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Research Article

EFFECT OF DIETARY SUPPLEMENTATION OF ARJUNA *(TERMINALIA ARJUNA)* BARK AND SAHJAN *(MORINGA OLEIFERA)* LEAF POWDER ON THE GROWTH PERFORMANCE, CARCASS QUALITY AND MEAT COMPOSITION OF UTTARA CHICKEN

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ABSTRACT: This study aimed to assess the impact of adding *Terminalia arjuna* bark and *Moringa oleifera* leaf powder to the diet on the growth, carcass quality, and meat composition of Uttara chickens. A total of 72-day-old chicks were divided into six treatment groups, each with three replicates of four birds. The birds were fed different diets: T_0 (control diet), T_1 (Basal diet + 1% Arjuna bark + 1% Moringa leaf), T_2 (Basal diet + 1% Arjuna + 2% Moringa), T_3 (Basal diet + 1% Arjuna + 3% Moringa), T_4 (Basal diet + 1% Arjuna + 4% Moringa), and T_5 (Basal diet + 1% Arjuna + 5% Moringa). The results showed that the average body weight was notably higher ($p<0.01$) in T_3 in contrast to T_0, T_4 and T_5 during the 8 to 20-week period. Additionally, T_3 demonstrated a significantly better ($p<0.01$) feed conversion ratio than T_0, T_4, and T_5 in the same timeframe. No significant difference found in feed intake. In comparison to T_0, T_4, and T_5, T_3 exhibited considerably higher ($p<0.05$) dressing (%), eviscerated yield (%), and edible yield (%). Compared to T_0, T_4, and T_5, T_3's gizzard (%) was considerably higher ($p<0.05$). There was no discernible change in the growth of the digestive and lymphoid organs, shrinkage, or the yield of the heart and liver (%). Breast and thigh percentages were considerably greater ($p<0.05$) in T_3 groups compared to T_0, T_4, and T_5. No discernible change in the drumstick, wings, neck, or back (%). Moisture and CP (%) were substantially higher ($P<0.05$) in T_3's thigh and breast muscles than in T_0, T_4, and T_5. In both the breast and thigh muscles, T_3 had a considerably lower ($p<0.05$) ether extract percentage than T_0, T_4 and T_5. Therefore, it can be said that 1% Arjuna bark and 3% Sahjan leaf had a positive impact on the growth, carcass quality, and chemical makeup of the thigh and breast muscle, suggesting that they could be useful dietary supplements.

Keywords: Body weight, Crude protein, Dressing percentage, Edible yield, Feed conversion ratio.

INTRODUCTION

Antibiotics are the most cost-effective method for maintaining feed efficiency and health in monogastric animals, such as chickens [1]. Human practices are dynamic and subject to change based on changing conditions and usage. The intentional use of herbs and plant products in modern poultry farming is a remarkable development. The need for alternatives to synthetic drugs has intensified due to concerns about their deleterious impact on poultry and consumer health, as well as rising costs associated with their use in chicken production. This served as the foundation for the European Union's decision to ban certain antibiotic growth enhancers. Herbs such as moringa, black cumin seed, pawpaw seed, neem, green tea, lavender, garlic, and essential oils have been used as natural alternatives to antibiotics and as growth enhancers in poultry. These plants serve as antiviral, anticocidiosis, antiparasite, and immunomodulatory medicines, in addition to being antibiotic and growth promoter alternatives [2]. There's a lot of evidence pointing to the idea that they could really help out the beneficial gut microflora while keeping harmful bacteria like clostridia, colibacteria, and salmonellae in check [3, 4, 5, 6, 7, 8]. Herbs and spices contain active compounds with antibacterial, immunomodulatory, and antioxidant properties that can benefit animals. This means they might play a significant role in boosting the productivity and overall health of animals, as well as improving the quality of the products [9].

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Majority of people in India (60%) lives in area where rice or wheat is the main crop and protein intake is quite poor. So, it is important to ensure healthy growth and promote sound health for preventing protein deficiency. Also, backyard poultry with improved chicken varieties or native breeds has gained popularity as potential source of protein and also generating supplemental income to rural and tribal people of India. Their products are more expensive than those made from commercial fowl and are more preferred by peoples. So, locally available medicinal plant can be added in the diet of backyard poultry. Therefore, medicinal plant could be used in the diet of both commercial and backyard poultry. *Terminalia arjuna* is a perennial, evergreen, and deciduous tree in the *Combretaceae* family. It may grow up to 30 m tall and has approximately 200 species found worldwide [10, 11]. According to reports, the plants contain a number of minerals and phytocomponents with potential medical uses, including glycosides, flavonoids, triterpenoids, alkaloids, tannins, polysteroids, saponins, and phenolic compounds [12, 13]. It has been noted that leaves and stem bark have the following properties: cytotoxic, hepato-protective, osteogenic, hypoglycemic, analgesic, anti-inflammatory, antioxidant, antibacterial, anti-mutagenic, cardioprotective, antiviral, gastroprotective, immune-stimulatory, antifungal, anti-atherosclerotic, anti-cancer, anti-dabetic, and osteogenic [14]. *Moringa oleifera* is a common cultivated plant from the genus Moringa (family *Moringaceae*) in the order *Brassicales*. The most nutrient-dense portion of M. oleifera is its leaves, which are a major source of protein, manganese, vitamin K, vitamin B complex, vitamin C, pro-vitamin A as beta-carotene, and other essential nutrients [16]. The leaves of Moringa oleifera are high in lipids, proteins, vitamins, and minerals and have antibacterial properties [15,17]. Low levels of polyphenols found in Moringa oleifera leaf extracts may have an impact on blood lipid metabolism [16, 18]. Poultry can be fed Moringa oleifera as a dietary supplement and as a source of micronutrients [19, 20].

Although indigenous chickens are resistant to disease but chickens tend to grow more slowly and have lower feed efficiency compared to commercial chickens. Supplementing the diet with nutrient-rich plants such as Arjuna and Moringa can increase growth rates, improve the feed conversion ratio and increase overall yield without affecting disease resistance. Also, many rural and smallholder farmers rely on indigenous chickens for their livelihood. The performance of these chickens can be improved in a cost-effective and locally sourced manner. In this regard, the current study is conducted on indigenous chickens to assess the effects of dietary supplementation with Arjuna bark and Moringa oleifera leaf powder on growth performance, carcass quality, and meat composition of Uttara chickens.

