



Effect of *Moringa oleifera* Leaf Powder Feeding on the Growth Performance and Meat Quality of Kadaknath Chicken

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ABSTRACT

An experiment was conducted to study the growth parameters, nutrient retention, carcass attributes, meat quality and feed cost economics of Kadaknath chicken breed under supplementary feeding of *Moringa oleifera* dried leaf powder, an unconventional feed ingredient. 160-day old chicks were randomly assigned to four treatment groups T1, T2, T3 and T4 of 40 birds each. The levels of *M.oleifera* leaf powder dietary inclusion to these groups were 0%, 5%, 10%, and 15% to the basal diet. Growth performance was studied for 17 weeks, by recording weekly feed intake and feed efficiency at three weeks interval. There was a significant reduction ($p<0.05$) in the feed intake of supplemented groups, however feed efficiency was improved ($P<0.05$). The final body weight of T2 group was statistically similar to the T1, whereas there was a significant reduction ($P<0.01$) in T3 and T4 groups. Nutrient balance study was performed in adult chicken (16-weeks-old), to validate the results of growth trial. There was no significant ($P>0.05$) variation in the apparent digestibility of nutrients and the reduction in feed intake of supplemented groups did not affect their retention of nutrients. Carcass parameters, sensory, physical and nutritive quality of meat was estimated by sacrificing the birds in each group that have attained market weight of the breed. There was no significant difference in the yield and quality of meat in terms of dressing percentage (71-72%), pH (5.96-6.18), water holding capacity (89-90%), except for the Thiobarbituric acid reactive species values of frozen meat. The oxidative stability of meat from supplemented groups was significantly increased ($P<0.05$) with the increase in dietary inclusion level. Inclusion of leaf powder to basal diets also reduced the feed cost. It is concluded that the maximum possible inclusion level of *M.oleifera* leaf powder starter (5%) and grower phase (10%) in the diet of slow growing breeds of chicken.

Keywords: Feed cost, Intensive rearing, *Moringa oleifera*, Nutrient

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INTRODUCTION

Kadaknath is one of the indigenous breed of chicken native to Madhya Pradesh. This breed is well-known for its characteristic black flesh, which is highly relished for its medicinal and aphrodisiac properties. Most of the internal organs exhibits hyperpigmentation or intense black coloration due to the autosomally located fibromelanosis (*Fm*) gene and sex linked (*Id*) resulting in the melanin deposition in the connective tissue of organs and

skin (Arora et al.,2011). Semi intensive and intensive rearing of indigenous or low input variety chicken assures the nutritional security to the below poverty line families, however the cost of feed should be reduced by replacing the traditional feed ingredients with unconventional feed resources.

Energy and protein sources accounts for 95% of total feed cost in poultry production. The plant protein feed stuffs invariably contribute significantly towards the dietary protein supply in most of the

practical poultry rations formulated worldwide. Rations based on soybean meal and groundnut meal are generally favoured over other protein sources. With the increasing population and growing demand, there will be acute shortage of major feed ingredients i.e. maize and soybean in near future (Thirumalaisamy et al., 2016). Rations based on these feed stuffs need to be supplemented with other vegetable protein sources. Increasing population across the globe and changing food habits, concerning the ban of antibiotic growth promoters augmented the quest for alternatives like probiotics, prebiotics, essential oils, phytobiotics with growth promoting, antibiotic, antioxidant, anti-inflammatory and immunostimulant properties have gained lot of importance recently (Mahanta et al., 2017). Recently a number of additives from the plant origin scientifically documented to have wide range of beneficial properties such as growth promoters, antibacterial, antifungal, antioxidant, anti-inflammatory (Hashemi and Davoodi, 2010). *Moringa oleifera* is well known in tropical and sub tropical regions. *Moringa* leaves are rich in crude protein (24-29%) and can be utilized as feed supplement for poultry, having considerable content of protein in comparison to conventional sources (Su and Chen, 2020). It is commonly called as drumstick tree or horse radish tree. It also one of the well cultivated, fast growing and drought resistant plant. The tree is grown throughout the tropics for multipurpose use. It is a rich source of carotenoids, proteins, vitamin K, vitamin C, flavonoids, polyphenols, alkaloids, sterols, manganese, selenium providing with immune modulatory, antioxidant, antibiotic and growth promoting effects (Nkukwana et al., 2015). Almost all the parts of this plant like root, bark, gum, leaves, seed and seed oil have been used for treating various ailments and in the preparation of the indigenous medicine including the treatment of infectious diseases. There has been an increased interest in the utilization of *M.oleifera* in improving the performance and health of the poultry. Besides the leaves also possess antioxidant and antimicrobial properties containing bioactive phytochemicals like flavonoids, polyphenols

(Gopalakrishnan et al., 2016).

The maximum levels of inclusions in different classes and species of poultry need to be standardized, in order to utilize the beneficial effects of those unconventional feed resources without having any prominent compromise on the palatability of feed, performance and health status of birds. The present study was conducted to test the efficiency of utilization of nutrients in terms of growth performance, carcass yield and meat quality of Kadaknath chicken fed with different dietary levels of dried *M. oleifera* leaf powder.

