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Research Article

Investigation of the Growth of Broiler Chickens Fed with Azolla Mixed Feed: A Sustainable Protein Source for Rural Farming

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ABSTRACT

The inclusion of Azolla in broiler feed is becoming popular in rural areas to produce meat chicken at a reasonable cost in a sustainable manner. The present study investigated the effects of Azolla inclusion in feeding of broiler chickens under rural farming conditions. For this experiment, conventional and Azolla mixed (10% Azolla with 90% conventional) feedings were carried out with chicks (n=90) and 45 chicks in each feeding group with three replicates and collected data for six weeks. Thirty non-trained panelists carried out the sensory analysis of cooked meat. The data were statistically analyzed. The results showed that mean weight gain, FCR, organs weight except for head as well as sensory parameters of cooked meat were not significantly different while the weight of head was significantly different ($p<0.05$) between conventional and Azolla mixed feeding groups. The study concluded that the inclusion of 10% dry Azolla in the broiler feed had no negative effects on weight gain, FCR, organs weight and meat sensory characteristics. It is recommended that 10% dry Azolla on weight basis can be included in the feed for the broiler chicken production sustainably in the rural areas without negative effects on the performance of birds and meat sensory quality.

Introduction

Increasing food production from the sustainable sources to meet the increasing demand for food due to increasing world population is a main global concern. Because of the improvements in living standards together with urbanization, the consumption pattern of the people changing with more demand for meat especially for chicken meat. This exerts a pressure on the poultry industry to produce more meat. In addition to the expansion of large-scale poultry farms, small and medium scale broiler farms keep on expanding in rural and semi-urban areas in Sri Lanka. According to Nisamiya et al. (2023), 79% of the farmers in Kurunegala district in Sri Lanka raise less than 3000 broiler birds in their farms. The poultry industry in Sri Lanka plays a prominent role in the protein supply to the nation, which is considered important to safeguard children from malnutrition. Hence, it is necessary to ensure the sustainability of the poultry production, which can be fulfilled by identifying the factors that are found to be the hindrance for its performance, and sustainability.

Feed is considered the largest single production cost in broiler production and can constitute up to 80% of total livestock production costs and 86- 87% of the total variable production cost (Tandoğan and Çiçek, 2016). In broiler farms, the farmers spend about 65-75% of the total production cost to produce a complete diet formulation. Protein sources in the diet are considered the significant expensive portion of the broilers' diet formulation; with increased demand for protein sources, the cost also rises, and the necessity to find a new, cost-effective source of dietary protein is necessary (El-Deek et al., 2020). The incorporation of

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conventional feed ingredients, like maize, soya bean, fish meal etc., in poultry feed has caused an enormous increase in the cost of feed, thus any attempt to reduce the cost of feed may lead to a significant reduction in the total production cost (Swain et al., 2014).

Feeds of plant origin, like green plants, are considered excellent sources of protein and fat. Recently, aquatic plants are gaining much interest in food and biomedical research due to its broad range of uses such as human food, animal feed and bio-fertilizers. Among these aquatic plants, floating fern Azolla (*Azolla pinnata*) has been widely used as an alternative feed source for poultry (Samad et al., 2020). According to Swain et al. (2022), Azolla is rich in proteins, essential amino acids, vitamins (vitamin A, vitamin B12, α Carotene), growth promoter mediators and minerals including calcium, phosphorous, magnesium, potassium, iron and copper with 20.4-28.5 % crude protein on dry matter basis. With regard to the feed cost, Basak et al. (2002) concluded that Azolla meal is unconventional feed ingredients might be used to reduce feed cost. Further, Kamel and Hamed (2021) reported that dry Azolla could be a profitable protein source for the feed formulation for broiler chickens.