MATERIALS AND METHODS

Experimental birds

Following sexing, 72 female day-old Uttara chicks were maintained at the College of Veterinary & Animal Sciences' Instructional Poultry Farm in Pantnagar. All of the birds were weighed individually before being randomly assigned to six treatment groups having three replicates with four chicks each.

Housing and management

All of the birds in the experiment were housed in a deep litter system for 20 weeks. Fresh and dried wheat straw were utilised as bedding material. The day-old chicks were wing banded individually for identification and weighed individually before allocating to different dietary treatments. Adequate light for 24 hours and ventilation were provided during brooding phase. Every day, the weighed quantity of feed was given, and there was always clean, fresh drinking water available. Individual bird body weights and leftover feed were measured once a week, replicate-wise.

Collection of Arjuna (*Terminalia arjuna)* bark and Sahjan (*Moringa oleifera*) leaf

Arjuna bark and Sahjan leaves were collected from the surrounding areas of Pantnagar. Arjuna bark was shade dried to avoid nutrient loss and grounded to powder by an electric grinding machine at Department of Agronomy, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar. Sahjan leaves was also shade dried and grounded to powder by an electric grinding machine at Department of Animal Nutrition, College of Veterinary and Animal Sciences, G.B. Pant University of Agriculture and Technology, Pantnagar. Various levels of powdered Arjuna bark and Sahjan leaf were added to the feed of chicken.

Experimental diets

Standard chicken diets were prepared for chick (0-8 weeks) and grower (9-20 weeks) by mixing the ingredients to meet the nutrient requirements of layer chicken as per recommendations of BIS (2007) [21]. Proximate composition of experimental feed, Arjuna bark and Sahjan leaf was analyzed using AOAC (2005) procedure [22].

Experimental design

The birds were given different diets: T_0 was the control diet, T_1 included the basal diet along with 1% Arjuna bark powder and 1% Sahjan leaf powder, T_2 had the basal diet with 1% Arjuna and 2% Sahjan, T_3 featured the basal diet with 1% Arjuna and 3% Sahjan, T_4 consisted of the basal diet with 1% Arjuna and 4% Sahjan, and finally, T_5 was the basal diet with 1% Arjuna and 5% Sahjan.

Growth performance parameters

Average body weight (g), feed intake (g) and feed conversion ratio (FCR) were recorded from 0 to 20 weeks of age.

Carcass quality traits

Two birds from each treatment group (12 total) were selected at 20 weeks of age for slaughter in order to examine a number of slaughter characteristics, including pre-slaughter fasting shrinkage in live weight (%), dressing (%), eviscerated yield (%), giblet (%), edible yield (%), development of digestive and lymphoid organs. Further, percent yield of cut-of-parts (thighs, drumsticks, breast, back, neck and wing) were also determined. The length and weight of each digestive organ (proventriculus, small intestine, large intestine, and caecum) and weight of lymphoid organs (spleen, thymus, bursa) were also measured independently.

Chemical composition of feed, supplements, breast (*pectoralis major*) and thigh (*ilio tibialis*) muscle

Samples of feed, breast (*pectoralis major*) and thigh (*ilio tibialis*) muscles were processed and examined for moisture, total ash, crude protein, crude fibre, crude fat, NFE, calcium and phosphorous of chick, grower feeds, Arjuna bark and Sahjan leaf powder were determined [21]. Chemical composition of thigh and breast muscles such as moisture, total ash, crude protein, crude fat, calcium and phosphorous were also determined after slaughter of birds.

RESULTS AND DISCUSSION

Chemical composition of feed and supplement

Prepared ration has been presented in Table 1. Proximate composition of chicken diets fed to chicks, growers and layer feed has been presented in Table 2. The feed was adequate in all nutrients as per nutritional requirements [22]. Chemical composition of Arjuna bark and Sahjan leaf powder is presented in Table 3.

Body weight

The average body weight (g) of Uttara chicken among various treatment groups from 0 to 20 weeks of age has been tabulated in Table 4. The findings showed that, from 8 to 20 weeks of age, the average body weight of Uttara chicken was considerably higher ($p<0.01$) in the T_3 group as compared to T_0, T_4 and T_5 groups. The body weight (g) of the T_3 group was 11.03% greater than that of the T_0 (control) group at 20 weeks of age. During 0–4 weeks, there was no notable difference in the body weight of the birds among the different treatment groups.

Current findings are supported by a number of other investigations. Mikhail *et al.* (2020) reported that birds fed *Moringa oleifera* leaf meal (MOLM) significantly ($p<0.05$) acquired higher weight than those

Table 1. Proportion of ingredients (%) of basal diets of chick and grower feed.

Feed Ingredient (%)	Chick Feed	Grower Feed
Yellow maize	60	35
Deoiled rice bran (DORB)	-	25
Rice polish (oiled)	3.1	5.1
Groundnut cake (solvent extract)	15	11
Soyabean meal (solvent extract)	18	9
Wheat	-	10
Lime stone powder	2	3
Common salt	0.3	0.3
Choline chloride	0.05	0.05
Lysine	0.05	0.07
DL methionine	0.05	0.05
Poultry trace minerals (Manganese, Zinc, Iron, Copper, Selenium, Iodine)	0.1	0.1
Vitamin BV-250 (Zinc sulphate, Manganese sulphate, Vitamin A, Vitamin B_2, Vitamin D_3, Vitamin K_3, Vitamin B_1, Vitamin B_6, Vitamin B_{12}, Biotin, Niacin, Calcium Pantothenate, Vitamin E, Folic acid, Yeast)	0.05	0.05
Hepatocare	0.1	0.1
Toxin binder	0.1	0.1
Coccidiostat	0.05	0.04
Multienzyme (Xylanase, α-Amylase, Cellulase, Protease, β-glucanase, Mannanase, Pectinase, Phytase, α-galactosidase, β-galactosidase, Lipase)	0.05	0.04
Di-Calcium Phosphate	1	1

Table 2. Chemical composition of basal feed given to birds during different phases of growth.

