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EFFECT OF DIETARY SUPPLEMENTATION OF AZOLLA (*AZOLLA PINNATA*) ON GROWTH PERFORMANCE AND ECONOMICS OF JAPANESE QUAIL

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ABSTRACT

The present study was carried out to study the effect of dietary supplementation of Azolla (Azolla pinnata) on growth performance and economics of Japanese quail. Six week (0-6 weeks of age) feeding trial was conducted by randomly assigning 96 quail chicks (day old) in four treatments (T0, T1, T2 and T3) and fed with experimental diets prepared by incorporating Azolla meal at 0, 1, 3 and 5% levels respectively by partially replacing soybean meal and other ingredients. Each experimental diet was offered *ad lib* to four treatment groups of chicks from 1-42 days of age. Response criteria were weekly body weight gain, feed intake and feed conversion ratio (FCR). At the end of the feeding trial result revealed that, the treatment group T3 exhibited a significantly ($p<0.05$) higher average body weight as compared to control and other dietary treatments. The feed intake was highest in the treatment T0, while the treatment T3 exhibited the lowest feed intake. The significantly better ($p<0.05$) cumulative FCR reported in the treatment T3 supplemented with 5% azolla meal compared to the control and other treatment group (T0, T1 and T2). The feed cost for production per kg weight gain was lower in T4 treatment group (5% azolla) followed by T3 and T2 and higher cost reported in control group compared to treatment group. Finally it was concluded that the partial replacement of dietary protein with Azolla pinnata at 5% level in maize soybean-based diet is beneficial and recommended for better performance and economics in Japanese quail production.

***Key words*:** Azolla pinnata, Growth performance, Economics, Japanese quail.

Introduction

Poultry produces 4.995 million tonnes of meat annually, contributing 51.14% of total meat production in India (BAHS, 2023). Poultry includes chickens, quails, ducks, geese and other species raised worldwide. Quails, the smallest avian species used for table eggs and meat, offer advantages such as small body weight, minimal space requirements, short generation intervals and rapid growth. Quail meat has lowest calorie content and highest protein level (Lonita *et al.*, 2008). Quail feed costs 60-70% of total production cost, with protein being the most expensive nutrient. Green plants synthesize amino acids from primary elements, making them an excellent protein source (Fasuyi and Aletor, 2005). With the growing human population and limited cultivation land, finding alternative poultry feed sources is crucial due to direct food competition between humans and poultry.

Azolla, a free-floating aquatic fern, has high protein content (Lumpkin and Plucknette, 1982; Katole *et al.*, 2017). It grows in stagnant water, doubling its biomass in every three days, earning the tittle “green gold mine” (El-Fadel *et al.*, 2020; Kour *et al.*, 2020). Azolla contains protein, essential amino acids, vitamins, and minerals (Bhattacharyya *et al.*, 2016), consisting of 25-35% crude protein, 10-15% minerals, and 15% total ash (Kamaruddin *et al.*, 2019). Azolla is a low-cost protein source (Joysowal *et al.*, 2018). Incorporating it into poultry feed reduces costs, enhances health, immunity and matching with

Table 1: Composition of diet.

S. No.	Ingredients (kg/100Kg of ration)	Starter diet (0-3 weeks) 25% CP; 2900 Kcal ME/Kg				Grower diet (4-6 weeks) 21.5% CP; 2950 Kcal ME/Kg			
		T0	T1	T2	T3	T0	T1	T2	T3
1	Maize (kg)	50.00	53.00	52.00	49.00	60.00	57.00	55.00	56.15
2	Soybean meal (kg)	43.00	41.15	40.35	38	32.35	31.65	30.65	30.00
3	Rice polish (kg)	4.00	2.00	1.80	3.80	4.80	7.50	8.50	6.00
4	Azolla (kg)	-	1.00	3.00	5.00	-	1.00	3.00	5.00
5	Limestone powder (kg)	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
6	Dicalcium phosphate (kg)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
7	Trace minerals (kg)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
8	Vitamin mixture (kg)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
9	Salt (kg)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
10	Coccidiostat (kg)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total		100							

soybean meal growth rates (Mishra *et al.*, 2016; Kumar *et al.*, 2018). Considering the importance of azolla on the performance of the chicken the current study was carried out.

