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Carcass Characteristic and Physico-chemical Properties of Broiler Chicken Meat Supplemented with *Azolla pinnata*

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ABSTRACT

An experiment was conducted on 110, day old commercial poultry broiler birds which were divided into 5 groups (1 control and 4 treatments) within 2 replicates having 11 chicks in each replicate. Four levels of *Azolla* were included in the diet i.e. 2.5 percent *Azolla*, 2.5 percent *Azolla* with carbohydrase and phytase enzymes, 5.0 percent *Azolla* and 5.0 percent *Azolla* with carbohydrase and phytase enzymes served as components of treatment T_1, T_2, T_3 and T_4, respectively, where as T_0 served as standard control diet. These dietary treatments were arranged in complete randomized block design and analyzed for the carcass, physico-chemical and sensory quality of meat. Results revealed that the overall acceptability of cooked meat was significantly higher ($P<0.05$) in broilers offered *Azolla* meal at 5 percent substitution. The breast meat yield and cooking yield value was significantly ($P<0.05$) higher in *Azolla* fed groups. There was significantly ($P<0.05$) higher gizzard weight in treatment T_1 and treatment T_2 offered 2.5 percent *Azolla* substituted feed as compared to the control T_0. The results may be attributed to improved digestibility of nutrients because of better gizzard functioning owing to increased thickness and increased gastro-duodenal reflexes facilitating the contact between nutrients and digestive enzymes. Based on the findings it can be concluded that dried *Azolla* meal can be safely administered as unconventional feed ingredient in commercial poultry broiler feed up to 5 per cent level without affecting the organoleptic parameters.

Keywords: *Azolla* feeding, carcass characteristics, broiler meat, physico-chemical properties

The intensifying income and changing consumer preferences lead to significant market opportunities for higher-value agricultural products. India is one of the largest poultry producing country in Asia. Before 1960s, from being largely a backyard endeavor, Indian poultry sector has evolved into an effervescent agribusiness spurred by domestic economic growth and consumption dynamics. The share of poultry in domestic meat production has grown swiftly. By 2006, India was producing 2.0 million metric tons of poultry-meat (Hellin and Erenstein, 2009) and presently producing approximately 3.2 million metric tons (DAHD, 2016-17). By 2030, it is expected to reach about 3.0 million metric tons per annum (Joshi and Kumar, 2012). The per-capita consumption of meat is expected to increase in India, from its current level of 3.1 kg to 18 kg by 2050, of which 12.5 kg would be chicken (Alexandratos and Bruinsma, 2012). Poultry meat is widely accepted due to its rich taste high protein content, low fat content and comparatively economical than other meat products without disparity among regions and religions (Manning and Baines, 2004). The poultry industry in India has benefited from scientific advances in poultry breeding and disease control but an additional factor has been the accessibility of low-priced, high-quality feed (Ravindran, 2013). Feed is the largest single input cost for broiler production (Davis *et al*., 2013) and can constitute up to 70 percent of the total cost. Thus, of the feed proteins that are generally used in poultry most are of plant origin and economically cheaper than protein of animal origin. Though, very limited work has been done in our country,

on the use of unconventional feed ingredients in poultry diet. Thus poultry nutritionist's world over are exploiting the use of various un-conventional feed ingredients in poultry feeding to enhance the consumer demand for eggs and meat.

One of such plant which can be used as non conventional feed resource (NCFR) is *Azolla* (*Azolla pinnata*). *Azolla* is a floating fern and belongs to the family of *Azollaceae*. *Azolla* (*Azolla pinnata*) is found ubiquitously in ponds, ditches and paddy fields in tropical and subtropical regions of the world. *Azolla* is very rich in proteins, essential amino acids, vitamins (vitamin A, vitamin B_{12}, ß-Carotene), growth promoter intermediaries and minerals including calcium, phosphorous, potassium, ferrous, copper, magnesium (Kamalasanana *et al*., 2002). *Azolla*'s composition therefore makes it one of the most economic and efficient feed substitutes for livestock, since it can be easily digested by livestock owing to its high protein and low lignin content (Rana *et al.,* 2017). *Azolla* can be used as a food, mosquito inhibitor, green manure, herbicide, water saver, water purifier, nitrogen fertilizer saver, and drug for reclaiming saline soils. *Azolla* can survive a water pH range of 3.5–10, but optimum growth occurs when the water is between pH 4.5 - 7.0. Thus, *Azolla* appears to be a potential source of nutrients and has a considerably high feeding. The present study was undertaken to evaluate the carcass characteristics and meat physico-chemical properties of broiler chickens fed graded dietary supplement of *Azolla*.