Particulars	Moisture (%)	Crude protein (%)	Ether extract (%)	Crude fibre (%)	Total ash (%)	Nitrogen free extract (%)	Ca (%)	P (%)	Metabolizable Energy (ME) (Kcal/Kg)
Chick feed (0-8 weeks)	11.64	20.22	2.26	7.34	8.75	61.43	0.95	0.46	2880
Grower feed (8-20 weeks)	11.41	16.25	2.11	8.76	9.06	63.82	1.03	0.40	2700

Table 3. Chemical composition (%) of Arjuna (Terminalia arjuna) bark and Sahjan (Moringa oleifera) leaf powder.

Particulars	Moisture	Crude protein	Ether extract	Crude fibre	Total ash	Nitrogen free extract	Ca	P
Arjuna bark (*Terminalia arjuna*)	6.12	4.07	4.35	15.45	27.65	48.47	3.05	0.03
Sahjan leaf (*Moringa oleifera*)	6.43	24.50	2.84	9.76	9.82	53.09	2.64	0.39

fed the control diet [23]. The heaviest body weight was demonstrated by birds fed on a (5% MOLM) diet. Daramola (2019) observed that birds fed a control feed and a feed containing mixture of 0.2% MOLM and 0.2% bitter leaf meal (BLM) gained more weight ($p<0.05$) than birds fed diets containing 0.2% BLM and 0.2% MOLM alone [24]. Sogut and Mohammad (2018) determined that birds fed on 1% Moringa (*Moringa oleifera*) leaves powder (MLP) and 1% mixture of Moringa, Sumac, and Thyme leaves powder had higher ($p<0.05$) live body weight compared to the control group [25]. Jimoh *et al.* (2022) revealed that under heat stress, birds that were provided supplements of moringa and mistletoe performed better than birds that weren't supplemented, while birds that were fed mistletoe had the best survival rate overall [26]. Abu Hafsa *et al.* (2019) found the chicks given 0.5% and 1% MOL had higher final body weight (FBW) [27]. Arif *et al.* (2019) discovered that increasing the dietary level of herbal mixture in feed containing equal proportion of black cumin, Moringa oleifera, and chicory seeds was resulted in a gradual but significant gain in body weight [28]. Ansari (2017) found that supplementing the ration with 1% arjun powder increased the average weekly body weight significantly [29]. In the study by Mousa *et al.* (2017), supplements significantly increased body weight, however the control group had the lowest mean value of the treatments [30]. The group fed 0.75% *Moringa oleifera* plus 0.75% *Cichorium intybus* gained more weight (2393±80 g) than the other groups (2180±48, 2020.5±97, and 1893±54 g) for groups *Cichorium intybus*, *Moringa oleifera*, and control). Result revealed that T_3 group was found best performance in weekly and biweekly body weight in both type of indigenous chicken. This might be due to the property of *M. oleifera* levels when added at 3 percent level with 1 percent *T. arjuna* resulted better than the inclusion of higher percentage.it is believed that *M. oleifera* improves the absorption of different vitamins, minerals and other micro-nutrients. Inclusion of *M. oleifera* more than 3 percent in dietary supplementation is not suggested as per findings during the study.

Feed intake

The average feed intake (g) of Uttara chicken among various treatment groups from 0 to 20 weeks of age has been tabulated in Table 5. Result showed that there was no significant difference in average feed intake of chicken aged 0 to 20 weeks.

No remarkable difference in average feed intake of chicken from 0 to 20 weeks of age. There are few studies which are in agreement with present findings. Verma *et al.* (2022) found that antibiotic supplement group, the group receiving an aqueous extract of 1.5% *Moringa oleifera* leaf powder exhibited no difference in feed intake [31]. Gadzirayi *et al.* (2012) evaluated the effects of adding MOLM as a protein source to soya bean meals in fowl and observed no notable differences in broiler

feed intake [32]. According to Cui *et al.* (2018), MOL incorporation in the diet had not a linear or quadratic influence on the average daily feed consumption ($p > 0.05$) [33]. Nkukwana *et al.* (2014) revealed that during time interval of 0 to 35 days, there was no significant variation in feed intake across groups [34].

Feed conversion ratio (FCR)

The feed conversion ratio of Uttara chicken among various treatment groups from 0 to 20 weeks of age has been tabulated in Table 6. T_3 treatment groups had significant ($p<0.01$) feed conversion ratio as compared to T_0, T_4 and T_5 group at 8 to 20 weeks of age.

At 20 weeks of age, T_3 had significantly better ($p<0.01$) FCR than T_0 group. At 8-20 weeks of age, T_3 treatment groups showed significantly higher feed conversion ratios ($p<0.01$) than T_0, T_4 and T_5 groups. There are few researches that accord with our findings. Wafai *et al.* (2020) found remarkable ($P<0.05$) improvement in feed conversion ratio for birds given MOLM-based ration compared to the control group [35]. This could be ascribed to birds fed MOLM-based diets properly using the nutrients they consumed. Abu Hafsa *et al.* (2019) investigated that the broiler fed the 1% MOL diet shown improved feed conversion ratio (FCR) ($p<0.05$) [27]. Daramola (2019) reported that broilers fed on control diets and diets with 0.2% of a mixture of bitter leaf meal and MOLM (1:1) had feed conversion ratios that were better at 1.91 and 2.03, respectively [24]. Kumar *et al.* (2018) observed that group which received 5% MOLM into the diet of Vanaraja birds in a tropical environment had a lower feed conversion ratio ($p<0.05$), indicating improved production efficiency [36]. When compared to the control group, Arif *et al.* (2019) found that increasing the dietary level of phytogenic feed mixture containing equal ratios of black cumin, Moringa oleifera, and chicory seeds led to improvement in the feed conversion ratio [37]. Swain *et al.* (2017) discovered a significant ($p<0.05$) improvement in feed conversion ratio (FCR) in

Table 4. Average body weight (g) of Uttara chicken.