Several studies have been conducted on the effects of Azolla inclusion in poultry feed. In a study as a feed ingredient in broiler ration, Basak et al. (2002) found that Azolla is a good source of protein and may be used up to 5% level in dry form in the broiler feed to improve the performance without affecting feed palatability. Kamel and Hamed (2021) concluded that the inclusion of 4%, 8%, and 12% dry Azolla can improve the growth performance, hematological and biochemical parameters, and antioxidant properties without adverse effect on health condition of broiler chicks. Samad et al. (2020) found that 15% inclusion level of Azolla spp. in broiler feed ration improved the body performance of broilers in terms of overall body weight and body weight gain. In terms of feed conversion ratio (FCR) and feed intake, there were no significant differences among the treatments but it showed chicken's fed with Azolla spp. have better in FCR and feed intake. Together with that, Azolla spp. also may able to improve the nutrient digestibility of broiler chickens. Mahanthesh et al. (2018) concluded that the use of 30% of Azolla (w/w) along with 70% commercial feed in poultry broiler diet increased the body weight gain, improved the FCR, and reduced the mortality rate due to heat stress during summer. In addition to the growth performance, meat quality characteristics are important especially with regard to the consumer preference. Though plenty of studies conducted on Azolla supplementation for feeding broiler chickens, research work under rural farm settings is lacking. Hence, the present study was an attempt to investigate the effects of Azolla supplementation in broiler chickens under farmer conditions in rural areas.

Materials and Methods

Ethical review committee (ERC) approval

The ethics review committee of the Faculty of Technology, South Eastern University of Sri Lanka (ERC/FT/2023/05) approved the study.

Study area

This study was set up in a small broiler cage at Ambalkulam village in Kilinochi District, situated in northern Sri Lanka (9.3964° N, 80.4037° E). Annual rainfall ranges from 1,400 to 1,800 mm, average temperature varies between 25°C to 30°C and winds predominantly blow from the northeast during the dry season, shifting to the southwest during the wet season (Vinujan et al., 2016).

Construction of shed and preparation of shed

A system of open houses with natural ventilation was established to conduct the experiment in such a way that long axis was in east- west direction to prevent the direct sunshine over the birds. Experimental broiler cage 12 feet length, 12 feet width and 8 feet height were set up for 90 chicks. The cage roof was covered with aluminum roofing sheet and coconut leaves were placed on the roof to reduce the heat. Four feet height stone wall was built around it and the upper part was covered with wire net.

Experimental design

This experimental design was the complete randomized design (CRD). Chicks (n=90) were divided into 02 groups randomly i.e.; one group was fed with conventional feed and the second was fed with Azolla supplementation with 45 chicks in each group and each group consisted of three replicates with 15 chicks for each replicate.

Introducing chicks to the brooder and cage

Chicks were purchased from a private chick supplier in Colombo, western province. Before the chicks were brought to the farm, the brooder was set up and the floor was cleaned and prepared with lighting, and ventilation. The dry paddy husks were spread as litter material. The chicks were introduced into separate brooders as per the experimental protocol. The chickens were initially weighed, when the chickens were brought to the cage, they were given glucose in water for the first three hours. After 7 days of brooding, chicks were transferred into broiler cage.

Feeding and watering

In the first week, one group was given starter mash (conventional feed) only and another group was given the feed mixture containing starter mash 90% and dry Azolla 10%. The inclusion of 10% of Azolla was determined having our preliminary observations at rural areas where farmers used 10% dry Azolla and claimed better performance of broiler chickens with this level of inclusion. After four weeks, the chicks in first were given the finisher only (conventional feed) and the chicks in second group were fed with 90% finisher with 10% dry Azolla up to 42 days. Feed was given twice daily according to their age and water was given ad libitum.

Sensory analysis

At 42 days, six birds were randomly selected from each conventional and Azolla mixed feeding groups. Birds were fasted overnight (12hr), live birds' weight was measured and taken the readings and then slaughtered by cutting jugular vein afterward de-feathering was completed. Each bird was eviscerated manually (Althaus et al., 2017). Meat samples were cooked with salt and spice separately from each group. All meat samples were named based on their feeding (Küçüközet et al., 2018). Thirty non-trained panels of judges carried out the sensory analysis. The color, flavor, taste, texture and overall acceptability were taken by using a nine-point hedonic scale (Kennedy et al., 2004). Scale scorings are, 9-like extremely, 8-like very much, 7 – like moderately, 6 – like slightly, 5 – neither like or dislike, 4 -dislike slightly, 3 – Dislike moderately, 2 -dislike very much, 1 – dislike extremely. The questionnaire, which included all the details about the sensory evaluation and that, was given to each panelist. This evaluation was conducted from 11.00 a.m. to 01.00 p.m.

