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Effect of feeding *Azolla pinnata* on the growth and performance of broiler chicks

Mangesh Kumar, RK Dhuria, Dinesh Jain, T Sharma, Rajesh Nehra and UK Prajapat

Abstract
A feeding trial was carried out to determine the effect of Azolla supplementation on performance of broiler chicks. Maize-soybean based poultry feed was substitute with Azolla and five dietary treatment groups designated as C, T_1, T_2, T_3 and T_4 were formulated by incorporating 0.0, 2.5, 5.0, 7.5 and 10.0% levels of dried Azolla. All the rations formulated for various treatments were made iso-caloric and iso-nitrogenous. Body weight, weight gain, feed consumption, feed conversion ratio (FCR), performance index and protein efficiency ratio (PER) were measured. Azolla in diet had a significant effect on Body weight, weight gain, feed consumption, FCR, performance index and PER. Looking to the performance of broilers in terms of live body weight gain suggested that inclusion of *Azolla pinnata* up to 7.5% level is quite effective and could be a viable proposition for lucrative rearing of broilers for meat production.

Keywords: Azolla, growth, performance, PER, FCR

1. Introduction
Among Indian livestock based vocations, poultry farming occupies a special position due to its enormous potential to bring about rapid economic growth with low investment. In India, poultry industry had developed leaps and bound from a small-scale backyard venture to the status of full-fledged, modernized, agro-based industry. It is transformed into one of the most dynamic and self-sustaining sector of livestock production. It is the most profitable enterprise responsible for employment for rural peoples. The growth of poultry population is directly proportional to feed industry growth. Feed is by far the most important single factor under the environment which plays a significant role, since it accounts for more than two-thirds of total poultry production cost. Conventional protein and energy rich ingredients are nowadays not only becoming scarce but also costly. Poultry producers and nutritionists to seek the alternative non-conventional feed resources for economic consequence. Among aquatic plants floating fern *Azolla pinnata* can be used as unconventional high potential feed resource. Azolla is a little aquatic fern which flows on the water surface. Azolla have a symbiotic relationship with the nitrogen-fixing blue-green algae. The fern provides nutrients and a protective cavity in each leaf to Anabaena colonies in exchange for fixed atmospheric nitrogen and possibly other growth-promoting substances (Pillai *et al*. 2002) [1]. Incorporation of azolla as an alternative protein ingredient in poultry ration could make poultry production economical.

2. Materials Methods
2.1 Experimental site
The experiment was conducted at Poultry Farm and Department of Animal Nutrition of College of Veterinary and Animal Science, Bikaner (Rajasthan).

2.2 Experimental design
One hundred and Fifty day-old, unsexed, apparently healthy broiler chicks individually weighed and randomly divided into five groups of 30 chicks each having almost similar average body weight. Each group of 30 chicks was further subdivided into three replicates having 10 chicks each. Identical to standard management practices were followed for each group. Five dietary treatment groups designated as C, T_1, T_2, T_3 and T_4 were formulated by incorporating 0.0, 2.5, 5.0, 7.5 and 10.0% levels of dried Azolla, respectively.

2.3 Azolla Meal Preparation

The Azolla had been cultivated at Livestock Feed Resource Management and Training Center, Rajasthan University of Veterinary and Animal Sciences, Bikaner was dried and included in the broiler ration. Several methods of Azolla production had been explored in the institute *i.e.* in grounded pits, Azolla beds. Azolla is harvested and washed to remove the extraneous material and dried under shade for 3 to 5 days. The dried leaves were then milled and used as feed ingredient. Chemical composition of the azolla was analyzed and is presented in Table 1.

Table 1: Chemical composition of the azolla

Constituents	% DM
Dry matter (DM)	91.78
Organic matter (OM)	74.50
Crude protein (CP)	22.25
Crude fiber (CF)	11.19
Ether extract (EE)	2.45
Nitrogen free extract (NFE)	38.61
Total ash (TA)	25.50
Acid insoluble ash (AIA).	7.94

2.4 Ration Formulation

As Azolla contain a higher content of protein; parts of soybean meal and maize were replaced with graded level of Azolla incorporation in the diet. Proximate composition of feed ingredients is presented in Table 2. The crude protein content of starter and finisher ration was 22 percent and 19 percent, respectively. All the rations formulated for various treatments were made iso-caloric and iso-nitrogenous. The nutrient compositions of experimental starter and finisher rations have been presented in Table 3.

Table 2: Proximate composition of feed ingredients (% DM basis)

Ingredients	DM	CP	CF	EE	NFE	TA
Maize	91.00	10.00	3.17	2.78	79.38	4.67
Soya meal	90.40	43.80	10.50	1.00	39.84	4.86
Azolla	91.78	22.25	11.19	2.45	38.61	25.50
Premix	95.15	40.12	5.00	5.74	12.71	36.43

*Premix contained (g/100g): Lysine-2.85g, DL-Methionine-2.12g, Cystine-0.65g, Calcium-9.20g, Phosphorus-4g, Chloride-2.30g, Sodium-1.30g.

