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Influence of Different Forms of Plantain (*Plantago lanceolata* L.) Herb on Performance, Serum Metabolites, and Meat Quality of Broilers

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Abstract

A total of 200 day-old COBB-500 chicks were randomly allocated into four dietary treatments with five replications and ten birds per replicate for 28 days to select the most effective forms of plantain herb for broiler performance and meat quality. The control diet (**CL-D**) and different forms of plantain diets were based on corn-soybean meal that was iso-caloric and iso-nitrogenous. The different forms of plantain diets were fresh plantain-diet (**FP-D**): CL-D + fresh-plantain, shade-dried plantain-diet (**SP-D**): CL-D + shade-dried plantain powder, and blanched-dried plantain-diet (**BP-D**): CL-D + blanched-dried plantain powder. Plantain herb was given at a 1.0% dry matter basis. Daily feed consumption and weekly body weight were noted, whereas blood samples were taken and a meat panel test was confirmed by specialists in meat on day 28. Birds given the different forms of plantain diets revealed a 6-10% greater body weight gain compared to the CL-D ($P < 0.05$). Plantain diets in different forms showed a 3–6% better feed, crude protein, and metabolizable energy conversion ratio compared to the CL-D ($P < 0.05$), but no difference was observed between BP-D and SP-D ($P > 0.05$). Compared to the CL-D, birds fed the different forms of plantain diets reduced serum triglyceride and total cholesterol by 4–11% and 6–9%, respectively ($P < 0.05$). Birds that were fed the different forms of plantain diets had a lower meat ether extract and a greater meat saturation index (redness) than the CL-D ($P < 0.05$). Compared to the CL-D, birds fed the redifferent forms of plantain diets showed better meat juiciness, tenderness, and acceptance ($P < 0.05$). Therefore, fresh plantain demonstrated superior broiler performance and improved meat quality, whereas both blanched-dried and shade-dried plantain powder might be considered for inclusion in feed formulations to enhance broiler performance and meat quality.

Introduction

The demand for broiler meat is rising while the need for safe meat is drawing more consumer's attention due to quicker population growth and higher per capita income. Additionally, broiler meat is receiving significant attention from meat consumers owing to its superior nutritional value and lower production costs in comparison to beef, lamb, and pork meat (Scollan *et al.*, 2017; Adamski *et al.*, 2017). To meet the growing demand for safer meat, optimal doses of herbal supplements are being utilized as additives, leveraging their antioxidant, anti-inflammatory, immune-stimulant, and antimicrobial properties (Ebrahim *et al.*, 2015; Qureshi *et al.*, 2016). Due to these properties, herbal supplements have attracted considerable attention for their ability to potentially improve broiler production and meat quality by effectively altering serum metabolites while ensuring meat safety (Alipour *et al.*, 2015; Rahman *et al.*, 2022).

An herbal supplement like plantain (*Plantago lenceolata* L.) is a soft, low-crude-fiber, high-protein, and secondary-metabolites-rich herb used as a suitable additive in broiler and layer feed (Redoy *et*

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al., 2021; Rahman *et al.,* 2021). Plantain contains an enormous volume of secondary metabolites like acteoside and aucubin, which have anti-oxidative, anti-inflammatory properties and insulin sensitivities (Al-Mamun *et al.,* 2008a; Al-Mamun *et al.,* 2017; Redoy *et al.,* 2021). Owing to these properties, it has been reported that broilers given plantain herb extract or seed show improved performance and meat quality by modifying blood metabolites effectively (Mazhari *et al.,* 2016; Camy *et al.,* 2020; Al-Mamun *et al.,* 2023). Additionally, research showed that adding 0.9% shade-dried plantain powder improves the quality and productive performance in commercial layers (Rahman *et al.,* 2021). When broilers were fed a basal diet with 0.5, 1.0, or 1.5% fresh plantain herb, the 1.0% fresh plantain herb significantly exhibits increased productive performance, serum antioxidant levels, unsaturated fatty acids and ameliorates the meat color (Redoy *et al.,* 2021). Therefore, the inclusion of plantain herb in the ration formulation ensures improved broiler performance and meat quality.