Materials and Methods

Experimental diets and design

A total 96 number of day old quail chicks were weighed, wing banded and randomly distributed in 4 treatment groups (24 birds per treatment). Each treatment had 3 replicates consisting 8 chicks per replicate. Experiment was conducted in floor house which had individual pens on either side of the central passage. House was thoroughly cleaned, washed, disinfected and dried. Sawdust litter material was spread on floor in 2 cm thickness. Proper brooding, feeding and watering arrangements were done. Four experimental diets were prepared by incorporating azolla meal at 0, 1, 3 and 5% levels (Diet T0, T1, T2 and T3 respectively) by replacing soybean meal and other ingredients partly. Chicks were fed with standard quail chick starter diet (0-3 week), grower diet (4-6 week) as per ICAR (2013) standards. Each experimental diet was offered *ad lib* to four groups of chicks from 0-42 days. Composition of diet is given in Table 1.

Procurement and maintenance of Azolla culture

Azolla (*Azolla pinnata*) culture was procured from Krishi Vigyan Kendra, Jabalpur (JNKVV) and was cultivated in multiple artificial ponds of 12 × 4 ft size. The grown azolla was collected from the pond and dried in shady area and its dried meal was included in the quail diet at graded levels.

Body weight

The quail birds were weighed individually from each replicate at day-old and weekly intervals to arrive at average weekly body weight and weight gain per bird for various treatments.

Feed intake

Total feed intake was calculated by subtracting total residual feed from total feed offered in a week.

Feed conversion ratio

The feed conversion ratio was obtained as ratio of total feed consumed (g) and total body weight gain (g) (on weekly interval basis).

Economics of production

Economics of production was calculated by cost of feed consumed per kg weight gain for each dietary treatment.

Statistical analysis

Analysis (One way ANOVA) was carried out to study the effect of treatments on production performance (Snedecor and Cochran, 1989).

Results and Discussions

Body weight

The overall mean for weekly body weight (g) from 0-6 weeks of age are summarized in Table 2. Treatment T3, incorporated with azolla meal @ 5% in the diet, achieved significantly higher ($p<0.05$) body weight and weight gain compared to T2 (3% azolla), T1 (1% azolla) and T0 (control diet). These findings align with the results of Dhumal *et al.*, (2009) in broilers. Shamna *et al.*, (2013), Parvez *et al.*, (2018) and, Verma *et al.*, (2024) reported significant improvement ($p<0.01$) in the body weight and weight gain of Japanese quails with 5% azolla supplementation. Marked enhancement in the final body weight and weight gain receiving 5% dried azolla in diet could be attributed to azolla's high protein levels, especially the essential amino acids. Additionally, the presence of

Table 2: Effect of feeding of different levels of Azolla meal on weekly body weight (g) in Japanese quails.

Weeks	Treatments			
	T0	T1	T2	T3
Day old	7.23± 0.05	7.15± 0.03	7.23± 0.04	7.21± 0.04
1st week	23.75± 0.33	23.86± 0.24	24.02± 0.36	24.23± 0.29
2nd week	58.06^{b}± 0.34	58.14^{b}± 0.37	58.84^{ab}± 0.55	60.06^{a}± 0.58
3rd week	100.40^{b}± 0.54	100.53^{b}± 0.47	101.61^{ab}± 0.53	102.68^{a}± 0.63
4th week	138.55^{c}± 0.57	138.58^{c}± 0.63	140.84^{b}± 0.58	142.63^{a}±0 0.59
5th week	167.39^{c}± 0.59	168.59^{bc}± 0.82	170.30^{b}± 0.69	173.87^{a}± 0.86
6th week	189.70^{d}± 1.20	191.18^{c}± 1.02	193.65^{b}± 1.41	199.78^{a}± 1.13
Means bearing different superscripts in a row differs significantly ($p<0.05$)				

vitamins and significant content of minerals such as iron, calcium, potassium, magnesium, phosphorus and manganese contributed positively to growth performance. Acharya *et al*., (2015) highlighted that azolla possesses carotenoids and biopolymers, which function as natural agents for antioxidant activity and immune modulation, contributing significantly to enhancing the productivity and health of animals.