MATERIALS AND METHODS

Experimental design

The experimental work was conducted at Central Avian Research Institute, Izzatnagar, Uttar Pradesh, India, during the summer season (March to July 2021) when the actual temperature ranged from 34-41°C and relative humidity of 47-54%. The growth bioassay was conducted for 17 weeks to evaluate the effects of *Moringa oleifera* dried leaf powder on the performance of Kadaknath chicken. 160-day old chicks were randomly allotted to the 4 dietary treatment groups i.e., T1, T2, T3 & T4 with 0 %, 5%, 10% and 15% inclusion of dried *M.oleifera* leaf powder (MOLP) to basal maize and soybean based feed having 40 birds each treatment with 4 replicates of 10 birds. Chicks were immunized with Marek's disease vaccine and lasota strain vaccine of Ranikhet disease. They were also given identification marks using wing bands. The chicks were reared in battery brooder cages for 8 weeks under chick starter ration, later they were shifted to deep litter system and were offered grower ration following the standard managerial practices throughout the experimental period.

Experimental diets

The nutrient composition of dried leaf powder (Table 3) was analyzed as per the standard protocol (AOAC, 1990), calcium (Talapatra et al., 1940), phosphorous (AOAC, 1990), iron, zinc, copper and manganese by using the principle of atomic absorption spectrophotometry. The fresh leaves of

M.oleifera plant have been harvested and were shade dried at room temperature (32-35°C) for 3-5 days to a moisture level of less than 10%. Dried leaves were grinded into leaf powder and preserved in air tight

containers for use. The leaf powder was weighed and added to the basal feed as per the dietary inclusion level of the respective treatment group (Table 1 and 2).

Table 1. Feed composition of different dietary treatments used as Chick Starter diet for 0-8 weeks of age

Ingredients	Price (Rs./Kg)	T1 (Control)	T2 (5%)	T3 (10%)	T4 (15%)
Maize, yellow	22.82	54.45	54.015	54.545	54.566
Deoiled rice bran	16.88	11	10	8	6
<i>Moringa oleifera</i> leaf Powder	0.00	0	5	10	15
Soyabean meal (Solvent extracted)	66.94	31.126	27.57	24.04	21.01
Limestone powder	6.60	1.1	1.1	1.1	1.1
Di-calcium Phosphate	34.35	1.6	1.6	1.6	1.6
Salt	12.60	0.3	0.3	0.3	0.3
DL-Methionine	477.00	0.06	0.06	0.676706	0.06
L-lysine HCl	372.00	0.05	0.05	0.05	0.05
TM. Premix1*	8348.96	0.1	0.1	0.1	0.1
Vit Premix2**	1845.00	0.15	0.15	0.15	0.15
B complex premix***	1390.00	0.015	0.015	0.015	0.015
Choline chloride, 60%	109.00	0.05	0.05	0.05	0.05
Total		100.001	100.01	100.01	100.001
Analysed nutrient composition					
Moisture (%)		8.54	8.35	8.46	8.27
Dry matter (%)		91.4	91.6	91.5	91.7
Crude protein (%)		20.3	20.1	20.2	20.1
Ether extract or Crude fat (%)		1.85	1.79	1.82	1.86
Crude fibre (%)		13.42	13.8	15.8	15.9
Nitrogen free extract (%)		48.3	48.3	45.9	45.7
Total ash (%)		7.54	7.48	7.67	8.02
Acid insoluble ash (%)		1.25	1.38	1.36	1.29
Calcium (%)		1.05	1.08	1.06	1.04
Phosphorous (%)		1.39	1.27	1.17	1.28

*TM.Premix1: each gram of mineral mixture contains 200 mg ferrous sulphate ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$), 20 mg copper sulphate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$), 200 mg manganese sulphate ($\text{MnSO}_4 \cdot \text{H}_2\text{O}$), 150 mg Zinc sulphate ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$), and 1mg potassium sulphate (KI); **Vit.Premix2: each gram of vitamin mixture contains 540 mg vitamin A (retinol), 50 mg vitamin B2 (riboflavin), 400 mg vitamin D3 (cholecalciferol), and 10 mg vitamin K (menadione); *** B-complex premix: each gram contains 2 mg vitamin B1 (thiamine), 10 mg folic acid, 4 mg pyridoxine HCL, 10 mg cyanocobalamin, and 12 mg nicotinamide.

Performance of Native Kadaknath Chicken Under *Moringa oleifera* Feed Supplementation

Table 2. Feed composition of different dietary treatments used as Grower diet for 9-17 weeks of age

Ingredients	Price	T1	T2	T3	T4
	(Rs./Kg)				
Maize, yellow	22.82	52.5	54.5	52.85	52.5
DORB	16.88	16	11	9.5	7.5
<i>Moringa oleifera</i> leaf Powder	0.00	0	5	10	15
Soyabean meal (Solvent extracted)	66.94	26	24	22.15	19.5
Limestone powder	06.60	1.25	1.25	1.25	1.25
Di-calcium Phosphate	34.35	2.12	2.12	2.12	2.12
Salt	12.60	0.3	0.3	0.3	0.3
DL-Methionine	477.00	0.25	0.25	0.25	0.25
L-lysine HCl	372.00	0.85	0.85	0.85	0.85
TM. Premix1*	8348.00	0.1	0.1	0.1	0.1
Vit Premix2**	1845.00	0.3	0.3	0.3	0.3
B complex premix***	1390.00	0.2	0.2	0.2	0.2
Ch. Chloride, 60%	109.00	0.03	0.03	0.03	0.03
Coccidiostat	298.00	0.03	0.03	0.03	0.03
Liver tonic	110.00	0.025	0.025	0.025	0.025
Toxin binder	207.00	0.05	0.05	0.05	0.05
Total		100.005	100.005	100.005	100.005