However, incorporating fresh plantain into commercial diet formulations is challenging due to its high moisture content. Drying is the most effective strategy to reduce its moisture content, making it suitable for using as a novel additive in diet formulations. Several drying methods exist, including freeze, sun, shade, microwave, and blanched drying. Among all drying methods, shade and blanched plantain powder seem to be the most efficient, feasible, and effective strategies for minimizing the loss of essential secondary metabolites and nutrients (Sadiq *et al.,* 2021). So, the present study was designed on broilers offered fresh, shade-dried, and blanched-dried plantain powder and to select the most suitable drying method for plantain powder based on bird's growth performance, serum metabolites and meat quality.

Materials and methods

Birds, dietary treatments, and management

This research procedure was approved by Bangladesh Agricultural University's (BAU's) Animal Welfare and Experimentation Ethics Committee (AWEEC/BAU/2022 (53)). A total of 200 day-old straight-run broiler (COBB-500) chicks were procured from Kazi Poultry & Hatchery Ltd. and reared for 28 days in the small non-ruminant shed at Shahjalal Animal Nutrition Field laboratory (SANFL), BAU. The birds (initial body weight 37 ± 0.8 g) were randomly split into four dietary treatments in a completely randomized design, with five replications and ten birds per replication. The dietary treatments comprised of corn-soybean meal-based diet with 22.21% crude protein and 3088 kcal/kg metabolizable energy, designated as the control diet (**CL-D**) (Table 1). Then, birds served CL-D with different forms of plantain herbs like fresh plantain (**FP-D**): CL-D + fresh plantain; shade-dried plantain (**SP-D**): CL-D + shade-dried plantain powder; and blanched-dried plantain (**BP-D**): CL-D + blanched-dried plantain powder. The different forms of plantain herb were supplied at 1.0% on a dry matter basis from the 4th day to the 28th day of the trial. The CL-D and different forms of plantain diets were formulated and analyzed the crude protein, crude fiber, ether extract and ash (Table 1) according to AOAC (2005).

The plantain herb was grown at the Forage Herbs Bank (SANFL) and harvested (aerial part) daily from 56 to 79 days. It was then chopped (0.5 – 1.5 cm) and offered to the birds as fresh from days 4 to 28, respectively. The aerial parts of the fresh plantain herb were harvested at 53, 59, 65, and 71 days, respectively, for the production of shade-dried and blanched-dried plantain powder. This harvesting process aimed to ensure a consistent supply of plantain in shade and blanched-dried from day 4 to 28, preserving its bioactive components similar to those found in fresh plantain. Each time, fresh plantain was dried at 27 ± 3.0°C with proper wilting for 2-3 days without sunlight using artificial ventilation for preparation of shade-dried plantain. Besides, each time fresh plantain was provided with certain heat (90–100°C) and immediate cold shock (0–5°C) for 1-10 seconds in accordance with Minh *et al.* (2019). Then, the moist plantain was dried in a temperature control locally made dryer at 50°C for preparing blanched-dried plantain. Both shade and blanched-dried plantain were minced into 1 mm size using a locally made grinder.

The birds were raised in a 20-floor cage, ensuring 0.1 m^2 space for each bird and having 4–5 cm sawdust bedding. The sawdust was properly wilted and changed at 19 days of the trail, ensuring less stress for all birds. The temperature was kept under a hoover at around 34°C during brooding and then adjusted to 3°C each week until it reached 21°C. Birds provided continuous access to fresh and clean water in drinkers and offered *ad libitum* diets in feeder two times in a day (08:00 and 16:00 h) over the entire trial. Drinkers were cleaned twice daily, while feeders were cleaned once a week. The experimental birds were administered vaccins against New Castle disease and infectious bursal disease on days 5 and 12, respectively. Strict biosecurity was maintained throughout the entire trial.