Table 3: Ingredient composition of experimental ration (kg/100kg feed)

Ingredients	C	T_1	T_2	T_3	T_4
	Starter ration (0-3 weeks)				
Maize	63.00	61.40	59.80	58.18	56.59
Soyabean meal	27.00	26.10	25.20	24.32	23.41
Azolla	-	2.50	5.00	7.50	10.00
Premix*	10.00	10.00	10.00	10.00	10.00
Soya Oil	-	-	-	-	-
	Finisher ration (4-6 week)				
Maize	70.03	68.23	66.40	64.74	63.00
Soya bean meal	18.94	18.24	17.57	16.84	16.13
Azolla	-	2.50	5.00	7.50	10.00
Premix*	10.00	10.00	10.00	10.00	10.00
Soya Oil	1.03	1.03	1.03	0.92	0.87

*Premix contained (g/100g): Lysine-2.85g, DL-Methionine-2.12g, Cystine-0.65g, Calcium-9.20g, Phosphorus-4g, Chloride-2.30g, Sodium-1.30g.

2.5 Data collection

a) Body weight (g)

The chicks were weighed individually at the start of the experiment and subsequently at weekly intervals for 6 weeks.

b) Body weight gain (g)

The weekly average live weight gain was calculated from the difference in body weight attained at the end and the start of the concerned period.

c) Average daily body weight gain (ADG)

ADG in grams will be estimated by dividing the total body weight gain by number of days.

d) Feed consumption (g)

Feed consumption of each pen as recorded weekly and average feed intake in gram/chick/week was calculated by dividing the total amount of feed by the number of chicks in the particular pen. Cumulative feed consumption for the experimental period was also recorded.

e) Feed conversion ratio (FCR)

Feed conversion ratio (FCR) was calculated by dividing the cumulative feed intake by body weight gain of chicks for every week.

f) Performance index (PI)

Considering the feed efficiency as well as the growth rate, a performance index was obtained for each treatment by dividing the average weight gained by the feed conversion ratio.

$$\text{Performance index (PI)} = \frac{\text{Body weight gain (g)}}{\text{Feed conversion ratio}}$$

g) Protein efficiency ratio (PER)

The protein efficiency ratio (PER) was calculated as:

$$\text{Protein efficiency ratio (PI)} = \frac{\text{Body weight gain (g)}}{\text{Protein consumed (g)}}$$

3. Result

3.1 Body weight

The weekly average body weights, for the broiler in the five groups, are presented in Table-1 as well as in figure 1. Body weights in any week, except the I week and VI week, did not differ significantly between groups. Body weight at I week and VI week differ significantly. At I week the treatment groups have significantly higher body weight over control. At VI week T_2, T_3 and T_4 group have significantly higher body weight than control but there was no significant difference observed between control and T_1. Body weight of T_2, T_3 and T_4, and T_1 and T_4 are comparable with each other at VI week of age. These results of mean body weight recorded in study in text corroborate well with the result of Dhumal *et al*. (2009) reported that supplementation of azolla at 2.5% and 5% level in broiler feed improve of body weight with high numeric value of body weight at 5% level.

Table 1: Effect of feeding Azolla (*Azolla pinnata*) on body weight (g) at different weeks

Main effects	Periods (weeks)						
	0	I	II	III	IV	V	VI
C	39.37	142.80[a]	353.47	662.50	1091.83	1583.60	2072.66[a]
T_1	39.80	153.87[b]	358.73	657.17	1093.67	1592.57	2115.16[ab]
T_2	39.90	150.70[b]	355.63	681.67	1126.83	1645.40	2213.00[c]
T_3	39.93	149.60[b]	357.20	674.17	1118.33	1651.77	2222.00[c]
T_4	39.00	154.50[b]	361.23	669.50	1107.50	1601.93	2171.67[bc]
SEM	0.9630	5.7319	13.8604	28.1277	47.0237	59.2142	67.6958
Significance	NS	S**	NS	NS	NS	NS	S**

a, b, c - Means superscripted with different letters within a column differ significantly from each other. SEM: Standard error of means; NS: Non significant; S**: Highly significant (P<0.01); S*: Significant (P<0.05)