Analysed nutrient composition of experimental diets

Moisture (%)	8.80	8.86	8.77	8.41
Dry matter (%)	91.20	91.14	91.23	91.59
Crude protein (%)	17.53	17.30	17.57	17.50
Ether extract or Crude fat (%)	1.65	1.08	1.04	1.89
Crude fibre (%)	16.16	16.37	19.16	19.51
Nitrogen free extract (%)	47.54	49.62	43.78	43.75
Total ash (%)	8.62	8.60	9.35	8.89
Acid insoluble ash (%)	1.69	1.85	1.92	1.458
Calcium (%)	1.23	1.23	1.36	1.44
Phosphorous (%)	1.44	1.28	1.42	1.28

*TM.Premix1: each gram of mineral mixture contains 200 mg ferrous sulphate (FeSO₄. 7H₂O), 20 mg copper sulphate (CuSO₄.5H₂O), 200 mg manganese sulphate (MnSO₄.H₂O), 150 mg Zinc sulphate (ZnSO₄.7H₂O), and 1mg potassium sulphate (KI); **Vit.Premix2: each gram of vitamin mixture contains 540 mg vitamin A (retinol), 50 mg vitamin B2 (riboflavin), 400 mg vitamin D3 (cholecalciferol), and 10 mg vitamin K (menadione); *** B-complex premix: each gram contains 2 mg vitamin B1 (thiamine), 10 mg folic acid, 4 mg pyridoxine HCL, 10 mg cyanocobalamin, and 12 mg nicotinamide.

Growth performance

Growth parameters like body weight, body weight gain, feed intake and feed conversion ratio are the primary criteria for the purpose of evaluating the performance. The body weights of the individual birds were weighed individually using electronic weighing balance on the day of hatch and also on every 3-week interval. The weekly feed intake of each replicate was recorded, whereas body weight gain and feed conversion ratio were calculated at an interval of 3 weeks i.e., 0-3, 4-6, 7-9, 10-12, 13-15, 16-17 and overall body weight gain (0-17). Economics of *M.oleifera* dietary inclusion was calculated for starter and grower diets on the body weight gain as per the prevailing market prices of feed ingredients utilized during the experiment, Cost of MOLP was not included as the leaves were harvested from the institute farm and shade dried. The cost of (Rs/Kg) starter and grower feed of T1, T2, T3 and T4 were 47.6 & 54.2, 45.0 & 52.5, 42.4 & 50.6 and 40.0 & 48.4 respectively. Cost of feed per kg body weight gain was calculated by using total cost of feed intake during starter and grower phases for individual treatments.

Nutrient balance study

The effect of moringa leaf powder dietary inclusion on the utilization of nutrients was estimated by performing nutrient balance study on 16-week-old Kadaknath birds, six birds per treatment were selected randomly and housed individually in cages suitable for metabolism study. The apparent digestibility of nutrients such as nitrogen, calcium and phosphorous were calculated and expressed as % nutrient retention using the amount of feed intake and excreta voided per bird per day.

Carcass characteristics

Carcass characteristics were studied in 8 birds per treatment group on 17th week by sacrificing in a humane way with electrical stunning after 12 hours fasting prior to the slaughter. Carcass parameters like dressing percentage, carcass yield, yield of carcass cuts such as neck & back, breast, wing, thigh and leg, relative weights of giblet and immune organs

were calculated in relation to the pre slaughter live weight.

Meat quality

The quality of meat samples of pooled breast and thigh were collected after sacrificing the birds from mixed sex at 17 weeks of age was tested for different sensory, physical, antioxidant and nutritional properties and evaluated for the effect of feeding *Moringa oleifera* leaf powder. The meat samples of four dietary treatment groups were tested for sensory parameters like colour and appearance, flavor, texture, juiciness and overall acceptability by panel on 8-point Hedonic scale. pH drip loss%, extract release volume(ml) and water holding capacity were estimated in 6 samples from each treatment after 5 days storage at -18°C by following the standard protocols. The lipid oxidation status of meat samples was estimated by following the method given by Witte et al.(1970). The extract of meat samples was prepared by triturating 10 grams of sample in 25 ml of precooled 20% of trichloroacetic acid in 2M Orthophosphoric acid solution. Contents were filtered through Whatmann filter paper No. 1. Exactly 3ml of filtrate was mixed with 3ml of 0.005M thiobarbituric acid solution and then incubated in dark for 16 hours. The absorbance of the samples was measured using spectrophotometer at 532 nm. The optical density at 532 nm was multiplied with a factor to calculate the TBARS values of each sample in duplicate and the average is expressed as mg MDA per Kg of sample.

The nutritional composition of meat – moisture content, crude protein, crude fat and total ash was studied using the standard protocol of AOAC (1990). *Macro mineral* content of 6 meat samples from each treatment was studied using the principle of atomic absorption spectrophotometry. *Fatty acid profile* was estimated using gas chromatography technique.

Statistical analysis

The data obtained from the experiment were subjected to one-way (Snedecor and Cochran, 1980) using the SPSS.24 and the means were tested as per Duncan's Multiple Range Test (Duncan, 1955) for the treatment effects.