Table 1. Feed ingredients composition and nutritive value of control and different forms of plantain diet

Ingredients (%)	CL-D	Different forms of plantain diet (FP-D, SP-D and BP-D)
Corn	45.50	45.50
Soybean meal (42.5% crude protein)	25.00	25.00
Rice polish	4.00	4.00
Protein concentrate (60% crude protein)	10.00	10.00
Soybean oil	6.50	6.50
Fish meal	6.00	6.00
Common salt	0.25	0.25
Di-calcium Phosphate	1.50	1.50
Limestone	1.00	1.00
Plantain (fresh, shade and blanched-dried powder on a dry matter (DM) basis)	0.00	1.00
Vitamin-mineral premix*	0.25	0.25
Nutrient composition (%)		
Crude protein	22.21	22.34
Crude fiber	4.50	4.66
Ether extract	3.96	3.99
Ash	8.53	8.66
Calcium#	1.01	1.05
Available phosphorus#	0.45	0.45
ME (Kcal/kg)#	3088	3091

*Nutrient content of premix per kg diet: vitamin A palmitate, 6,600 IU; cholecalciferol, 2,200 IU; menadione dimethylpyridine bisulfite, 2.2 mg; riboflavin, 4.4 mg; pantothenic acid, 13 mg; niacin, 40 mg; choline chloride, 500 mg; biotin, 1 mg; vitamin B12, 22 µg; ethoxyquin, 125 mg; iron, 50 mg; copper, 6 mg; zinc, 40 mg; manganese, 60 mg; selenium, 0.2 mg; CL-D: Corn-soybean meal-based diet, ME=3088 Kcal/kg, CP=22.21%; FP-D: CL-D + 1% DM of fresh plantain; SP-D: CL-D + 1% DM of shade-dried plantain; BP-D: CL-D + 1% DM of blanched-dried plantain powder.
#Calculated value

Data recording, sampling, and analysis

Total feed refusal was subtracted from the total amount of supplied feed in a day to calculate the daily total feed intake (TFI). Weekly cage body weights were documented, and the change between the initial and final body weight (BW) was used to calculate body weight gain (BWG). The ratio between TFI and BWG was used to calculate the feed conversion ratio (FCR). Besides, the total intake of crude protein and metabolizable energy was divided by the total BWG and expressed as the crude protein conversion ratio (CPCR) and the metabolizable energy conversion ratio (MECR), respectively (Attia *et al.,* 2021). Birds were observed twice daily, and the weight of dead birds was recorded to calculate feed consumption. On the 28th of the trial, three birds from each replication (15 birds/treatment) were sacrificed using sharp knives and blood samples were collected using a 15 ml falcon tube and immediately centrifuged at 6000 × g for 15 min to separate serum and preserved at 4°C in 2 ml Eppendorf tube (Redoy *et al.,* 2021). Using a Bio-analyzer (Urit-810; URIT Medical Electronic Group Co., Ltd., Guangxi, China), serum total cholesterol, triglyceride, and high-density lipoprotein (HDL) cholesterol were measured using different kits (Linear, Joaquim Costa, 18–2a, Planta, Barcelona, Spain). The serum low-density lipoprotein (LDL) cholesterol was calculated by adopting the equation of Lee and Siddiqui (2021). The breast meat proximate components were analyzed in accordance with AOAC (2005). The breast meat was separated from the bird, washed with clean water and refrigerated at 4°C for 24 h. After being removed from the refrigerator, the meat sample was prepared using a new cloth. Then, the CR-410 colorimeter (Minolta, Japan) was used to measure the breast meat color i.e., lightness (L*), redness (a*), and yellowness (b*), by following the instructions of the manufacturer. Besides, the saturation index (SI) was determined using the equation: $\sqrt{(a^2+b^2)}$.

Sensory evaluation

The sacrificed birds (15 birds/treatment) were processed, and breast muscles were collected and thermally treated by roasting in a gas cylinder with 5% salt, without the addition of fat or oil. After proper boiling, the samples were cleaned of subcutaneous fat and connective tissue, cut into uniform slices (around 2 cm thick), chilled to room temperature, and served to the meat panelists. Panelists were requested to rate the breast muscle samples for color, taste, juiciness, tenderness, and overall acceptability by adopting the 5-point hedonic scale of Berdos *et al.* (2020).