Data collection and analysis

The initial weight was obtained when the chicks were brought to the cage. Again, the weight was taken once a week up to 42 days. The feed given and the feed left in the feeders were weighed using a digital scale after each feeding and the amount of feed consumed by the birds was thus determined. The data on sensory parameters were obtained as explained above using a hedonic scale. FCR was calculated having the feed consumption and weight at slaughtering. Statistical analysis was performed to compare the mean weight gain, FCR and sensory parameters between two feeding groups using SPSS software version 27.

Results and Discussions

Comparison of weight gain of broiler chicken fed with conventional and Azolla mixed feed

The results of ANOVA on the comparisons of the weight gain of broiler chickens depending on the type of feed they consumed are given in Table 1.

Table 1: Effects of conventional and Azolla mixed feeds on weight gain (mean ± SD) of broiler chickens

Weeks	Conventional feeding	Azolla mixed feeding	p-value
1	17.80 ±0.60	18.83 ±1.11	0.200
2	32.96 ± 0.26	31.94 ±1.17	0.200
3	50.37 ± 0.63	49.44 ±3.69	0.700
4	56.20 ± 0.54	54.49 ±0.18	0.100
5	80.03 ±2.35	100.48 ±7.34	0.100
6	155.83 ± 2.05	143.24 ±11.69	0.400

Note: Means are significant at $p<0.05$.

The results of the weekly weight gain from the both feeding trials are shown in Table 1. The mean weight gain of broiler chickens between conventional feeding and Azolla mixed feeding over the course of six weeks indicated no significant difference ($p<0.05$). The results may indicate that 10% of Azolla in dry form (on weight basis) can be fed mixing with conventional feed without negative effects on weight gain of broiler chickens. Our findings are in agreement with previous findings. Though several studies favored the inclusion 5% of Azolla for the better performance of broiler chickens (Basak et al., 2002; Abdelatty et al., 2020), Samad et al. (2020) concluded that the inclusion of *Azolla spp*. up to 15% in broiler feed can improve growth performance with no adverse effect on nutrient digestibility of the birds. Further, AL-Shwilly (2022) concluded that the inclusion of Azolla at 15, 30 and 45% in feed had a positive effect on broiler body weight. However, Basak et al. (2002) found that broiler chickens fed with the higher level of Azolla (10% and 15%) resulted in poor growth than 5% inclusion due to the increasing level of fiber content. Azolla in high concentrations negatively affects the appetite of the birds and consequently reduces the growth rate (Saikia et al. (2014) and further limits the efficient feed utilization of monogastric animals (Buckingham et al., 1978). The weight gain in both cases did not show any particular growth pattern. Having the results, it is concluded that 10% dry Azolla can be included in the poultry feed both in starter and finisher feed on weight basis under local and rural conditions. Sharma et al. (2015) concluded that the inclusion of dry Azolla meal up to 5.5% in broiler feed is

an alternative sustainable feed ingredient without affecting their performance.

Table 2: Weekly feed intake of broiler chicken

	Feed intake	
Week	**Conventional feeding**	**Azolla mixed feeding**
1	76.5	76.5
2	113.2	113.2
3	697.5	697.5
4	1458.9	1458.9
5	2230.2	2230.2
6	3146.4	3146.4
7	4091.4	4091.4
8	4496.4	4496.4