Treatment	T_0	T_1	T_2	T_3	T_4	T_5	Sig. Level
Day old	36.62±0.07	36.75±0.07	36.75±0.07	36.66±0.04	36.70±0.08	36.79±0.08	NS
4th week	135.53±1.23	136.56±1.34	136.88±1.34	137.24±1.38	134.70±1.33	134.26±1.32	NS
8th week	424.36±0.58^{b}	427.81±0.98^{bc}	428.59±1.18^{c}	438.70±2.18^{d}	416.05±0.37^{a}	413.65±0.44^{a}	P<0.01
12th week	650.26±2.82^{b}	662.77±3.16^{c}	671.29±3.68^{c}	701.82±5.87^{d}	630.93±2.55^{a}	622.29±1.56^{a}	P<0.01
16th week	920.30±5.81^{b}	944.66±6.47^{c}	964.51±6.73^{c}	1021.87±8.85^{d}	892.79±5.69^{a}	878.01±4.35^{a}	P<0.01
20th week	1194.01±7.76^{b}	1226.71±8.03^{c}	1255.91±8.12^{d}	1325.71±10.4^{e}	1160.12±7.34^{a}	1143.78±5.62^{a}	P<0.01

Means with various superscripts within a row exhibit significant differences ($p<0.05$).

Table 5. Feed intake (g) of Uttara chicken.

Treatment	4th week	8th week	12th week	16th week	20th week
T_0	215.81±0.93	619.12±2.74	970.16±4.26	1324.09±3.12	1470.67±3.36
T_1	215.88±2.22	619.34±2.81	970.81±4.29	1325.33±2.95	1472.36±3.09
T_2	215.81±2.02	619.56±2.86	971.25±4.00	1326.17±3.04	1473.00±3.07
T_3	215.99±2.25	618.86±2.97	971.33±3.97	1326.49±3.04	1473.56±3.12
T_4	214.90±2.44	617.73±3.23	969.96±4.26	1323.58±3.19	1469.85±3.19
T_5	214.71±2.61	617.32±2.83	969.85±4.28	1323.30±3.21	1469.36±3.19
Sig. Level	NS	NS	NS	NS	NS

Table 6. Feed conversion ratio of Uttara chicken.

Treatment	4th week	8th week	12th week	16th week	20th week
T_0	2.18±0.033	2.14±0.007^{b}	4.29±0.062^{c}	4.9±0.065^{c}	5.37±0.05^{d}
T_1	2.16±0.030	2.12±0.004^{b}	4.13±0.059^{bc}	4.7±0.065^{b}	5.22±0.04^{c}
T_2	2.15±0.029	2.12±0.004^{b}	4.00±0.058^{b}	4.52±0.057^{b}	5.05±0.035^{b}
T_3	2.14±0.029	2.05±0.010^{a}	3.69±0.067^{a}	4.14±0.048^{a}	4.85±0.035^{a}
T_4	2.19±0.025	2.19±0.011^{c}	4.51±0.066^{d}	5.05±0.072^{cd}	5.49±0.045^{de}
T_5	2.20±0.025	2.20±0.009^{c}	4.64±0.050^{d}	5.17±0.071^{d}	5.52±0.039^{e}
Sig. Level	NS	p<0.01	p<0.01	p<0.01	p<0.01

Means with various superscripts within a column exhibit significant differences (p<0.05).

Table 7. Carcass yield of Uttara chicken at 20 weeks of age (% live weight).

Treatment	Shrinkage (%)	Dressing (%)	Eviscerated yield (%)	Edible yield (%)	Heart (%)	Liver (%)	Gizzard (%)
T_0	4.89±0.04	72.19±0.03^{b}	62.00±0.92^{a}	67.10±0.97^{a}	0.48±0.020	2.35±0.014	2.26±0.014^{a}
T_1	4.88±0.06	72.98±0.09^{c}	63.79±0.95^{ab}	69.15±1.08^{ab}	0.53±0.017	2.41±0.032	2.41±0.087^{ab}
T_2	4.87±0.04	73.67±0.23^{c}	64.77±0.60^{b}	70.23±0.70^{b}	0.54±0.023	2.41±0.007	2.50±0.082^{b}
T_3	4.87±0.02	74.99±0.14^{d}	66.16±0.90^{b}	71.72±0.98^{b}	0.55±0.028	2.42±0.015	2.57±0.064^{b}
T_4	4.92±0.03	71.95±0.23^{ab}	61.26±0.64^{a}	66.34±0.71^{a}	0.47±0.019	2.34±0.027	2.25±0.016^{a}
T_5	4.94±0.02	71.43±0.08^{a}	61.04±0.44^{a}	66.13±0.48^{a}	0.46±0.020	2.36±0.008	2.25±0.014^{a}
Sig. Level	NS	p<0.01	p<0.05	p<0.05	NS	NS	p<0.05

Means with various superscripts within a column exhibit significant differences (p<0.05).; NS: Not significant.

Table 8. Development of digestive organs of Uttara chicken at 20 weeks of age.

Treatment	Proventriculus (%)	SI weight (g/100g)	LI weight (g/100g)	Cecal Wt. (g/100g)	SI length (cm/100g)	LI length (cm/100g)	Cecal length (cm/100g)
T_0	0.36±0.006	3.88±0.01	0.41±0.007	0.78±0.012	8.92±0.02	0.48±0.008	1.34±0.007
T_1	0.38±0.009	3.89±0.02	0.41±0.013	0.78±0.014	8.92±0.02	0.49±0.009	1.35±0.010
T_2	0.38±0.001	3.90±0.02	0.42±0.009	0.79±0.009	8.93±0.003	0.49±0.012	1.36±0.011
T_3	0.38±0.002	3.92±0.03	0.43±0.006	0.81±0.009	8.93±0.02	0.49±0.011	1.37±0.014
T_4	0.36±0.003	3.88±0.02	0.40±0.013	0.78±0.006	8.91±0.02	0.47±0.009	1.33±0.003
T_5	0.36±0.004	3.88±0.02	0.41±0.014	0.77±0.012	8.90±0.02	0.48±0.003	1.32±0.008
Sig. Level	NS	NS	NS	NS	NS	NS	NS

NS: Not significant.