Statistical analysis

Data was displayed as a mean ± SD (standard deviation). Then, the data was arranged and analyzed by Excel and SPSS (version 20, Inc., Chicago, IL, USA) for one-way analysis of variance

(ANOVA), respectively. The significance of variations among mean was evaluated using Tukey's HSD test, with statistical significance at $P < 0.05$.

Results

Growth performance

Birds offered the different forms of plantain diets (FP-D, BP-D and SP-D) showed substantially higher final BW and BWG along with better FCR, CPCR and MECR compared to the CL-D (Table 2). However, the TFI of the birds was unaffected. Additionally, birds offered the CL-D, FP-D, SP-D, and BP-D exhibited FCR values of 1.84, 1.72, 1.77, and 1.75, respectively, which were significantly different ($P < 0.05$). However, no significant difference in FCR was observed between FP-D and BP-D or between BP-D and SP-D. Furthermore, as compared to birds given the CL-D, the different forms of plantain diets revealed better CPCR and MECR ($P < 0.05$), but no difference was observed between BP-D and SP-D ($P > 0.05$).

Table 2. Effect of different forms of plantain diets on growth performance of broilers†

Variables	CL-D	Different forms of plantain diets			*SEM*	P-value
		FP-D	SP-D	BP-D		
Final BW (g)	1108.90^{b}±36.53	1221.35^{a}±53.60	1179.37^{ab}±20.55	1189.93^{a}±37.82	15.67	0.04
BW gain (g)	1071.93^{b}±36.80	1184.00^{a}±53.75	1142.03^{ab}±20.88	1154.40^{a}±38.38	15.72	0.04
TFI (g)	1967.77±62.14	2037.22±81.48	2019.84±59.84	2015.63±77.29	19.08	0.68
FCR	1.84^{a}±0.02	1.72^{c}±0.02	1.77^{b}±0.03	1.75^{bc}±0.02	0.012	0.001
CPCR	0.408^{a}±0.004	0.384^{c}±0.005	0.395^{b}±0.006	0.390^{bc}±0.004	0.003	0.002
MECR	5.67^{a}±0.05	5.32^{c}±0.07	5.47^{b}±0.09	5.40^{bc}±0.05	0.043	0.001

CL-D: Corn-soybean meal-based diet having ME=3088 Kcal/kg, and CP=22.21%; FP-D: CL-D + 1% DM of fresh plantain; SP-D: CL-D + 1% DM of shade-dried plantain powder; BP-D: CL-D + 1% DM of blanched-dried plantain powder; BW: Body weight; TFI: Total feed intake; FCR: Feed conversion ratio; CPCR: Crude protein conversion ratio; MECR: Metabolizable energy conversion ratio; *SEM*: Standard error mean; ^{a,b,c}Means with different superscript in a row differ significantly ($P < 0.05$).

†Values for each parameter represent mean ± standard deviation with fifty observations at 28th days.

Serum metabolites

Birds given the different forms of plantain diets showed almost 4–11% lower serum triglyceride compared to the CL-D ($P < 0.05$) (Table 3). Serum total cholesterol concentrations varied significantly among birds receiving the CL-D, FP-D, SP-D, and BP-D, measuring 86.45, 78.60, 80.98, and 81.33 mg/dl, respectively ($P < 0.05$). Additionally, the serum HDL-C concentration of the birds was unchanged, but the serum LDL-C concentration of the birds supplied different forms of plantain diets tended to be lower ($P = 0.09$).

