by 25.55-39.56% as compared to control having 20 parts cassava chips and 0 parts Moringa leaf meal. The author notices improvement in aroma and colour of egg yolk by incorporation of Moringa leaf meal in diet which might have unconsciously influenced other factors. The birds receiving Moringa leaf meal in diet tend to produce more colouration in egg yolk which indicates the viability of leaf meal as a yolk colouring agent that enhances the marketability of eggs.

The present study also corresponds with the results of Talukdar *et al*. (2020) [11], who presented no variations in the organoleptic evaluation of quail eggs, particularly overall acceptability of eggs, maintained at 0.00, 0.25, 0.50, 0.75 and 1.00% inclusion level of Moringa leaf meal. However, the score for overall acceptance of eggs across the groups ranged between 5.53-5.97 which according to the hedonic scale, can be said of good to very good quality. A similar report by Paguia *et al*. (2014) [4] throws light on no significant variations in scores for sensory evaluation of eggs among control and *Moringa oleifera* leaf meal groups.

In the present study, the overall acceptability of eggs has increased in the Moringa leaf meal included treatments than control due to improvement in the flavour and off-flavour scores.

Table 3: Average scores in quality evaluation of layer Japanese quail eggs (Mean ± SE) under different dietary treatments

Properties	T_0	$T_{0.5}$	T_1	$T_{1.5}$	T_2
Flavour	4.10^{a}±0.17	4.60^{ab}±0.16	4.90^{b}±0.23	4.70^{b}±0.21	4.60^{ab}±0.16
Off-flavour	2.60±0.16	2.50±0.22	2.40±0.16	2.40±0.22	2.60±0.16
Acceptability	4.50±0.22	4.70±0.21	5.10±0.10	4.90±0.23	4.70±0.21

[a and b] Mean with different superscript differ significantly within rows ($P \leq 0.05$)

Conclusion

It can be concluded that the dietary inclusion of *Moringa oleifera* leaf meal at any level can lead to the production of good quality meat, and slightly desirable to desirable eggs. Besides, a 1% inclusion level of *Moringa oleifera* leaf meal in the diet of Japanese quails can be more fruitful for improvement in the quality of meat and eggs.

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