Vanaraja layers fed a diet supplemented with MOLM @ 0.5 kg per 100 Kg of basal diet compared to the control [38]. Results of present study revealed that inclusion of *M. oleifera* leaf powder at 3% level showed pattern results in all aspects of FCR in indigenous chicken this might be due to the reason that *M. oleifera* along with Arjuna improves the gut microflora of the bird as well as better absorption of feeds given to the birds.

Table 9. Development of lymphoid organs of Uttara chicken at 20 weeks of age.

Treatment	Spleen (%)	Thymus (%)	Bursa (%)
T_0	0.07±0.001	0.19±0.003	0.16±0.007
T_1	0.08±0.001	0.19±0.004	0.15±0.007
T_2	0.08±0.002	0.18±0.002	0.16±0.006
T_3	0.08±0.003	0.18±0.001	0.17±0.005
T_4	0.07±0.003	0.19±0.004	0.16±0.003
T_5	0.07±0.001	0.19±0.001	0.16±0.005
Sig. Level	NS	NS	NS

Table 10. Cut up parts of Uttara chicken at 20 weeks of age (%) of dressed weight.

Treatment	Breast	Back	Neck	Wings	Drumstick	Thigh
T_0	$16.22±0.28^{ab}$	12.76±0.12	4.69±0.13	7.12±0.13	10.82±0.02	$10.37±0.21^{a}$
T_1	$16.41±0.36^{ab}$	12.96±0.10	4.91±0.16	7.28±0.12	11.04±0.10	$11.17±0.07^{b}$
T_2	$16.70±0.12^{c}$	12.98±0.13	5.08±0.13	7.32±0.09	11.09±0.07	$11.57±0.04^{bc}$
T_3	$17.17±0.01^{c}$	13.20±0.18	5.29±0.23	7.51±0.11	11.10±0.16	$11.87±0.20^{c}$
T_4	$15.86±0.09^{a}$	12.56±0.17	4.65±0.09	7.04±0.09	10.77±0.01	$10.35±0.17^{a}$
T_5	$15.77±0.08^{a}$	12.5±0.14	4.61±0.1	7.02±0.01	10.72±0.01	$10.40±0.07^{a}$
Sig. Level	$p<0.05$	NS	NS	NS	NS	$p<0.01$

NS: Not significant.

Carcass quality traits

Carcass yield of Uttara chicken has been presented in Table 7. Result indicated that T_3 had significantly higher ($p<0.05$) dressing (%), eviscerated yield (%) and edible yield (%) in contrast to T_0, T_4, T_5 in chicken. The study found no notable differences in shrinkage or the percentage yield of the heart and liver. Additionally, there were no significant variations in the development of the digestive and lymphoid organs (Table 8 and 9).

The findings of the current study align with only a few previous investigations. For instance, Alshukri *et al.* (2018) found that birds fed diets enriched with 1% *Moringa oleifera* leaf meal exhibited significantly higher carcass weights and dressing yields, along with increased total edible portions, compared to the control and other treatment groups ($p\leq0.05$) [39]. However, the addition of *Moringa oleifera* leaf meal did not significantly affect the relative weights of the liver and heart. Similarly, Alabi *et al.* (2017) noted that aqueous extracts of Moringa oleifera leaves had a significant impact ($p<0.05$) on the dressing percentage of broiler chickens [40]. Our result also supported by Aderinola *et al.* (2013) who investigated how broiler chicken responded to *Moringa oleifera* leaf meal [41]. These outcomes are in line with the rising growth rates that led to higher slaughter weights. El Tazi (2014) found that chickens that were given diets enriched with Moringa oleifera leaf meal showed significantly higher average weights for both hot and cold eviscerated carcass, as well as a better dressing percentage, when compared to the control group [42]. These observations support the hypothesis that higher growth rates led to bigger slaughter weights. Hayse and Marion (1973) found similar results, showing that bigger birds at slaughter will have higher dressing (%) and eviscerated output than lighter chickens [43]. According to Karthivashan *et al.* (2015), feeds given with 0, 0.5, 1.0, and 1.5% extarcts of *Moringa oleifera* leaf meal produced significantly higher dressing percentages than control feed, with 1.0% *Moringa oleifera* leaf meal showing the highest dressing percentages among the treatments [44]. However, there was no effect on proportion of

internal organs. Additionally, according to Onunkwo and George (2015), adding *Moringa oleifera* leaf meal to broiler diets had no impact on the proportion of the bird's organs [45].

T_3 had significantly higher ($p<0.05$) gizzard (%) than T_0, T_4 and T_5 groups. There are few researches which are in agreement with our results. Abu Hafsa *et al.* (2019) reported that the addition of MOL to experiment feed had no effect on the relative weights of the heart and liver, while the gizzard relative weight ($p<0.05$) increased in broilers fed diets supplemented with 1% and 5% MOL [27]. According to Mulaudzi *et al.* (2022), pre-treating dietary MOLP with a mixture of exogenous fibrolytic enzymes resulted in a quadratic response in the size of the gizzards, which initially increased and subsequently decreased [46]. According to theory, birds' gizzards and intestines change in size as a coping mechanism in response to high-fiber diets [47]. Consuming high-fibre feed, according to Musa *et al.* (2006), causes gizzard expansion, which improves the muscle grinding of feed particles and increases nutritional digestibility [48].

Result related to yield of cut-up-parts indicated that T_3 groups had significantly higher ($p<0.05$) breast and thigh (%) than T_0, T_4 and T_5 groups. However, there was no significant difference in back, neck, wings, drumstick (%) among various treatment groups (Table 10). The result was complementary with many other studies. Onunkwo and George (2015) found that the maximum value of thigh was reported at 10.0% addition of *Moringa oleifera* leaf meal [45]. The findings are consistent with those of Ologhobo *et al.* (2014), who noted that birds fed diets containing *Moringa oleifera* leaf meal had greater mean values of slaughter weights than those fed the control diet, which had the lowest mean value [49]. El Tazi *et al.* (2014) reported that the

Table 11. Chemical composition of breast muscle (pectoralis major) of Uttara chicken.