MATERIAL AND METHODS

A biological trial was conducted for a period of 42 days using one hundred and ten commercial broiler chicks (Vencobb). The chicks were weighed individually and there after randomly allotted to five dietary groups viz., T_0, T_1, T_2, T_3 and T_4. Each group comprised of two replicates of eleven birds each. The group T_0 was fed a control ration formulated as per the BIS (1992) and this diet was included with dried *Azolla* at 2.5 percent T_1, 2.5 percent with enzymes i.e. carbohydrase (CE) and Phytase (PE) T_2, 5.0 percent T_3 and 5.0 percent with enzymes i.e. carbohydrase (CE) and Phytase (PE) T_4 levels respectively. The birds were provided with starter ration from 0 to 3 weeks of age and thereafter finisher ration from 4 to 6 weeks of age. All the rations were made isocaloric and isonitrogenous.

At the end of trial five birds per treatment close to the average weight were selected randomly and slaughtered by Jhatka method. The carcass yield was recorded. The birds were immediately eviscerated and dressed to find out the dressing percentage. The dressed meat was packed in aluminum foil and stored at –20°C for further evaluation. Thereafter the weights of giblet (liver, heart, gizzard), spleen, pancreas, proventriculus, skin, feet, head, wing, tail and dressing percentage was recorded.

Breast muscle yield

The frozen dressed carcass was thawed at 7°C for 48 hrs. Breast muscles (*Pectoralis major* and *P. minor*) were manually dissected and their yield was recorded.

Estimation of pH of broiler meat

The pH of fresh minced chicken was determined (Trout *et al.,* 1992) by combination electrode digital pH meter; 10 gram of sample was homogenized with the help of tissue homogenizer for about 2-3 minute in 50 ml of distilled water. The pH was recorded by immersing the electrode directly into the meat homogenate.

Estimation of cooking yield

The weight of meat before and after cooking was recorded. Cooking yield was calculated using formula:

$$\text{Cooking loss (\%)} = \frac{\text{Weight of cooked meat}}{\text{Weight of raw meat}} \times 100$$

Proximate analysis of broiler fresh and cooked meat

The proximate analysis such as moisture and ash (determined by oven drying), fat (by Soxhlet extraction with petroleum ether) and protein (Kjeldahl nitrogen estimation) were estimated following the procedure as recommended in AOAC (2005). The pressure cooker was used for meat cooking and 10 percent water along with 1 percent salt was used as ingredient before cooking.

Sensory evaluation

The cooked chicken chunks was evaluated by the standard sensory evaluation method using 8-point descriptive scale

(Keeton, 1983) with modifications where 8=excellent; 1=extremely poor. The raw chicken chunks samples were applied with 1 percent salt and 1 percent spices before being cooked to the internal temperature of 80˚C±2˚C in a pressure cooker. The time-temperature was noted before the start of trials. The 6 panelists consisting of scientists from the institute evaluated chicken for sensory attributes (appearance, flavor, juiciness, tenderness and overall acceptability). The panelists were briefly explained about the nature of the experiment without disclosing the identity of samples/treatments. The experiment of sensory evaluation was repeated three times.