Effects of conventional and Azolla mixed feed on FCR in broiler chicken

The pattern of feed intake in the conventional and Azolla mixed feeding groups was observed to have a stable and the same increase during the experimental period. In both treatments, the feed intake progressively rose to 4496.4 g in week 8, starting with 76.5g in week 1, which is a normal growth-linked increase in nutrient requirements of broiler chickens. Significantly, the Azolla concentration of 10 percent in the diet did not result in the deviation of the feed consumption in comparison with the traditional feeding regime (Table 2). This shows that the palatability of the Azolla-contaminated feed and acceptability were similar to that of the usual diet, and the birds did not show any hesitation to ingest the modified food. The lack of differences in the feed intake between the two groups also substantiates the results of no significant difference in the weight gain and feed conversion ratio (FCR), indicating that Azolla inclusion did not adversely affect feeding behavior and nutrient utilization. Thus, the findings indicate that the use of 10% Azolla in the broiler diets is feasible and sustainable method of feeding under rural setting because it does not alter the normal patterns of feed intake without affecting the performance of the birds.

The study compared the mean FCR of broiler chickens fed with conventional and Azolla mixed diets using ANOVA and the results are given in Table 3.

Table 3: Effects of conventional and Azolla mixed feed on FCR (mean ± SD) in broiler chicken

Weeks	Conventional feeding	Azolla mixed feeding	p-value
1	1.36 ± 0.05	1.29 ± 0.08	0.200
2	1.30 ± 0.02	1.30 ± 0.06	0.700
3	1.44 ± 0.01	1.46 ± 0.06	0.700
4	1.44 ± 0.06	1.39 ± 0.07	0.400
5	1.27 ± 1.01	1.28 ±0.07	0.700
6	1.46 ± 0.00	1.46 ±0.06	0.700

Note: Means are significant at $p<0.05$.

The results (Table 3) showed that no significant difference was obtained on FCR between the two feeding methods ($p<0.05$). From week 1 to week 6 mean FCR varied from 1.36 ± 0.05 to 1.46 ± 0.00 in conventional feeding while it varied from 1.29 ± 0.08 to 1.46 ±0.06 in Azolla mix feeding indicating almost similar performance in feed conversion in both feeding methods. The results may indicate that the performance in the feed conversion of broiler chickens was not affected by the inclusion of 10% dry Azolla in the broiler feed. The findings in the present study were in in agreement with previous findings. For example, Samad et al. (2019) found that the inclusion of 10% dry Azolla showed no significant differences in the FCR of starter feeding, finisher feeding and in the overall results. Further, they found that the overall results on the FCR of treatment groups was lowest than control. However, Kamel et al. (2021) found that the FCR was significantly different among broiler chickens fed with 4%, 8% and 12% dry Azolla compared to the group of chickens that were fed with conventional feed. The researchers in general favored the inclusion of Azolla in broiler feed in terms of better FCR at a limited rate (Swain et al., 2022; Abdelatty et al., 2020; Mahanthesh et al., 2018; Kamel et al., 2021; Samad et al., 2019). As additional benefits, Tarif (2021) concluded that the inclusion of Azolla might reduce the cost of production to a minimum without any side effects on the growth and production of birds. Further, Azolla production through low-cost technology can be popularized and included in the feeds of chicken and ducks either in

fresh or dried form for economic production of meat and egg (Swain et al., 2022).

Effects of conventional and Azolla mixed feed on mean weight of body parts of chicken

The results of ANOVA on the comparisons of the weight of body parts of broiler chickens depending on the type of feed they consumed are given in Table 4.

Table 4: Mean weight of body parts of chicken (mean ± SD) fed with conventional and Azolla mixed feed

Body parts	Conventional feeding	Azolla mixed feeding	p-value
Legs (both)	57.33±3.06	63.08±2.40	0.063
Liver	54.67±3.06	69.00±13.89	0.156
Gizzard	63.33±5.78	72.67±4.19	0.086
Heart	19.67±0.58	19.00±1.00	0.374
Head	69.33±1.16	74.00±2.65	0.049
Feather (whole)	474.33±64.39	428.00±7.09	0.283
Intestine	134.00±4.00	138.66±7.91	0.413
Breast (whole)	340.00±10.00	365.16±13.42	0.060
Wing (both)	103.33±5.77	103.16±5.48	0.973
Drumstick (both)	134.00±3.61	138.50±10.69	0.528
Thigh (both)	216.67±5.78	220.16±5.25	0.481

Note: Means are significant at $p<0.05$.