Treatment	Moisture (%)	CP (%)	EE (%)	Total ash (%)	Ca (mg/100g)	P (mg/100g)
T_0	73.26 ± 0.07^{ab}	21.8 ± 0.085^{a}	2.16 ± 0.030^{cd}	1.1±0.015	4.86±0.57	160.29±7.17
T_1	73.43 ± 0.02^{bc}	22.35 ± 0.065^{b}	2.09 ± 0.020^{bc}	1.12±0.014	4.88±0.635	161.05±8.66
T_2	73.60 ± 0.030^{c}	22.90 ± 0.080^{c}	2.00 ± 0.015^{ab}	1.14±0.015	4.87±0.605	162.05±8.55
T_3	73.83 ± 0.04^{d}	23.36 ± 0.060^{d}	1.96 ± 0.015^{a}	1.16±0.010	4.85±0.649	163.72±9.19
T_4	73.17 ± 0.04^{a}	21.74 ± 0.084^{a}	2.19 ± 0.040^{cd}	1.09±0.015	4.85±0.57	158.43±6.43
T_5	73.08 ± 0.06^{a}	21.71 ± 0.089^{a}	2.21 ± 0.044^{d}	1.11±0.014	4.84±0.595	160.01±6.67
Sig. Level	p<0.01	p<0.01	p<0.05	NS	NS	NS

Means with various superscripts within a column exhibit significant differences ($p<0.05$); NS: Not significant.

Table 12. Chemical composition of thigh muscle (ilio tibialis) of Uttara chicken.

Treatment	Moisture (%)	CP (%)	EE (%)	Total ash (%)	Ca (mg/100g)	P (mg/100g)
T_0	74.09 ± 0.08^{ab}	20.24 ± 0.069^{a}	4.02 ± 0.024^{d}	1.32±0.025	5.26±0.08	167.19±5.25
T_1	74.31 ± 0.05^{bc}	21.06 ± 0.054^{b}	3.90 ± 0.020^{c}	1.36±0.024	5.31±0.069	170.69±6.31
T_2	74.49 ± 0.05^{cd}	21.54 ± 0.064^{c}	3.77 ± 0.024^{b}	1.38±0.034	5.25±0.094	170.22±7.02
T_3	74.62 ± 0.06^{d}	22.26 ± 0.054^{d}	3.47 ± 0.030^{a}	1.34±0.02	5.3±0.115	173.33±5.15
T_4	74.03 ± 0.07^{a}	20.18 ± 0.050^{a}	4.08 ± 0.035^{d}	1.31±0.02	5.22±0.085	165.29±5.34
T_5	73.94 ± 0.09^{a}	20.14 ± 0.054^{a}	4.13 ± 0.044^{d}	1.33±0.02	5.21±0.08	164.94±6.56
Sig. Level	p<0.01	p<0.01	p<0.01	NS	NS	NS

Means with various superscripts within a column exhibit significant differences ($p<0.05$); NS: Not significant.

chicken given feed which composed of MOLM produced significantly ($p<0.05$) larger percentage of breast [42]. Melesse *et al.* (2013) discovered that chickens raised on diets with 110 g/kg and 140 g/kg MLM (*Moringa stenopetala* leaf meal) in place of the roasted soybean had greater value ($p<0.01$) of breast yield [50]. Chickens fed 80 g/kg, 110 g/kg, and 140 g/kg MLM diets had higher thigh weight ($p<0.01$) than chickens given the control diet. In contrast, Alshukri *et al.* (2018) found that the relative weights of the thighs, back, wing and neck were not significantly changed by the dietary addition of *Moringa oleifera* leaf meal [39].

Chemical composition of meat

Result related to the composition of breast and thigh muscle indicated that T3 had significantly higher ($p<0.05$) moisture (%) as seen in T_0, T_4 and T_5 groups in both thigh and breast muscles (Table 11 and 12). The CP (%) was significantly higher ($p<0.01$) in T_3 than T_0, T_4 and T_5 groups in both thigh and breast muscles. The ether extract (%) was significantly lower ($p<0.05$) in T_3 than T_0, T_4 and T_5 groups in both thigh and breast muscles.

Results in present study are according to several previous studies. Meena *et al.* (2022) found that with regard to graded amounts of dietary Arjuna bark powder, CP content of *L. rohita* fed Arjuna bark powder @10g per kg of feed exhibited significantly higher ($P<0.05$) values than control [51]. The ash content of *L. rohita* did not significantly change in response to Arjuna bark powder when given in diet. Tesfaye *et al.* (2013) determined that when *Moringa oleifera* leaf meal (MOLM) was used in place of soybean meal, the thigh muscle had a higher CP content for 15% MOLM than for 5 and 20% MOLM [52]. Kumar *et al.* (2018) found that the fat content of the chicken decreased significantly ($p<0.05$) with increased MOLM supplementation [36]. The fat content appeared to be decreasing as the meat's moisture level increased. The negative correlation between carcass moisture and fat content has been supported by Mendes *et al.* (1995) [53]. Selim *et al.* (2021) reported that dietary MOL supplementation significantly increased ($p<0.05$) the crude protein content of the meat but decreased ($p<0.05$) the relative content of ether extract in the rabbit meat [54].

CONCLUSION

Based on the current study, it can be concluded that adding 1% powdered Arjuna bark and 3% powdered Sahjan leaf to the diet significantly improved growth performance of chicken in terms of body weight and feed conversion ratio. Supplementing the diet with 1% powdered Arjuna bark and 3% powdered Sahjan leaf produced significantly higher dressing, eviscerated yield, edible yield, gizzard, breast and thigh (%). In both the thigh and breast muscles, dietary supplementation with 1% powdered Arjuna bark and 3% powdered Sahjan leaf led to significantly higher moisture and CP (%) and significantly lower ether extract (%). Therefore, it may be concluded from current study that adding 1% powdered Arjuna bark and 3% powdered Sahjan leaf to chickens can increase their growth performance, carcass quality, and the composition of their breast and thigh meat.

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REFERENCES

1. Looft T, Johnson TA, Allen HK, *et al.* In-feed antibiotic effects on the swine intestinal microbiome. Proc Natl Acad Sci USA. 2012; 109(5): 1691–1696.