RESULTS AND DISCUSSION

Carcass characteristics of broiler chicken supplemented with *Azolla pinnata*

The results obtained regarding the carcass characteristics and weights of important by products of broiler chicken were determined at the end of trial and have been presented in Table 1. Perusal of the results revealed that the average value of live weight (g), carcass weight (g), dressed weight (g) and dressing percent in control T_0 and treatment T_1, T_2, T_3, and T_4 exhibited no significant ($P<0.05$) difference compared to control. However, in recent study (Pinkihan, 2013) reported no significant effect of *Azolla* meal in terms of dressing percentage. The results are in accordance to Dhumal *et al.* (2009) who reported that there were non-significant differences amongst the means of various traits such as carcass yield percentage, abdominal fat and abdominal pad thickness signifying the non-influence of *Azolla* meal on carcass quality. The results obtained regarding the giblet yield (liver, heart, gizzard) of broiler chicken were determined at the end of trial. Perusal of the results revealed that the average value for liver weight and heart weight (g) in control T_0 and treatment T_1, T_2, T_3 and T_4 both revealed no significant ($P<0.05$) difference.

The average value of gizzard weight (g) in control T_0 and treatment T_1, T_2, T_3 and T_4 were significantly ($P<0.05$) higher in treatment T_1 and treatment T_2 as compared to the control T_0. Average value of gizzard weight ranged between 39.60±2.48 to 50.00±2.68 g with the lowest weight recorded in T_0 and highest in T_1 followed by T_2. Results exhibited corroborated the findings of Mateous *et al*. (2012) that the change in the quantity and quality of crude fibre (CF) content affect the development and the function of the digestive organs including size of gizzard and of gastrointestinal tract. Inclusion of *Azolla* increased the overall CF content of the test diet T_1, T_2, T_3 and T_4. The results are in accordance to Pinkihan (2013) who reported that the weight of giblets from birds fed with 15 percent *Azolla* meal was heavier although no significant difference was noted compared to those in other treatments. This finding showed that the levels of *Azolla* meal incorporated in the diet in broiler had no detrimental effects on the growth performance of the experimental birds. Also similar results were obtained by Basak *et al*. (2002) who reported that percent giblet yield was significantly higher in 15 percent *Azolla* meal fed group followed by 10 percent, 5 percent and control group.

The results obtained regarding the non edible parts (spleen, pancreas, proventriculus, feet, head, skin, wing, tail) of broiler chicken were determined at the end of trial and have been presented in Table 1. Perusal of the results revealed that the average value of spleen, pancreas, proventriculus, feet, and head weight in control T_0 and treatment T_1, T_2, T_3 and T_4 did not exhibit any significant ($P<0.05$) difference amongst different treatments compared to control. The highest average value of skin weight was recorded in T_2 and the lowest value in T_4 exhibiting significant ($P<0.01$) difference. Similarly the average value of wing weight (g) in control T_0 and treatment T_1, T_2, T_3 and T_4 were significantly ($P<0.05$) higher in control T_0 compared to all the treatments. The average value of tail weight (g) were significantly ($P<0.05$) higher in treatment T_1 as compared to the control T_0. Naghshi *et al*. (2014) also said that supplementation of *Azolla* powder up to 5 percent significantly increased carcass efficiency percentage ($P< 0.05$) and thigh relative percentage ($P<0.05$) while, lower percentage is related to diets containing 15 percent *Azolla*.

The results obtained regarding the breast yield (gm) of broiler chicken were determined at the end of trial and have been presented in Table 1. Perusal of the results revealed that the average value of boned breast yield and deboned breast yield (g) (*Pectoralis minor*) in control T_0 and treatment T_1, T_2, T_3 and T_4 did not exhibit any significant ($P<0.05$) difference amongst different treatments compared to control. Whereas the average value of deboned breast yield (g) (*Pectoralis major*) were significantly ($P<0.05$) higher in treatment T_1 and treatment T_3 as compared to the control T_0. The average value of

Table 1: Carcass characteristics and weight of important by-products of broiler chicken supplemented with different doses of *Azolla pinnata*