Table 3. Effect of different forms of plantain diets on serum metabolites of broilers†

Variables (mg/dl)	CL-D	Different forms of plantain diets			*SEM*	P-value
		FP-D	SP-D	BP-D		
Triglyceride	61.27^{ab}±1.95	55.11^{b}±1.63	58.54^{ab}±1.17	54.43^{b}±1.85	2.57	0.04
Total cholesterol	86.45^{a}±1.28	78.60^{b}±1.32	80.98^{b}±3.30	81.33^{b}±1.51	5.62	0.03
HDL- C	51.34±2.90	48.56±2.43	49.30±2.88	49.79±3.44	1.89	0.13
LDL-C	20.85±2.01	18.99±3.41	20.01±2.73	19.65±2.30	0.94	0.09

CL-D: Corn-soybean meal-based diet having ME=3088 Kcal/kg, CP=22.21%; FP-D: CL-D + 1% DM of fresh plantain; SP-D: CL-D + 1% DM of shade-dried plantain powder; BP-D: CL-D + 1% DM of blanched-dried plantain powder; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; Standard error mean; ^{a,b}Means with different superscript in a row differ significantly ($P < 0.05$). †Values for each parameter represent mean ± standard deviation with fifteen observations at 28th days.

Meat composition and color

Broilers given the CL-D, FP-D, SP-D, and BP-D showed meat ether extract contents of 0.96, 0.77, 0.88, and 0.82%, which significantly varied from one another (Table 4). But, the protein and nitrogen free extract contents of the broiler meat tended to be greater and lower in the different forms of plantain diets, respectively ($P < 0.10$), and the moisture and ash contents of the broiler meat remained alike ($P > 0.05$). Compared to the CL-D and SP-D, the FP-D showed better meat a* value ($P < 0.05$). Moreover, the FP-D, BP-D, and SP-D showed substantially greater meat SI compared to the CL-D. However, meat L* and b* values were similar among all dietary treatments ($P > 0.05$).

Meat sensory evaluation

Birds receiving the CL-D and the different forms of plantain diets did not show an influence on meat flavor ($P > 0.05$), while optimum meat juiciness and color were obtained in the FP-D compared to birds given the CL-D ($P < 0.05$) (Fig. 1). Moreover, birds served different forms of plantain diets showed better meat juiciness and tenderness compared to the CL-D

($P < 0.05$). Optimum meat acceptability was the highest in birds fed the FP-D, but no substantial variation was observed between CL-D and different forms of plantain diets.

Table 4. Effect of different forms of plantain diets on meat composition and color of broilers†

Variables	CL-D	Different forms of plantain diets			*SEM*	P- value
		FP-D	SP-D	BP-D		
Meat composition (%)						
Moisture	74.34 ±0.80	74.88± 0.62	75.92± 0.57	74.05±0.38	5.43	0.13
Crude protein	21.36±0.29	23.87±0.81	22.24±0.61	22.52±0.87	1.23	0.07
Ether extract	0.96^{a}±0.03	0.77^{d}±0.02	0.88^{b}±0.01	0.82^{c}±0.02	0.07	0.02
Ash	1.19±0.01	1.07±0.02	1.04±0.01	1.22±0.02	0.23	0.11
NFE	76.96±0.33	74.17±0.92	76.32±0.61	76.03±0.87	6.79	0.06
Breast meat color						
L*	42.28±1.92	46.49±2.82	44.69±1.90	45.34±1.72	0.70	0.18
a*	5.19^{b}±0.43	7.01^{a}±0.54	5.66^{b}±0.31	6.51^{ab}±0.70	0.25	0.01
b*	8.71±0.57	9.68±0.64	9.42±0.34	9.74±0.91	0.19	0.39
SI	10.13^{c}±0.42	11.96^{a}±0.80	10.99^{ab}±0.35	11.75^{a}±0.37	0.24	0.02

CL-D: Corn-soybean meal-based diet having ME=3088 Kcal/kg, CP=22.21%; FP-D: CL-D + 1% DM of fresh plantain; SP-D: CL-D + 1% DM of shade-dried plantain powder; BP-D: CL-D + 1% DM of blanched-dried plantain powder; NFE: Nitrogen free extract; L*: Lightness; a*: Redness; b*: Yellowness; SI: Saturation index; *SEM*: Standard error mean; ^{a,b,c,d}Means with different superscript in a row differ significantly ($P < 0.05$). †Values for each parameter represent mean ± standard deviation with fifteen observations at 28th days.