2. Dhama K, Latheef SK, Mani S, *et al.* Multiple beneficial applications and modes of action of herbs in poultry health and production—A review. Int J Pharmacol. 2015; 11(3): 152–176.

3. Dorman HJ, Deans SG. Antimicrobial agents from plants: antibacterial activity of plant volatile oils. J Appl Microbiol. 2000;88(2):308-316.

4. Griggs JP, Jacob JP. Alternatives to antibiotics for organic poultry production. J Appl Poult Res. 2005; 14:750-756.

5. Bölükbaşi Ş, Erhan MK. Effect of dietary thyme (*Thymus vulgaris*) on laying hens' performance and *Escherichia coli* concentration in feces. Int J Nat Eng Sci. 2007;1(2):55-58.

6. Windisch W, Schedle K, Plitzner C, Kroismaye A. Use of phytogenetic products as feed additives for swine and poultry. J Anim Sci. 2008; 86:140-148.

7. Frankič T, Voljč M, Salobir J, Rezar V. Use of herbs and spices and their extracts in animal nutrition. Acta Agriculturae Slovenica. 2009; 94(2): 95-102.

8. Khan RU, Nikousefat Z, Tufarelli V, *et al.* Garlic (*Allium sativum*) supplementation in poultry diets: effect on production and physiology. Worlds Poult Sci J. 2012;68(3):417-424.

9. Madhupriya V, Shamsudeen P, Manohar GR, *et al.* Phyto feed additives in poultry nutrition: A review. Int J Sci Educ. 2018; 7:815–822.

10. Wang W, Ali Z, Shen Y, *et al*. Ursane triterpenoids from the bark of *Terminalia arjuna*. Fitoterapia. 2010; 81(6): 480-484.

11. Greco G, Turrini E, Tacchini M, *et al.* The alcoholic bark extract of *Terminalia arjuna* exhibits cytotoxic and cytostatic activity on Jurkat leukemia cells. Venoms Toxins. 2021; 1(1):56-66.

12. Jain S, Yadav PP, Gill V, *et al. Terminalia arjuna* a sacred medicinal plant: phytochemical and pharmacological profile. Phytochemistry Rev. 2009; 8(2):491-502.

13. Aneja KR, Sharma C, Joshi R. Antimicrobial activity of *Terminalia arjuna* Wight & Arn. an ethnomedicinal plant against pathogens causing ear infection. Braz J Otorhinolaryngol. 2012; 78(1):68-74.

14. Wang W, Ali Z, Li XC, *et al*. Triterpenoids from two *Terminalia* species. Planta Med. 2010; 76(15):1751-1754.

15. Onunkwo DN, George OS. Effects of *Moringa oleifera* leaf meal on the growth performance and carcass characteristics of broiler birds. J Agric Vet Sci. 2015; 8:63–66.

16. Leone A, Spada A, Battezzati A, *et al.* Cultivation, genetic, ethnopharmacology, phytochemistry and pharmacology of *Moringa oleifera* leaves: An overview. Int J Mol Sci. 2015; 16:12791–12835.

17. Abbas TE. The use of *Moringa oleifera* in poultry diets. Turk J Vet Anim Sci. 2013; 37:492–496.

18. Sreelatha S, Padma PR. Antioxidant activity and total phenolic content of *Moringa oleifera* leaves in two stages of maturity. Plant Foods Hum Nutr. 2009; 64:303–311.

19. Makkar HP, Francis G, Becker K. Bioactivity of phytochemicals in some lesser-known plants and their effects and potential applications in livestock and aquaculture production systems. Animal. 2007; 1:1371–1391.

20. Mahajan S, Mali R, Mehta A. Protective effect of ethanolic extract of seeds of *Moringa oleifera* Lam. against inflammation associated with development of arthritis in rats. J Immunotoxicol. 2007; 4:39–47.

21. BIS. Indian Standard: Poultry Feeds- Specification, IS-1374. New Delhi: Bureau of Indian Standard; 2007.

22. Official Methods of Analysis. AOAC International, Gaithersburg, MD, Method 2005.06.

23. Mikhail WZA, El-Samee MOA, El-Afifi TM, Mohammed AR. Effect of feeding *Moringa oleifera* leaf meal with or without enzyme on the performance and carcass characteristics of broiler chicks. Plant Arch. 2020; 20(1):3381-3388.

24. Daramola OT. Medicinal plants leaf meal supplementation in broiler chicken diet: Effects on performance characteristics, serum metabolite and antioxidant status. Anim Res Int. 2019; 16(2):3334-3342.

25. Sogut B, Mohammad AMA. Effect of Moringa, thyme, sumac powders and their mixture on growth performance in broiler chicken. Turk J Agric Nat Sci. 2018; 5(3):322-330.

26. Jimoh OA, Daramola OT, Okin-Aminu HO, Ojo OA. Performance, hemato-biochemical indices and oxidative stress markers of broiler chicken fed phytogenic during heat stress condition. J Anim Sci Technol. 2022; 64(5):970-984.

27. Abu Hafsa SH, Ibrahim SA, Eid YZ, Hassan AA. Effect of dietary *Moringa oleifera* leaves on the performance, ileal microbiota and antioxidative status of broiler chickens. J Anim Physiol Anim Nutr (Berl). 2020; 104(2):529-538.

28. Arif M, Hayat Z, Abd El-Hack ME, Saeed M, Imran HM, *et al.* Impacts of supplementing broiler diets with a powder mixture of black cumin, Moringa and chicory seeds. S Afr J Anim Sci. 2019; 49(3):564-572.

29. Ansari JA. Influence of Arjuna powder supplementation in diet on the growth attainment, F.C.R. and blood profile in caged broilers [thesis]. Allahabad-211007, India: Sam Higginbottom University of Agriculture, Technology & Sciences, (Formerly Allahabad Agricultural Institute); 2017. 15830.

30. Mousa AM, Osman AS, Hady HA. Performance, immunology and biochemical parameters of *Moringa oleifera* and/or *Cichorium intybus* addition to broiler chicken ration. J Vet Med Anim Health. 2017; 9(10):255-263.