According to Table 3, the weight of body parts i.e., leg, liver, gizzard, heart, feather, intestine, breast, wing, drumstick and thigh were not significantly different between conventional and Azolla mixed feeding groups while the weight of head was significantly different between two feeding methods ($p<0.05$). The findings in the present study are almost in agreement with the findings of Rana et al. (2017) where they found that inclusion of Azolla did not have significant influence on the weight of body parts. Abdelatty et al. (2020) also found that the inclusion of 10% Azolla meal in the broiler feed did not have significant effect on organs weight compared to the Azolla free feed. The results (Table 4) showed that the weight of the body parts in Azolla mixed feeding group was little higher than conventional feeding group except for feather though the weights of body parts were not significantly different. Goliomytis et al. (2003) found that the higher level of fiber content in feed might promote the development and functions of digestive organs mainly of gizzard and gastrointestinal tract. The higher fiber content in Azolla might have caused for the higher weight of gizzard and intestine in Azolla mixed feeding group. Though the present study found a significantly higher mean weight of head in the Azolla mixed feeding group, the study by Rana et al. (2017) showed no significant difference in the weight of head with the inclusion of Azolla. The findings in the present study in general may suggest that Azolla can be included in the broiler feed with no negative effects on the organs weight.

Effects of Azolla mixed feeding in broiler chicken meat sensory characteristics

The results obtained from the sensory analysis of cooked chicken meat of both feeding groups are given in Table 5.

Table 5: Sensory evaluation of cooked meat of broiler chickens fed with conventional and Azolla mixed feed

Properties	Conventional feeding	Azolla mixed feeding	p-value
Colour	6.73±0.86	7.16±1.01	1.00
Taste	6.0±1.57	6.6±1.42	0.832
Flavour	6.36±1.2	7.0±1.17	0.720
Texture	6.2±1.03	7.0±1.17	0.589
Overall acceptability	6.16±1.59	6.9±1.51	0.864

Note: Means are significant at $p<0.05$.

The results of the sensory analysis of cooked meat from conventional feeding group and Azolla mixed feeding group with regard to colour, taste, flavour, texture and overall acceptability (Table 5) showed no significant difference between both feeding groups. However, the above-mentioned sensory parameters were found to be at little higher level for Azolla mixed feeding group. Rana et al. (2017) found that no significant difference in

flavour in the cooked meat between the groups fed with Azolla mixed feed and conventional feed. However, they found that the overall acceptability of cooked meat was significantly higher in the group fed with Azolla mixed feeding than the group fed with conventional feed. The findings in the present study on sensory analysis may indicate that Azolla mixing in the feed may improve the sensory characteristics of broiler chickens, which is considered as important in the case of marketing.

Conclusions

This research aimed to evaluate the weight gain, FCR as well as the sensory attributes of the cooked meat of broiler chickens fed with conventional feed and Azolla mixed feed. Having the results on weight gain and organs weight, it is concluded that 10% dry Azolla can be included in the broiler starter and finisher feed under rural conditions without negative effects. The results on FCR indicated the inclusion of Azolla in the feed did not affect the performance of broiler chickens in the feed conversion. With regard to the sensory characteristics, the findings in the present study in general may suggest that Azolla can be included in the broiler feed with positive effects on the sensory characteristics. Having the findings of the study, it is recommended that 10% dry Azolla on weight basis can be included in the broiler feed for the chicken production in the rural areas on sustainable basis without negative effects on weight gain, FCR and with positive effects on sensory characteristics. It is further suggested that additional research should focus on assessing the cost-effectiveness of using Azolla in broiler feed.

Contribution of authors

M.G. Mohamed Thariq conceived, designed, analyzed the data, wrote the paper and finalized; T. Rajakopal collected the data and contributed to data analysis. M.M.M. Najim structured and corrected the manuscript. M.N.F. Nashath formatted and corrected the manuscript. All authors read and approved the final manuscript.

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Conflicts of Interest

We the authors declare that we do not have any conflict of interest.

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