Feed Intake

The mean values for weekly feed intake (g/bird/week) across different ages are presented in Table 3. Cumulative feed intake at 6th week of age was observed significantly higher ($p<0.05$) in T0 (616.77±0.64) followed by T1 (612.53±0.20), T2 (610.43±0.55) and T3 (606.97±0.38), respectively.

The present study revealed that feed intake was highest in the treatment T0, while the treatment T3 exhibited the lowest feed intake. These findings are in agreement with the studies conducted by Islam (2017) and Rathod *et al*., (2013), reported reduced feed intake in treatment groups incorporating azolla meal in their diet compared to the control group. Hassen *et al*., (2019) also conducted an experiment to study the effect of partial substitution of soybean meal with *Azolla pinnata* on feed intake in broiler chickens and reported significantly lower feed intake in treatment group fed with diet substituted with 5% azolla as compared to control group.

Saikia *et al*., (2014) reported that azolla contains higher amounts of fiber content which can make azolla less palatable to birds, potentially affecting their appetite.

Table 3: Effect of feeding of different levels of Azolla meal on weekly feed intake (g/bird/week) in Japanese quails.

Weeks	Treatments			
	T0	T1	T2	T3
1st week	34.60± 0.46	33.43± 0.12	33.93± 0.15	33.60± 0.12
2nd week	74.80± 0.23	74.60± 0.32	74.60± 0.17	74.17± 0.15
3rd week	98.57± 0.35	98.17± 0.13	97.90± 0.20	97.83± 0.35
4th week	112.47± 0.37	111.63± 0.57	111.30± 0.22	110.73± 0.25
5th week	135.47± 0.87	135.03± 0.37	134.43± 0.57	133.50± 0.82
6th week	160.77± 1.09	159.67± 1.09	158.27± 1.18	157.13± 1.10
Cumulative	616.67^{a}± 0.64	612.53^{b}± 0.20	610.43^{c}± 0.55	606.97^{d}± 0.38
Means bearing different superscripts in a row differs significantly ($p<0.05$)				

The higher fibre content contributes to the bulkiness of the azolla, which may further decrease its desirability as a food source for the birds, impacting their feed intake.

Feed Conversion Ratio

The weekly mean values of cumulative feed conversion ratio (FCR) are presented in Table 4. Statistical analysis revealed a significantly better ($p<0.05$) cumulative FCR in the treatment groups (T1, T2, T3) supplemented with azolla meal compared to the control diet group (T0). Meena *et al*., (2023) and Yadav *et al*., (2022), also reported that incorporating azolla meal at a 5% level in

Table 4: Effect of feeding of different levels of Azolla meal on cumulative feed conversion ratio in Japanese quails.

Weeks	Treatments			
	T0	T1	T2	T3
1st week	2.09± 0.04	2.00± 0.04	2.03± 0.06	1.97± 0.05
2nd week	2.15^{a}± 0.01	2.12^{ab}± 0.02	2.11^{ab}± 0.03	2.04^{c}± 0.05
3rd week	2.24^{a}± 0.02	2.21^{ab}± 0.02	2.19^{ab}± 0.02	2.16^{c}0± 0.03
4th week	2.44^{a}± 0.02	2.42^{ab}± 0.02	2.38^{bc}± 0.01	2.34^{c}± 0.02
5th week	2.85^{a}± 0.02	2.81^{a}± 0.03	2.78^{a}± 0.02	2.70^{b}± 0.02
6th week	3.38^{a}± 0.01	3.33^{b}± 0.01	3.27^{c}± 0.01	3.15^{d}± 0.01
Means bearing different superscripts in a row differs significantly ($p<0.05$)				

Table 5: Effect of different levels of Azolla meal on economics of production in Japanese quails.