31. Verma AK, Pramanik P, Gautam S, Kumar R, Verma MK, Panday G. Effect of *Moringa oleifera* leaf extracts on growth performance and haemato-biochemical indices of broiler chickens. Haryana Vet. 2022; 61(1):90-94.

32. Gadzirayi CT, Masamha B, Mupangwa JF, Washaya S. Performance of broiler chickens fed on mature *Moringa oleifera* leaf meal as a protein supplement to soybean meal. Int J Poult Sci. 2012; 11(1):5-10.

33. Cui YM, Wang J, Lu W, Zhang HJ, Wu SG, Qi GH. Effect of dietary supplementation with *Moringa oleifera* leaf on performance, meat quality, and oxidative stability of meat in broilers. Poult Sci. 2018; 97(8):2836-2844.

34. Nkukwana TT, Muchenje V, Pieterse E, Masika PJ, Mabusela TP, *et al.* Effect of *Moringa oleifera* leaf meal on growth performance, apparent digestibility, digestive organ size and carcass yield in broiler chickens. Livest Sci. 2014; 161:139-146.

35. Wafai Z, Mikhail A, Abd El-Samee MO, El-Afifi TME, Mohammed AR. Effect of feeding *Moringa oleifera* leaf meal with or without enzyme on the performance and carcass characteristics of broiler chicks. Plant Arch. 2020; 20:3381-3388.

36. Kumar A, Kumar K, Kumar S, Singh PK. Effect of feeding *Moringa oleifera* Leaf meal on production efficiency and carcass characteristics of Vanaraja chicken in tropics. Int J Curr Microbiol Appl Sci. 2018; 7:1213-1220.

37. Mahfuz S, Piao XS. Application of Moringa (*Moringa oleifera*) as natural feed supplement in poultry diets. Animals (Basel). 2019; 9(7):431. DOI: 10.3390/ani9070431.

38. Swain BK, Naik PK, Chakurkar EB, Singh NP. Effect of supplementation of *Moringa oleifera* leaf meal (MOLM) on the performance of Vanaraja laying hens. Indian J Anim Sci. 2017; 87(3):353-355.

39. Alshukri AY, Ali NA, Abbas RJ, Alkassar AM, Jameel YJ. Effect of dietary supplementation with differing levels of *Moringa oleifera* leaf meal on the productivity and carcass characteristics of broiler chickens. Int J Poult Sci. 2018; 17:536-542.

40. Alabi OJ, Malik AD, Ng'Ambi JW, Obaje P, Ojo BK. Effect of aqueous *Moringa oleifera* (Lam) leaf extracts on growth performance and carcass characteristics of Hubbard broiler chicken. Rev Bras Cienc Avic. 2017; 19(2):273-280.

41. Aderinola OA, Rafiu TA, Akinwumi AO, Alabi TA, Adeagbo OA. Utilization of *Moringa oleifera* leaf as feed supplement in broiler diet. Int J Food Agric Vet Sci. 2013; 3(3):94-102.

42. El Tazi SMA. Effect of feeding different levels of *Moringa oleifera* leaf meal on the performance and carcass quality of broiler chicks. Int J Sci Res. 2014; 3:147-151.

43. Hayse PL, Marion WW. Eviscerated yield, component parts, and meat, skin and bone ratios in the chicken broiler. Poultry Science. 1973; 52(2):718-722.

44. Karthivashan G, Arulselvan P, Alimon AR, Safinar Ismail I, Fakurazi S. Competing role of bioactive constituents in *Moringa oleifera* extract and conventional nutrition feed on the performance of cobb 500 broilers. BioMed Res Int. 2015; 1-13.

45. Onunkwo DN, George OS. Effects of *Moringa oleifera* leaf meal on the growth performance and carcass characteristics of broiler birds. J Agric Vet Sci. 2015; 8(3):63-66.

46. Mulaudzi A, Mnisi CM, Mlambo V. Effect of pre-treating dietary *Moringa oleifera* leaf Powder with fibrolytic enzymes on physiological and meat quality parameters in jumbo quail. Poultry. 2022; 1(2):54-65.

47. Kumanda C, Mlambo V, Mnisi CM. Valorization of red grape pomace waste using polyethylene glycol and fibrolytic enzymes physiological and meat quality responses in broilers. Animals. 2019; 9(10):779.

48. Musa HH, Chen GH, Cheng JH, Shuiep ES, Musa HH. Breed and sex effect on meat quality of chicken. Int J Poult Sci. 2006; 5(6):566-568.

49. Ologhobo AD, Akangbe EI, Adejumo IO, Adeleye O. Effect of *Moringa oleifera* leaf meal as replacement for oxytetracycline on carcass characteristics of the diets of broiler chickens. Annu Res Rev Biol. 2014; 4(2):423-431.

50. Melesse A, Getye Y, Berihun K, Banerjee S. Effect of feeding graded levels of *Moringa stenopetala* leaf meal on growth performance, carcass straits and some serum biochemical parameters of Koekoek chickens. Livest Sci. 2013; 157(2-3):498-505.

51. Meena DK, Sahoo AK, Jayant M, Sahu NP, Srivastava PP, *et al*. Bioconversion of *Terminalia arjuna* bark powder into a herbal feed for Labeorohita: Can it be a sustainability paradigm for green fish production? Anim Feed Sci Technol. 2022; 284:115132.

52. Tesfaye E, Animut G, Urge M, Dessie T. *Moringa olifera* leaf meal as an alternative protein feed ingredient in broiler ration. Int J Poult Sci. 2013;12(5):289-297.

53. Mendes AA, Ancona LH, Laveaga AE, Franco JG. Effect of energy: Protein ratio in the diet on abdominal fat specific gravity and chemical composition of the carcass of broiler chickens. Vet Zootech. 1995; 7:41-48.

54. Selim S, Seleiman MF, Hassan MM, Saleh AA, Mousa MA. Impact of dietary supplementation with *Moringa oleifera* leaves on performance, meat characteristics, oxidative stability, and fatty acid profile in growing rabbits. Animals. 2021; 11(2):248

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