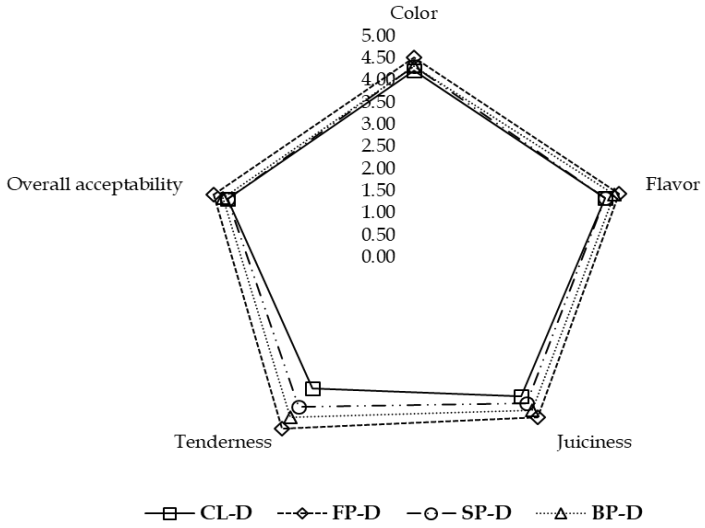

Figure 1. Effect of different forms of plantain diets on meat sensory evaluation of broiler†

Rank Value: 1=Poor, 2=Fair, 3=Good, 4=Very Good and 5=Excellent

CL-D: Corn-soybean meal-based diet having ME=3088 Kcal/kg, CP=22.21%; FP-D: CL-D + 1% DM of fresh plantain; SP-D: CL-D + 1% DM of shade-dried plantain powder; BP-D: CL-D + 1% DM of blanched-dried plantain powder.

† Values for each parameter represent mean ± standard deviation with fifty observations at 28th days.

Discussions

Growth performance

Better final BW, BWG, FCR, CPCR and MECR were obtained in the different forms of plantain diets due to the beneficiary effects of secondary metabolites at an optimum dose (Redoy *et al.,* 2021). Scientists revealed that broilers fed plantain seed (Mazhari *et al.,* 2016), or extract (Camy *et al.,* 2020), fresh plantain (Chacrabati *et al.,* 2013; Redoy *et al.,* 2021) showe higher body weight, better FCR and CPCR and MECR which supports the findings of the current study. In line with the current study, broilers offered 1.0% shade-dried *Lasia spinosa* powder exhibits greater body weight gain and better FCR (Zhang *et al.,* 2021). This better performance of broilers in different forms of herb-supplemented diets might be attributed to the presence of acteoside, aucubin and catalpol in plantain herbs (Al-Mamun *et al.,* 2008a). The inclusion of acteoside (5.0 mg/kg feed), a secondary metabolite derived from *Lipia citridora* does not influence the broiler performance (Marco *et al.,* 2015), which contradicts to present study. But, the combined effects of these secondary metabolites might be responsible for elevating the performance of broilers. Since acteoside in plantain acts as natural antioxidant which improves the nitrogen retention

capacity in broilers by suppressing oxidative stress (Marco *et al.,* 2015; Al-Mamun *et al.,* 2023), whereas aucubin in plantain enhances the immune status as well as better performance by accelerating secretion of lymphocyte interferon-gamma (Venkatalakshmi *et al.,* 2016). The improved and variable performance of broilers at FP-D, SP-D, and BP-D might be attributed to the presence of herbal secondary metabolites at different levels. Since previous findings (Le *et al.,* 2021; Hazrati *et al.,* 2021) revealed that different herbs exhibit the highest concentration of secondary metabolites in their fresh form (freeze-dried), followed by blanched and shade-dried forms. Furthermore, several secondary metabolites present in plantain act as anti-inflammatory, wound healing, and antimicrobial agents (Bahadori *et al.,* 2020), which might be other reasons to improve broiler performance.