Nutrient composition of *M.oleifera* leaf powder

Proximate composition of *M.oleifera* dried leaf powder was presented in Table 3 and the mineral content of leaf powder was 1.76% calcium, 0.68% phosphorous, 300.56 ppm iron, 42.40 ppm zinc, 8.69 ppm copper, and 22.02 ppm manganese. The obtained values of proximate analysis and mineral content of the leaf powder revealed higher crude protein% than the earlier reports 19.76 (Abou-Elezz et al., 2011) to 30.3% (Moyo et al., 2011). The crude fiber content of leaves was 19.63%, values were similar to reports of Alnidawi et al. (2016) i.e., 17.41%. In contrast, Mandal et al. (2014) reported lower values (9.13%). The calcium and phosphorous content of dried leaves were in agreement with the values reported Mandal et al. (2014). Micro minerals such as iron (300 ppm), zinc (42.4 ppm). Copper (8.69 ppm) were similar to the earlier documentation of Moyo et al. (2011). On the contrary manganese content was very less compared to the previous reports. Differences in the nutritive composition of leaves might be attributed to the difference in geographical conditions, seasonal and climatic variations, maturity of the plant at the time of harvest, and also the method of drying followed for the preparation of meal or powder.

Table 3. Nutrient composition of *M.oleifera* leaf powder

Nutrient	Dried leaf powder
Moisture (%)	8.30
Dry matter (%)	91.7
Crude protein (%)	34.3
Crude fibre (%)	19.6
Ether extract(%)	2.63
Nitrogen free extract (%)	33.4
Total ash (%)	9.98
Organic matter (%)	90.0
Acid insoluble ash (%)	0.58

Growth performance

Supplementation of MOLP resulted (Pd^{**}0.05) significant depression on body weight and feed intake (Table 4). The average body weight recorded on 3rd, 6th, 9th, 12th, 15th, and 17th weeks differed significantly (P<0.05) among the four treatment groups. Control group (T1) was having the highest body weight followed by T2, T3, and T4. However, 5% supplemented group recorded statistically similar body weight as that of control group on 15th and 17th weeks. The body weight of birds at 17th week ranged from 765.85 to 887.70 g, higher than those 741±4.47 g recorded by Thakur et al. (2006) at 18th week in their study of growth performance in Kadaknath chicken. In the current study, intensive management system (cage rearing day old to 8 weeks of age followed by deep litter from 9 to 17 weeks of age) might be the reason for the higher body weights of the birds in contrast to the previous study that was conducted in the backyard rearing. The supplementation of MOLP in the diets of Kadaknath chicken decreased the body weight of birds significantly (P<0.01) as the level of inclusion increased. Body weights of 0 and 5% group birds at 17 weeks of age were statistically similar. These findings are supported by the Olugbemi et al. (2010) in broiler chicken as the inclusion of *M.oleifera* leaf meal beyond a level of 5% in their studied significantly reduced the body weights. In contrast to the above findings, Gadzirayi et al. (2012) concluded that *M.oleifera* leaf meal can be fed to broiler chicken at a maximum inclusion level of 20% in their study on the feeding of *M.oleifera* leaf meal as a protein replacement to soybean meal in broiler chicken.

The weekly feed intake of the treatment groups varied significantly (p<0.05) during starter and grower phases except for the first week. Initially there was no particular trend in the feed intake in relation to the level of dietary inclusion as T4 and T3 groups had higher feed intake during the 2nd and 3rd week respectively. Although there was progressive depression of feed intake as the level of inclusion increased gradually in the rest of starter

phase. T1 group had the highest feed intake during the 4th, 5th, 6th, and 8th week followed by T2, T3 and T4. The variation of feed intake in grower phase among various treatment groups was highly significant ($p < 0.01$). The average weekly feed intake of birds during grower phase were in the range of 205 to 365 g, 197 to 354g, 197 to 355g and 149 to 271 g respectively. Supplementation of MOLP at 5% and 10% level of basal feed showed no effect on feed intake during grower phase. The average feed intake of the birds in the entire experimental period was in the order of $T1 > T2 > T3 > T4$. The variation in feed intake among the four treatment group birds was highly significant ($p < 0.01$). The results of the present study are in agreement with the earlier reports of Kamble et al. (2019) who had studied the feed intake at different levels of dietary protein and energy in Kadaknath chicken from 0 to 6 weeks of age and noticed an average feed intake of 1045.83 ± 40.59 g. As the level of inclusion of MOLP increased the feed intake of the birds decreased at a similar pace ($P < 0.01$). The results of this work were in agreement with the conclusions of Olugbemi et al. (2010), that the increased inclusion level of *M.oleifera* leaf meal reduced the feed intake in Arbor acres broilers. These findings are also supported by Abou-Elezz et al. (2011) in a study of replacing the diets of layer chicken with leaf meals. They had reported a significant reduction in feed intake at 10 and 15% levels of *M.oleifera* leaf meal. Sebola et al. (2015) did not find any significant change in the feed intake up to 10% inclusion of *M.oleifera* leaf meal in the diets of Ovambo, Potchefstroom Koekoek, and Black Australorp chicken. The results of the present study are not in agreement with those given by Gadzirayi et al. (2012). They have concluded that an inclusion level of 20% to layers and 25% to broiler diets did not show any significant change ($P > 0.05$) on feed intake compared to control group birds respectively. As the level of MOLP inclusion increased, there was an increase in fibre content of experimental diets. This may be the reason for lower feed intake by birds in all three supplemented groups than the control. The probable reason for decreased feed intake at higher levels may

be due to reduced palatability and increased bulk, also the longer retention time of digesta, and consequently, the gut filling effect. Chicken possessing a simple stomach, having poor fibre digesting capacity restricted only to caecal microflora (Abou-Elezz et al., 2011). In our study, 10% inclusion of MOLP showed a significant reduction in feed intake compared to 5% supplemented birds during the starter phase. However, there was no change in the feed intake at the grower phase between 5% and 10% level. As the age advances colonization of microflora takes place and gets established in the gastrointestinal tract. This can be a probable reason behind increase in feed intake of birds under 10% group.