Treatments	T0	T1	T2	T3
Cumulative feed intake (kg)	0.62	0.61	0.61	0.61
Cost of feed (Rs/kg)	35.23	34.64	33.97	33.39
Weight (g)	189.70	191.18	193.64	199.78
Cumulative weight gain (g)	182.48	184.03	186.41	192.58
Total cost of feed intake (Rs)	21.72	21.22	20.74	20.27
Feed cost (Rs)/kg weight gain	119.06	115.30	111.24	105.24
Miscellaneous charges (Rs)	5.00	5.00	5.00	5.00
Chick cost (Rs)	10.00	10.00	10.00	10.00
Input Cost (Rs)	36.72	36.22	35.74	35.27
Gross return/Bird (Rs 300/kg)	54.74	55.21	55.92	57.77
Net return/Bird (Rs)	18.02	18.99	20.19	22.51

poultry diets significantly enhanced FCR. Similar results were also observed by Naghshi *et al*., (2014), who demonstrated that azolla meal supplementation in Cobb broilers (1-42 days) using 0-15% azolla in powder form in corn-soybean meal diet at a 5% level notably improved the feed conversion ratio in poultry birds. Hassen *et al*., (2019) reported better feed conversion ratio in broiler chickens fed on diet having 5% azolla meal in diet and stated that it may be due to the fact that treatment group having 5% azolla meal in diet contains appropriate proportion of soybean meal and azolla meal as the main source of crude protein with better amino acid profile.

Economics of production

Economics for Japanese quail production was calculated as based on quantity of feed consumed and expenditure incurred on feed for per kg weight gain in each treatment group. Economics of production in different levels of azolla meal are summarized in Table 5.

In this study, economic performance in term of net profit was analyzed by considering only recurring expenses such as the cost of chicks and feed incurred during the experimental period. Feed costs were computed by multiplying the proportions of feed ingredients by their respective market prices, while chick costs were considered based on their sale price at the Poultry Farm, College of Veterinary Science and Animal Husbandry, Jabalpur.

The lowest feed cost per kg weight gain was observed in treatment group (T3) at Rs.105.24, whereas the highest feed cost per kg weight gain of Rs. 119.06 was recorded in treatment (T0). The highest gross net return from sale of bird was observed in treatment (T3) at Rs. 57.77, whereas the lowest revenue of Rs. 54.74 was recorded in treatment (T1), reflecting differences in body weight across treatments. Similarly, net returns were highest in treatment T3 at Rs. 22.51 and progressively decreased to Rs. 18.02 in treatment T1. The benefit-cost ratio also mirrored this trend, with treatment T3 achieving the highest ratio of 0.64, while treatment T1 had the lowest ratio of 0.49.

These findings indicate that treatment T3 (5% azolla in diet) was the most economically beneficial, offering the greatest profitability and cost efficiency compared to the other treatments. The present research is in correlation with the Kamel *et al*., (2021) who studied the effect of dried azolla on economics by substituting soybean meal with azolla meal at 0% (control), 4%, 8% and 12% concentration, respectively in broiler chickens. They reported higher gross and net returns in treatments having azolla meal in diet as compared to control. Verma *et al*., (2024) also conducted an experiment to study the effect of inclusion of azolla on performance and economics in Japanese quail and reported increase in net profit from sale per bird from T1 (5%) and T2 (10%) group compared to T0 (0%) group.

Conclusion

It was concluded that the partial replacement of dietary protein with Azolla pinnata at 5% level in maize soybean-based diet is beneficial for better performance and economics in Japanese quail production.

Conflict of interests: The authors declare that the research was conducted in the absence of any potential conflict of interest

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