Serum metabolites

Broilers fed herbal supplements result inconsistent changes in serum triglyceride, total cholesterol, HDL-C and LDL-C (Akbari *et al.,* 2016; Hosseini-Vashan and Raei-Moghadam, 2019). In the current study, broiler-served the different forms of plantain diets showed lowered serum triglyceride and total cholesterol which partially supports the previous findings (Mondal *et al.,* 2015; Mazhari *et al.,* 2016; Karim *et al.,* 2017). Additionally, Redoy *et al.* (2021) and Al-Mamun *et al.* (2023) stated that broilers fed fresh plantain (1.0% on DM basis) showe lower serum triglyceride and total cholesterol levels, which supports our findings. The higher antioxidant capacity of plantain herb results improved serum antioxidant status in broilers (Redoy *et al.,* 2021), which might be a key factor in improving the secretion of lipoprotein lipase enzyme, resulting in lower serum triglyceride and total cholesterol in birds (Adiputro *et al.,* 2013). Besides, this decreased serum triglyceride concentration in the different forms of plantain diets might be helpful to lower LDL-C and raise HDL-C concentrations (Fallah and Mirzaei, 2016), which is aligned with this research. In agreement with the findings of Najafian *et al.* (2018), our results showed that the secondary metabolites in plantain may reduce the HMG-CoA reductase activity, which is responsible for lower cholesterol synthesis.

Breast meat composition and color

Plantains' antihypercholesterolemic properties and capacity to scavenge free radicals might be responsible for the lower ether extract and greater protein levels in broiler meat, respectively (Al-Mamun *et al.,* 2008b; Camy *et al.,* 2020). Lower serum triglycerides and LDL-C concentration might be a major reason to deposit low fat in the abdomen and muscle, thus resulting in lean meat production in birds (Musa *et al.,* 2007; Camy *et al.,* 2020). The higher nitrogen retention in different forms of plantain diets might be due to the free radical scavenging activity of plantain, which reduced the breakdown of the body cells, thus resulting in the deposit of greater protein in muscle (Al-Mamun *et al.,* 2008b; Al-Mamun *et al.,* 2023). The birds that were fed FP-D, BP-D, and SP-D showed higher meat a* and SI values, which vary depending on the forms of plantain diets, while FP-D had the optimal results. This finding may be explained by the fact that fresh plantain has higher levels of secondary metabolites than blanched and shade-dried plantain (Hazrati *et al.,* 2021). Plantain is rich in lutein and α-tocopherol, which may contribute to the augmented a* and SI values of meat (Elgersma *et al.,* 2013). Fresh plantain added to the broiler diet increases meat color and serum antioxidant levels (Redoy *et al.,* 2021). Improved blood antioxidant levels may enhance meat redness by lowering phospholipase A2, calcium ion leakage activity, and meat oxidation in broilers (Carvalho *et al.,* 2017).

Sensory evaluation of meat

Previous studies (Camy *et al.,* 2020; Redoy *et al.,* 2021) illustrated that birds served plantain extract or fresh plantain substantially improve the meat unsaturated fatty acid level, juiciness, tenderness, flavor, and overall acceptability. These inconsistent results might be responsible for several types' of secondary metabolites available in herbs and their various modes of action in birds. The plantain herb's bioactive substances act as natural antioxidants and are vital in preventing the formation of free radicals, which minimize meat oxidation and improve its sensory quality. Besides, plantain is an excellent source of minerals (Redoy *et al.,* 2020) which aid in controlling acid-base balance, and maintain the osmotic pressure, cell permeability and neuromuscular activity, thus resulting in better sensory quality of meat fed the different forms of plantain diets (Mariod *et al.,* 2021).

Conclusion

In conclusion, the results of the present study showed that feeding fresh plantain (FP-D) at 1.0% on a dry matter basis showed optimum performance and ameliorated the meat quality in broilers. In small-scale farming FP-D might be introduced to enhance the production and ensure the better meat quality of broilers. Then supplementation of blanched (BP-D) or shade-dried plantain powder (SP-D) showed an almost similar performance on broiler growth performance and meat quality. So, it may be proposed that blanched or shade-dried plantain powder may be developed as an herbal additive for large-scale feed formulation (pellet or hand mix) to improve the growth performance and meat quality of broilers.

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