Nevertheless, having a depression in feed intake and body weight there was no much significant ($P > 0.05$) effect on body weight gain and feed conversion ratio of the chicken. The variation in the body weight gain of supplemented groups during 4-6 interval showed significant depression ($p < 0.05$) than that of control group. During the starter phase of 0-3, 4-6, 7-9 weeks interval order of body weight gain was $T1 > T2 > T3 > T4$, whereas in the grower phase supplemented groups recorded better values numerically ($p > 0.05$). The overall body weight gain of T2 group was statistically similar to the T1 group. The body weight gain increased as the age advanced till 15 weeks of age, except during 10-12 weeks interval which might be due to the peak temperatures of summer ($> 40^\circ\text{C}$) and higher humidity ($> 80\%$) contracted in the present study. The results were in accordance with the findings of Kamble et al. (2019) in their experiment of optimization of dietary protein and energy requirement of Kadaknath chicken during the starter phase (0-6 weeks). 5% inclusion level of MOLP showed no significant difference with the control group on body weight gain of birds during 0-17 weeks of age. These results were supported by the findings of Makanjuola et al. (2014), in their study on the effect of *M.oleifera* leaf meal on performance and hematological parameters of broiler chicken. They have concluded that inclusion up to 6% of diets had no significant

variation ($p>0.05$) on body weight gain of broilers. In the present study inclusion of *M. oleifera* leaf powder resulted in a significant decrease ($P<0.05$) in mean overall body weight gain during 0-17 weeks of age at 10% and 15% levels of feeding. The results were also supported by the findings of Zanu et al. (2012). Sebola et al. (2015) stated that there was no significant variation in body weight gain in three strains i.e. Ovambo (OV), Potchefstroom Koekoek (PK), and Black Australorp from Irene, Pretoria, South Africa fed 0%, 2.5%, 5% and 10% of *M.oleifera* leaf meal till 13 weeks of age. These findings are in contrast to our results. The depression in body weight gain at higher levels of inclusion might be due to the reduction in the feed consumption of birds upon inclusion of leaf powder.

There was significant variation in feed conversion ratio during the entire experimental period except for the 16-17 and 0-17 weeks interval. The FCR of supplemented groups was better than the control group, T4 had the better overall FCR than T3, T2 and T1. Feed conversion ratio of Kadaknath chicken at different intervals increased with age. Kamble et al. (2019) have also documented an increasing trend in the FCR as the age advanced. The range of FCR at different levels of dietary energy and protein used in their study was 3.00 ± 0.16 to 4.19 ± 0.18 and 3.74 ± 0.06 to 4.70 ± 0.25 at 0-3 and 0-6 weeks of age. They concluded that the performance of Kadaknath chicken was better in birds fed starter diet containing 19% CP, ME of 2800 kcal/kg during the cumulative period of 0-6 weeks of age. The CP% and ME of the starter diets used in the present study were 20 and 2850 kcal/kg respectively. These findings are in support of the results obtained in our experiment. FCR during 0 to 17 weeks period of the dietary treatment groups recorded significant variation ($p<0.05$). 15% inclusion (T4) recorded better FCR than control. Inclusion levels of 5 and 10% showed similar values of FCR. Nonetheless having a

significant ($p<0.05$) effect on the feed intake and body weight gain of birds at 10 and 15% levels of feeding MOLP, FCR of both the groups were better than the control group birds. The utilization of feed did not compromise even at 15% inclusion level. The lower body weight gain of the birds can be attributed to the progressively decreased feed intake upon inclusion at higher levels. Olugbemi et al. (2010) also recorded no significant ($p>0.05$) difference in FCR of 5% supplemented group than control birds, but at 10% inclusion FCR differed significantly ($p<0.05$) with the control group birds. In contrast, Gakuya et al. (2014) stated that 7.5% inclusion of *M.oleifera* leaf meal did not have any significant difference ($p>0.05$) on FCR of broilers, but higher levels of inclusion 15 and 30% had significant ($p<0.05$) negative effects on feed conversion efficiency. The better feed conversion efficiency recorded in this study might be due to the difference in the type of chicken. This shows that indigenous chicken possesses better efficiency of utilizing high fibre diets may be due to their inherent diversity of gut microflora.

Inclusion of leaf powder is advantageous economically, as there was significant ($p<0.05$) difference in the cost of feed required per Kg body weight gain. The calculation of feed cost economics for the effect of MOLP inclusion in starter and grower diets of Kadaknath revealed superior economic benefits in terms of feed cost per kg body weight and body weight gain. The results of this experiment were supported by the earlier experiments of Olugbemi et al. (2010) at 5 and 10% levels of inclusion in broilers, Ayssiwede et al. (2011) observed increased returns in senegal indigenous chicken up to 16% of inclusion level. Feed cost can be reduced by the inclusion of MOLP as there was significant difference in the amount required per kg body weight gain among dietary treatment groups.