Particulars	T_0	T_1	T_2	T_3	T_4
Live weight(g)	2178.8±18.78	2160.4±12.32	2238.2±13.34	2172.4±35.05	2280.4±34.34
Carcass weight(g)	2132.8±17.35	2032.8±15.84	2103±12.41	2107.2±23.68	2134±15.89
Dressed weight(g)	1464.4±26.66	1442.8±39.00	1499±54.12	1371.2±23.78	1516.8±47.73
Dressing per cent	66.64±1.02	66.75±1.50	66.92±2.04	63.19±1.61	64.30±1.82
Giblet yield					
Liver	47.60±1.32	41.60±2.13	43.60±2.63	44.00±3.52	51.20±5.67
Heart	12.40±0.40	11.60±0.74	11.60±0.40	12.00±0.63	12.40±0.74
gizzard	39.60±2.48^{a}	50.00±2.68^{c}	46.60±1.53^{b}	41.60±1.72^{a}	40.80±1.85^{a}
Non edible parts					
Spleen	2.03±0.04	2.00±0.31	1.80±0.37	1.96±0.07	1.78±0.11
Pancreas	5.00±0.44	5.20±0.37	4.40±0.50	5.40±0.40	6.20±0.37
Proventriculus	9.60±0.74	9.60±0.40	9.20±0.80	10.20±0.66	9.60±0.40
Skin	127.50±11.85^{ab}	122.00±9.83^{ab}	149.00±8.49^{b}	115.20±10.92^{ab}	102.00±8.04^{a}
Feet	85.00±2.23	79.00±2.23	82.00±4.47	79.60±3.18	79.00±2.23
Head	53.00±3.13	48.00±0.89	54.00±0.89	48.00±6.03	45.00±1.34
Wing	94.00±3.57^{b}	72.40±3.35^{a}	83.00±0.44^{ab}	79.60±3.65^{a}	82.00±0.89^{a}
Tail	17.00±1.34^{ab}	18.00±0.89^{b}	14.00±0.89^{a}	14.00±0.89^{a}	15.00±0.44^{ab}
Breast meat attributes					
Breast yield with bone	481.4±4.26	424.0±2.45	434.8±3.88	532.0±6.27	466.4±2.02
Breast meat lean yield	390.4±8.75^{ab}	401.8±18.99^{b}	376.4±9.10^{a}	457.8±2.48^{c}	396.8±5.41^{b}
Pectoralis major (yield)	297.4±8.74^{a}	315.4±13.67^{a}	290.0±8.96^{a}	374.4±1.57^{b}	308.4±5.60^{a}
Pectoralis minor (yield)	90.6±2.68	86.4±4.70	86.4±1.57	83.4±1.57	88.4±0.68

Value with common super scripts in a row does not vary statistically (P<0.05)

total breast yield (g) in control T_0 and treatment T_1, T_2, T_3 and T_4 were significantly (P<0.05) higher in treatment T_1 and treatment T_3 as compared to the control T_0.

Proximate composition of broiler meat supplemented with *Azolla pinnata*

The results obtained regarding proximate principles of broiler fresh and cooked meat viz: dry matter, ash, crude protein, ether extract, estimated from the muscle samples of control and different levels are presented in Table 2. Perusal of the results revealed that the average value for dry matter was significantly (P<0.05) higher in T_0, T_1, T_2 and T_4 as compared to T_3. Results exhibited revealed significant (P<0.05) reduction in dry matter yield of the experimental broilers offered 5 percent *Azolla* substituted feed. The average value for total ash was significantly (P<0.05) higher in treatment T_2 (1.31±0.00) and T_4 (1.48±0.11) offered 5 percent *Azolla* and 2.5 percent *Azolla* with enzyme in test diet respectively as compared to the control T_0 (1.06±0.05). The average value for crude protein was significantly (P<0.05) higher in treatment T_0, T_1 and T_2 as compared T_3 and T_4 offered 5 percent *Azolla* substituted feed. The average value for ether extract was significantly (P<0.05) higher in treatment T_1, T_2 and treatment T_3 as compared to control T_0.