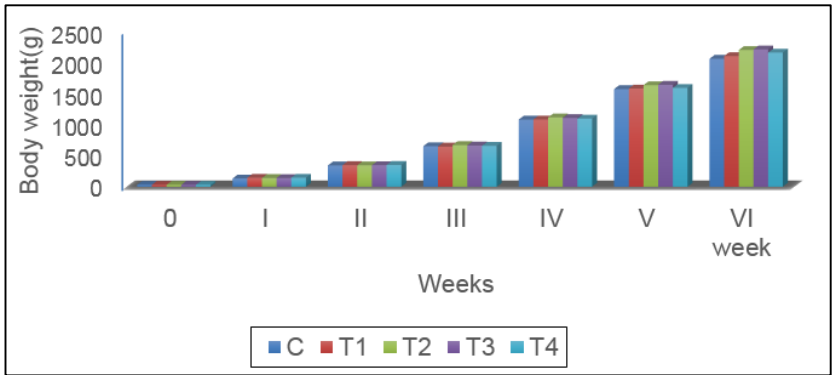

Fig 1: Effect of feeding Azolla pinnata on body weight at different weeks

3.2 Body weight gain

The weekly gain in weight is presented in Table-2 as well as in figure 2. The weekly gain in body weight was non-significant at II, III, IV and V week but differ significantly at first and last week. At I week of age the treatment group have body weight gain comparable with each other but significantly higher than control except T_3 which have non-significant difference from control. Weekly gain in body weight at VI week was higher in T_2, T_3 and T_4 which was comparable with each other but higher than C and T_1. On observing overall body weight gain, highest body weight gain was recorded in T_3 which was though comparable with T_2 and T_4 but significantly higher than C and T_1. C had lowest body weight gain. Basak *et al*. (2002) [3] observed highly significant improvement in live body weight of broiler chicks fed diet with 5 per cent Azolla meal. While diet containing AZM at higher levels (10%) resulted in significant reduction in body weight gain.

Table 2: Effect of feeding Azolla (*Azolla pinnata*) on body weight gain (g) at different weeks

Main effects	Periods (weeks)						
	0-I	I-II	II-III	III-IV	IV-V	V-VI	I-VI
C	103.43[a]	210.67	309.03	429.33	491.77	489.07[a]	2033.30[a]
T_1	114.07[b]	204.87	298.43	436.50	498.90	522.60[a]	2075.37[ab]
T_2	110.80[b]	204.93	326.03	445.17	518.57	567.60[b]	2173.10[c]
T_3	109.67[ab]	207.60	316.96	444.17	533.43	570.23[b]	2182.07[c]
T_4	115.50[b]	206.73	308.27	438.00	494.43	569.73[b]	2132.67[bc]
SEM	5.7351	10.9975	19.0560	25.9500	29.4567	29.8792	67.6171
Significance	S**	NS	NS	NS	NS	S**	S**

a, b, c - Means superscripted with different letters within a column differ significantly from each other. SEM: Standard error of means; NS: Non significant; S**: Highly significant (P<0.01); S*: Significant (P<0.05)

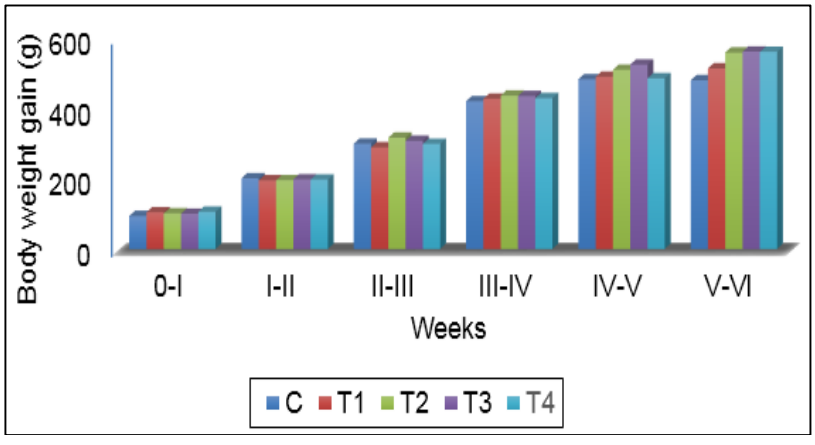

Fig 2: Effect of feeding *Azolla pinnata* on body weight gain at different weeks

3.3 Average daily body weight gain

The average daily gain in weight is presented in Table-3 as well as in figure 3. The average daily gain in body weight was non-significant at II, III, IV and V week but differ significantly at first and last week. At I week T_4 had significantly higher average daily gain in weight than control which was comparable with rest of the treatments. At VI week significantly higher average daily gain in weight was observed in treatments groups than control except T_1 which was comparable with control. On observing overall average daily body weight gain, highest average daily body weight gain was recorded in T_3 though statistically comparable with T_2 and T_4 but was significantly ($P<0.01$) higher then Control and T_1.