Table 4. Growth performance of Kadaknath chicken fed different dietary levels of MOLP

Parameter	T1 (0% MOLP)	T2 (5% MOLP)	T3 (10% MOLP)	T4 (15% MOLP)	Pooled SEM	P-value
Body weight (g/bird) (n=4 replicates, each replicate = 40)						
0 th day	27.9	28.5	27.5	28.5	0.20	0.98
3 rd week	91.5 ^a	82.5 ^b	85.0 ^{ab}	89.0 ^{ab}	1.35	0.05
6 th week	233.3 ^a	210.2 ^{ab}	180.5 ^{bc}	164.4 ^c	8.48	0.01
9 th week	427.3 ^a	402.8 ^{ab}	330.6 ^{bc}	302.2 ^c	16.8	0.01
12 th week	592.9 ^a	540.4 ^{ab}	482.2 ^{bc}	457.5 ^c	16.4	0.01
15 th week	772.4 ^a	768.8 ^a	685.2 ^b	639.4 ^b	23.3	0.01
17 th week	887.7 ^a	886.1 ^a	842.1 ^{ab}	765.8 ^b	16.4	0.01
Feed intake (g/bird/week) (n=4 replicates, each replicate = 40)						
Starter phase (0-8)	1064.7 ^a	983.1 ^{ab}	857.8 ^{bc}	775.5 ^c	36.1	0.01
Grower phase (9-17)	2683.8 ^a	2487.4 ^b	2471.4 ^b	2232.0 ^c	42.4	0.01
Body weight gain (g/bird) (n=4 replicates, each replicate = 40)						
0-3 weeks	63.6 ^a	54.2 ^b	57.2 ^{ab}	61.0 ^{ab}	1.36	0.05
4-6 weeks	139.5 ^a	127.9 ^a	95.3 ^b	75.0 ^b	8.12	0.01
7-9 weeks	190.0	192.6	150.0	137.2	9.68	0.08
10-12 weeks	157.0	136.5	149.5	154.8	5.46	0.59
13-15 weeks	187.0 ^b	228.3 ^a	203.0 ^{ab}	187.2 ^b	6.40	0.05
16-17 weeks	110.3	114.5	130.5	147.6	6.04	0.10
0-17 weeks	860.5 ^a	858.0 ^a	814.2 ^{ab}	758.9 ^b	14.64	0.02
Feed conversion ratio (n=4 replicates, each replicate = 40)						
0-3 weeks	3.82	4.39	4.37	4.15	0.12	0.33
4-6 weeks	3.30	2.92	3.28	3.89	0.14	0.07
7-9 weeks	3.31	3.02	3.31	3.10	0.08	0.51
10-12 weeks	4.62	4.62	4.47	4.27	0.14	0.84
13-15 weeks	5.50	4.37	4.49	4.15	0.21	0.09
16-17 weeks	6.69 ^b	5.96 ^{ab}	5.63 ^{ab}	4.34 ^a	0.32	0.05
0-17 weeks	4.35 ^b	4.05 ^{ab}	4.08 ^{ab}	3.97 ^a	0.53	0.05
Feed cost per Kg	227.62 ^c	203.86 ^b	198.0 ^b	183.5 ^a	4.56	0.01
Nutrient balance study of 16 week old chicken (n=6)						
Feed intake	73.50 ^a	56.50 ^b	53.0 ^b	40.5 ^b	3.83	0.01
Excreta voided	118.70	144.87	117.4	111.1	7.95	0.50
DM retention %	67	65	66	65	0.97	0.06
OM retention %	70	65	65	64	1.11	0.31
CP retention %	49	50	47	45	2.66	0.58
Ca retention %	49	44	49	45	1.78	0.20
P retention %	046	45	49	44	2.75	0.34

Means bearing different superscript within a row differ significantly (p < 0.05)

Nutrient balance study

The effect of feeding MOLP on the retention of dry matter and nutrients at 16 weeks of age was given in Table 4. The feed intake expressed as gram per day per bird showed significant variation ($P < 0.05$) among T1, T2, T3, and T4 with 73.50 ± 6.55 , 56.50 ± 4.57 , 53.00 ± 5.07 , and 40.50 ± 4.92 , respectively. There was no significant difference ($P > 0.05$) among the four dietary treatment groups in the amount of excreta voided (gram per bird per day), nutrient retention of dry matter, organic matter, crude protein, calcium, phosphorus. The values obtained in this metabolism trial were similar to the nutrient digestibility of native chicken in Indonesia fed different levels of dietary protein and energy by Sarjuni et al. (2021) Olukosi et al. (2015) studied nutrient retention of broiler chicken by indicator method for the effect of exogenous proteases, retention of dry matter and nitrogen of control group birds were 0.59 and 0.49, respectively. These values are similar to our study. The retention of minerals were supported by Juanpere et al. (2005), they have reported 0.55 phosphorous and 0.47 calcium retention in 42-day old broiler chicken. Effect of feeding MOLP had no significant difference ($p > 0.05$) on the nutrient retention of supplemented birds compared to the control group. This can be a probable reason for the better feed conversion ratio of birds fed 15% of MOLP.