Overall results exhibited significant (P<0.05) changes in the proximate principles *viz* dry matter, ash, crude protein and ether extract on feeding *Azolla* substituted feed in commercial broilers at 5 percent level exhibiting higher ash, EE content, lower CP and lower DM whereas supplementation of enzymes improved the EE, DM and total ash content but CP content was low compared to control T_0 and Treatment T_1. 2.5 percent substitution of *Azolla* exhibited higher proximate principles compared to

Table 2: Physico-chemical and sensory attributes of Broiler meat supplemented with *Azolla pinnata*

Proximate analysis (fresh meat)					
DM	73.83±0.32^{b}	74.38±0.31^{b}	74.10±0.31^{b}	70.61±0.20^{a}	73.33±0.19^{b}
Ash	1.06±0.05^{a}	1.02±0.08^{d}	1.31±0.00^{c}	1.18±0.03^{b}	1.48±0.11^{d}
CP	85.99±1.73^{b}	86.46±0.39^{b}	85.39±0.34^{b}	81.82±0.45^{a}	80.13±0.22^{a}
EE	1.21±0.01^{a}	1.93±0.02^{b}	4.3±0.06^{c}	4.24±0.30^{c}	1.33±0.04^{a}
pH (fresh)	4.99±0.03^{a}	5.19±0.09^{ab}	5.22±0.00^{b}	5.24±0.05^{b}	5.32±0.01^{b}
Proximate analysis (Cooked meat)					
DM	66.37±0.41^{bc}	64.86±0.50^{ab}	67.30±0.58^{c}	65.09±0.21^{ab}	64.35±0.12^{a}
Ash	1.69±0.04^{a}	2.73±0.03^{c}	1.75±0.01^{a}	2.52±0.01^{bc}	2.48±0.10^{b}
CP	74.03±1.13^{a}	72.64±0.45^{a}	85.75±0.51^{c}	83.1±0.22^{b}	85.69±0.35^{bc}
EE	1.62±1.61	1.62±0.00	1.91±0.00	1.47±0.02	2.46±0.17
pH (cooked)	5.45±0.10^{a}	5.52±0.03^{a}	5.79±0.01^{b}	5.75±0.00^{b}	5.81±0.05^{b}
Cooking yield (%)	81.71±0.06^{b}	82.33±0.93^{b}	78.37±0.43^{a}	80.38±0.06^{ab}	86.17±0.73^{c}
Sensory attributes					
Appearance	7.00±0.25	6.83±0.47	6.00±0.36	7.16±0.30	6.83±0.40
Flavor	6.58±0.37	6.41±0.27	5.91±0.37	6.66±0.21	6.37±0.24
Juiciness	6.16±0.30	6.00±0.36	6.00±0.36	6.66±0.21	5.83±0.30
Tenderness	5.75±0.25^{ab}	6.25±0.31^{ab}	5.25±0.51^{a}	6.83±0.30^{b}	6.16±0.30^{ab}
C T residue	5.91±0.20^{ab}	5.91±0.41^{ab}	4.75±0.65^{a}	7.16±0.30^{b}	6.16±0.47^{ab}
Overall acceptability	6.33± 0.21^{ab}	6.75± 0.17^{ab}	5.50± 0.50^{a}	6.83± 0.30^{b}	6.54± 0.24^{ab}

Value with common super scripts in a row does not vary statistically (P<0.05)

control T_0 where as enzyme supplementation increased the content of EE and TA.

The results obtained regarding proximate compositions of broiler cooked meat *viz* dry matter, ash, crude protein, ether extract, estimated from the muscle samples of control and different levels are presented in the Table 2**.** Perusal of the results revealed that the average value for dry matter yield was numerically more than control T_0 where as it was significantly (P<0.05) higher in T_2 compared to T_1, T_3 and T_4. The average value for total ash was significantly (P<0.05) highest in treatment T_1 and T_3 compared to control T_0 and treatment T_2, T_4. The average value for crude protein was significantly (P<0.05) highest in treatment T_2 offered 2.5 percent *Azolla* with enzyme in test diet and T_4 offered 5 percent *Azolla* with enzyme in test diet as compared to control T_0 and T_1. The average value of ether extract exhibited no significant (P<0.05) difference amongst *Azolla* fed and control treatments.