Carcass characteristics

Carcass quality parameters like pre slaughter live weight, dressing percentage and carcass yield are economically important and were presented in Table

4. Dietary inclusion of MOLP showed no statistical variation on the carcass characteristics like carcass yield, dressing percentage, yield of giblet, cut-up parts and immune organs except for the pre slaughter live weight. The percentage yield of carcass cuts like neck and back, breast, wing, thigh and leg were in the range of 13.2 to 13.5, 13.9 to 15.8, 9.68 to 10.4, 9.86 to 10.2 and 10.6 to 11.5 respectively. The relative weight of edible viscera such as giblet was between 4.99 to 5.79 %. The percentage yield of spleen, thymus and bursa were 0.10 to 0.13, 0.20 to 0.30 and 0.06 to 0.11 respectively. The values recorded in this study are similar to the findings of Ekka et al. (2018). Ayssiwede et al. (2011) also stated that there was no significant ($p > 0.05$) difference in dressing percentage, organ percentages of liver, heart, lungs, and spleen together upon *M.oleifera* leaf meal inclusion in the diets of indigenous chicken of Senegal. These results are also supported by Sebola et al. (2015) in their experiment on the inclusion of *M.oleifera* leaf meal at 2.5 to 10% in the diets of Ovambo, Potchefstroom Koekoek, and Black Australorp chicken. Abousekken (2015) reported a significant increase ($p < 0.05$) of thymus and spleen % in broilers fed *M.oleifera* leaf powder in feed at 5 & 10 % and leaf extract in drinking water. But the range of spleen %, bursa %, and thymus % were 0.10 ± 0.01 to 0.13 ± 0.01 , 0.06 ± 0.01 to 0.11 ± 0.01 and 0.20 ± 0.03 to 0.30 ± 0.02 , respectively, these values are similar to the highest values recorded in *M.oleifera* leaf powder fed group of birds in the earlier study. The reason for the variation of the results might be due to the inherent immunity of indigenous breeds (Zhang et al., 2006).

Table 5. Carcass characteristics and meat quality of Kadaknath chicken meat

Parameter	T1 (0% MOLP)	T2 (5% MOLP)	T3 (10% MOLP)	T4 (15% MOLP)	Pooled SEM	P-value
Carcass characteristics (n=8)						
Preslaughter live weight (g)	1019.7 ^a	1000.5 ^{ab}	928.5 ^{bc}	879.5 ^c	14.9	0.01
Dressing percentage	72.4	71.2	71.5	71.7	0.29	0.52
Carcass yield (%)	67.0	65.9	66.6	65.9	0.28	0.47
Physical properties of meat (n=6)						
pH	5.96	6.18	5.96	5.99	0.81	0.78
Drip loss (%)	2.54	1.68	1.46	2.89	0.23	0.06
Extract release volume (ml)	22.0	24.2	19.0	24.0	1.74	0.74
Water holding capacity (%)	90.9	88.9	90.2	89.8	1.36	0.98
TBARS (mg MDA/Kg)	0.23 ^b	0.22 ^b	0.15 ^a	0.15 ^a	0.14	0.02
Nutrient composition (n=6)						
Moisture (%)	75.0	73.0	72.9	73.7	0.41	0.21
Crude protein (%)	21.2	23.1	23.0	23.0	0.17	0.19
Crude fat (%)	5.69	5.55	5.28	5.12	0.13	0.13
Total ash (%)	5.06	5.06	5.11	5.05	0.05	0.23
Mg (ppm)	87.8	86.3	84.0	88.0	0.92	0.44
Na (ppm)	17.0	16.8	13.4	15.9	0.59	0.08
Fe (ppm)	59.4	57.8	60.7	61.8	1.81	0.28
Zn (ppm)	18.5	18.1	21.1	17.7	1.32	0.34
Mn (ppm)	2.14	2.30	1.56	2.53	0.28	0.06
Fatty acid profile (n=2)						
Σ SFA (%)	49.6	44.5	43.7	40.6	-	-
Σ MUFA (%)	20.2	19.5	17.9	19.6	-	-
Σ PUFA (%)	15.1	22.3	25.0	26.5	-	-
Σ TRANS FAT (%)	14.9	13.6	13.2	13.1	-	-
OMEGA-6 (%)	15.1	22.3	25.0	26.5	-	-

Means bearing different superscript within a row differ significantly ($p < 0.05$)

Meat quality

The variation of all the sensory qualities like color and appearance, flavor, texture, juiciness, and overall acceptability did not show any significant difference ($p > 0.05$) among the treatment groups, but numerically higher values were noted for the meat of moringa fed birds. Inclusion of MOLP at 5 to 15% level showed superior values for texture, juiciness, and overall acceptability upon organoleptic

evaluation on a 8-point hedonic scale by the sensory panel. Overall acceptability of meat from T1, T2, T3, and T4 groups were 6.38 ± 0.38 , 6.44 ± 0.26 , 7.19 ± 0.19 , and 6.44 ± 0.39 , respectively. Although supplementation of MOLP at 10% of feed resulted in better overall acceptability of meat among all the groups. The change was not statistically significant ($P > 0.05$). The results of meat quality were presented in Table 4. All the sensory attributes of meat such as

color and appearance, flavor, texture, juiciness and overall acceptability were improved in the meat from supplemented groups than the control. Supplementation of dietary MOLP to Kadaknath chicken resulted in better overall acceptability of meat than the control group, with no statistically significant change ($P>0.05$). El Tazi (2014) also found no significant change in the sensory quality of meat upon feeding *M.oleifera* leaf powder to broilers. Similar findings were reported by Biswas et al. (2015) in broiler chicken supplemented 0.5 to 2% *M.oleifera* leaf powder in the basal diet.

The physical properties of meat such as pH, drip loss(%), extract release volume (ml), and water holding capacity (%) have a direct effect on the keeping quality and tenderness of the meat. Supplementation of MOLP at 10% level improved the physical properties of meat than the control group birds. Though the numerical values of these parameters differ under different levels of dietary MOLP, however there was no significant difference ($P>0.05$). Effect of dietary supplementation of MOLP to Kadaknath chicken on the physical quality of the meat was studied after 7 days storage at -18°C . Nonetheless, supplemented groups showed better pH, drip loss %, extract release volume, and water holding capacity, however the change from the control group was not statistically significant ($P>0.05$). Cui et al. (2018) also found no significant difference in drip loss % and pH of breast meat from broiler chicken fed 0 to 15% of *M.oleifera* leaf powder.

The shelf life of meat and meat products depends on the antioxidant defense of meat against lipid peroxidation under normal storage conditions. The degradative changes in meat due to lipid peroxidation of polyunsaturated fatty acids after 14 days of refrigerated (-18°C) storage was estimated using TBARS test and results are expressed as mg MDA per kilogram of sample. Higher the value greater the spoilage due to lipid peroxidation. Meat samples from 10 and 15% supplemented groups had significantly ($P<0.05$) lower values than that of T1 and T2 groups. Oxidation of lipids during storage of meat upon exposure and interaction of molecular

oxygen and free fatty acids leads to deterioration of quality leading to rancidative changes (Wapi et al., 2013). Improving antioxidant defense against free radical damage through supplementation of antioxidants in feed was one of the efficient methods of increasing the oxidative stability of meat (Tavarez et al., 2011). Inclusion of MOLP in feed showed significant ($P<0.05$) defense than control group against oxidative damage of meat. There was no difference between 10 and 15% supplemented groups in their TBA values. These results were supported by the conclusions of Mandal et al. (2014) and Cui et al. (2018) in their studies on broilers fed 0.5 to 2% *M.oleifera* leaf powder upon 7 days of refrigerated storage and at 1 to 15% levels respectively. *In-vitro* and *in-vivo* antioxidant stability of different fractions of *M.oleifera* leaf were studied by Verma et al. (2009) concluding that carotenoids, phenolics, alkaloids, and flavonoids present in leaves are responsible for their potential antioxidant properties. These phytochemicals present in the leaves can be a probable reason for the better quality of meat from the birds of supplemented groups.

Nutrient composition of meat from Kadaknath chicken fed *M.oleifera* leaf powder at 0, 5, 10 and 15 % levels of basal diet showed no significant variation ($P>0.05$). Supplementation of MOLP had a beneficial effect on the fatty acid composition of meat. As the level of inclusion increased there was an increase in the poly-unsaturated fatty acid content and also there was a gradual decrease in the content of saturated fatty acid content of meat. Due to scarce resources, fatty acid estimation was done for the single sample of each treatment in duplicate. The results of fatty acid profile obtained in this study can only give the preliminary idea which needs further validation by repetition with large sample size. The inclusion of moringa resulted in an increase in the crude protein and decrease in crude fat content of meat, however, there was no significant difference with the control ($P>0.05$). moisture, crude protein, crude fat, and total ash content of meat. Results were in accordance with the reports of Ekka et al. (2018). In contrast, Gnanaraj et al. (2020) studied the proximate composition of meat from 8 weeks old

Kadakhnath, Nicobari, and naked neck chicken, with lower values of crude protein (18.89%) and total ash (1.01%) in meat. The superior nutritive composition of meat in this experiment compared to Gnanaraj et al. (2020) might be due to the difference in the age of chicken. The micro-mineral content of meat such as iron, zinc, sodium, manganese, and magnesium had no significant difference ($P>0.05$) among dietary treatment groups. Iron (57.8 ± 1.35 to 61.8 ± 1.71 ppm) and magnesium (84.0 ± 1.79 to 88.0 ± 1.66 ppm) content of Kadakhnath meat was comparatively higher than the broiler meat (13.4 to 17.5 ppm), whereas sodium (13.4 ± 0.34 to 17.0 ± 1.19 ppm) content of Kadakhnath meat was lower than broiler meat (37.7 to 59.8 ppm) as evaluated by Ahmed et al. (2015) in the broilers supplemented pomegranate by-product. Poly unsaturated fatty acid content of meat increased upon increasing levels of dietary inclusion of *M.oleifera*. These results were supported by Cui et al. (2018), who studied the fatty acid profile of broiler chicken meat supplemented *M.oleifera* leaf meal at 0, 1, 2, 5, 10, and 15% of basal diet. They have concluded that there was a significant ($P<0.01$) increase in the polyunsaturated fatty acid content in the supplemented groups compared to control group. Ahmed et al. (2015) recorded significant decrease ($P<0.05$) in the saturated fatty acid content of meat in broiler chicken fed 0 to 2% of pomegranate by-product, but the change in poly unsaturated fatty acid content was not significant ($P>0.05$). Feeding of MOLP had a progressively positive effect on the nutritive quality besides improving ($P<0.05$) the antioxidant defence against lipid peroxidation i.e. reduction in MDA (mg/kg) values of meat from supplemented groups, increasing the oxidative stability.

CONCLUSION

The growth performance of 5% supplemented group was superior among the dietary treatment groups. Nevertheless, showing a significant depression in body weight of birds supplemented groups recorded better FCR, indicating no adverse effect on nutrient utilization. There was a positive

effect on the meat quality as the peroxidative changes of meat was reduced upon inclusion of dried leaf powder. *M.oleifera* leaf powder can be included in the diets of slow growing indigenous chicken at 5% level during stater phase and can be increased up to 10 % level in grower phases during this period the capacity for utilizing high fibre diet increases with the colonization of microbes in caeca. Inclusion beyond 15% level of basal feed may reduce the palatability and increases fibre content of diet resulting major depression on the performance.

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