Contrary to the results obtained, Sharma (2014) reported that proximate composition of broiler meat i.e. dry matter, crude protein, crude fiber, crude fat, total ash, acid insoluble ash, ether extract, nitrogen free extract estimated from the muscle samples of control and different treatments with *Azolla* substitution at different levels exhibited no significant (P<0.05) difference between the treatments. Also, in a study involving use of probiotics, Khaksefidi and Rahimi (2005) revealed that the leg and breast meat of probiotic fed chickens was higher (P<0.05) in moisture, protein, ash and lower in fat as compared to the leg and breast meat of control chickens.

Physico-chemical attributes of chicken meat supplemented with *Azolla pinnata*

The results obtained regarding the pH of fresh and cooked meat and the cooking yield per cent of broiler meat were determined at the end of trial and are presented in Table 2. Perusal of the results revealed that the average pH value of fresh meat was significantly (P<0.05) higher in treatment T_3 and T_4 as compared to control T_0. Further, Jones and Grey (1989); Sams and Mills (1993) reported that at the end of the post-mortem process, the normal pH range lies between 5.6 and 5.8 or 5.78 to 5.86, respectively. Therefore, the pH value exhibited in the present study after *Azolla*

feeding both at 2.5 and 5 percent confer to the pH range as reported in the literature. Also Pelícia *et al*. (2004) also reported no differences in these qualitative characteristics due to the administration of probiotics and prebiotics to free-range broiler chickens. Further the average pH value of cooked meat was significantly ($P<0.05$) higher in treatment T_2 and T_4 compared to control T_0. Similar work done by supplementing probiotics/ prebiotics by ERL Pelicano *et al*. (2005) reported that breast meat pH values measured 5 hours after slaughter were not affected ($P>0.05$). The average value of cooking yield percent was significantly ($P<0.05$) higher in treatment T_1 and T_4 as compared to control T_0.

Sensory attributes of broiler meat

The results obtained regarding the sensory attributes of broiler meat were determined at the end of trial and have been presented in Table 2. The appearance of cooked meat from experimental broilers fed with different treatments groups were not significantly affected by the diet. Panelists agreed that samples in all treatments have good appearance. The flavor of all treatment groups ranged from 5.91 to 6.66. Thus there was no significant difference in terms of flavor among the diets containing *Azolla* meal than those in control diet. However, the panelists agreed that samples taken from treatment T_3 were very juicy while samples taken from treatment T_4 were moderately juicy. Tenderness score ranged from 5.25 to 6.83 and these values were significantly higher in treatment T_3 as compared to treatment control diet. Connective tissue (CT) residue score ranged from 4.75 to 7.16. Highly significant results were obtained among treatment T_3 given 5 percent *Azolla* as compared to T_0. Thus, the panelists agreed that samples taken from treatment T_2 had slightly high CT residue with those of samples taken from the treatment T_4 having moderately less residue. The overall acceptability scores ranged between 5.50 to 6.83. Samples taken from treatment T_3 which contained 5 percent inclusion of *Azolla* meal had the highest per cent acceptability. The observation shows that overall acceptability of meat could be enhanced if broilers are fed with *Azolla* meal. In one of the recent study, (Pinkihan, 2013) reported that baked meats from broilers fed with different levels of *Azolla* meal were moderately desirable in terms of color and appearance. Study statistical analysis revealed significant differences in juiciness, tenderness, flavor and aroma, and general acceptability. Baked meats of broilers from the two control diets were moderately tender and juicy while the baked meats from the treated treatments were slightly tender and juicy. The flavor and aroma, and the general acceptability of baked meat from all the treatment were moderately liked and accepted except the baked meat taken broilers fed with commercial feed which is like slightly and accepted.

CONCLUSION

The carcass and edible by-products yield was in higher side in broiler chicken fed with *Azolla*. The values of breast meat yield were significantly higher in *Azolla* feed broiler chicken compared to control and *Azolla* plus enzymes. However, no significant differences were observed in proximate analysis of broiler meat of different groups. Higher pH value increase the shelf life of chicken, which was observed in the *Azolla* feed broiler chicken in the present study. Tenderness, juiciness and overall acceptability were significantly higher by feeding *Azolla* at 5 percent level without any adverse effect on meat flavor. Therefore, it is concluded that 2.5 or 5.0 per cent *Azolla* can be incorporated in broiler feed without any adverse effect on meat quality.

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