Table 3: Effect of feeding Azolla (*Azolla pinnata*) on average daily body weight gain (g) at different weeks

Main effects	Periods (weeks)						
	0-I	I-II	II-III	III-IV	IV-V	V-VI	I-VI
C	14.78^{a}	30.10	44.15	61.33	70.25	69.87^{a}	283.33^{a}
T_1	15.58^{ab}	29.98	42.63	62.36	71.27	74.66^{ab}	296.48^{b}
T_2	15.83^{ab}	29.27	46.58	63.60	74.08	81.09^{b}	310.44^{c}
T_3	15.67^{ab}	29.66	45.28	63.45	76.20	81.46^{b}	311.72^{c}
T_4	16.50^{b}	29.53	44.04	62.57	70.63	81.39^{b}	304. 67^{bc}
SEM	0.2570	0.37857	0.6891	0.84314	1.12085	1.58109	2.25127
Significance	S*	NS	NS	NS	NS	S**	S**

a, b, c - Means superscripted with different letters within a column differ significantly from each other. SEM: Standard error of means; NS: Non significant; S**: Highly significant ($P<0.01$); S*: Significant ($P<0.05$)

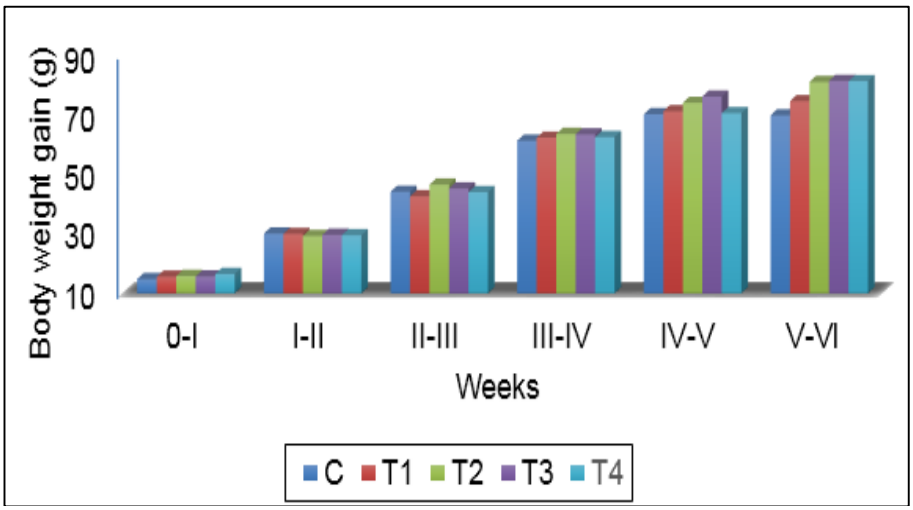

Fig 3: Effect of feeding *Azolla pinnata* on average daily body weight gain at different weeks

3.4 Feed consumption

The weekly feed consumptions, for the birds in the five groups, are presented in Table-4 as well as in figure 4. Highly significant effect on feed consumption was observed at all ages of the experimental period. At I, II and IV week, lowest feed consumption was recorded in T_4 while at III and VI week, and V week it was lowest in T_1 and T_2 group respectively. In control highest feed consumption was recorded in II and V week. At I week, III week and IV highest feed consumption was recorded in T_3, T_4 and T_1 group respectively. The overall feed consumption from day one to end of experiment was the highest in T_3 followed by T_4, C, T_2 and lowest in T_1. The results obtained in study in text corroborate well with the findings of Alalade *et al.* (2007) recorded decreases in feed intake up to 5% level but increase in feed intake on inclusion of Azolla at 7.5% level in the diet of broiler chicks.

Table 4: Effect of feeding Azolla (*Azolla pinnata*) on feed consumption (g) at different weeks

	Periods (week)						
Main effects	0-I	I-II	II-III	III-IV	IV-V	V-VI	I-VI
C	135.65^{d}	304.62^{e}	453.03^{d}	719.61^{b}	1057.15^{e}	1063.96^{b}	3734.02^{c}
T_1	132.83^{c}	292.65^{b}	418.53^{a}	745.91^{d}	951.62^{b}	1034.79^{a}	3576.33^{a}
T_2	127.35^{b}	295.69^{c}	450.30^{b}	720.13^{b}	816.78^{a}	1224.31^{d}	3634.56^{b}
T_3	140.03^{e}	299.31^{d}	450.90^{c}	740.30^{c}	1050.43^{d}	1220.00^{c}	3900.98^{e}
T_4	126.55^{a}	292.15^{a}	471.97^{e}	699.86^{a}	1030.33^{c}	1230.43^{e}	3851.30^{d}
SEM	0.0682	0.0679	0.1113	0.17432	0.164118	0.13374	0.18878
Significance	S**	S**	S**	S**	S**	S**	S**

a, b, c, d, e - Means superscripted with different letters within a column differ significantly from each other. SEM: Standard error of means; NS: Non significant; S**: Highly significant ($P<0.01$); S*: Significant ($P<0.05$)

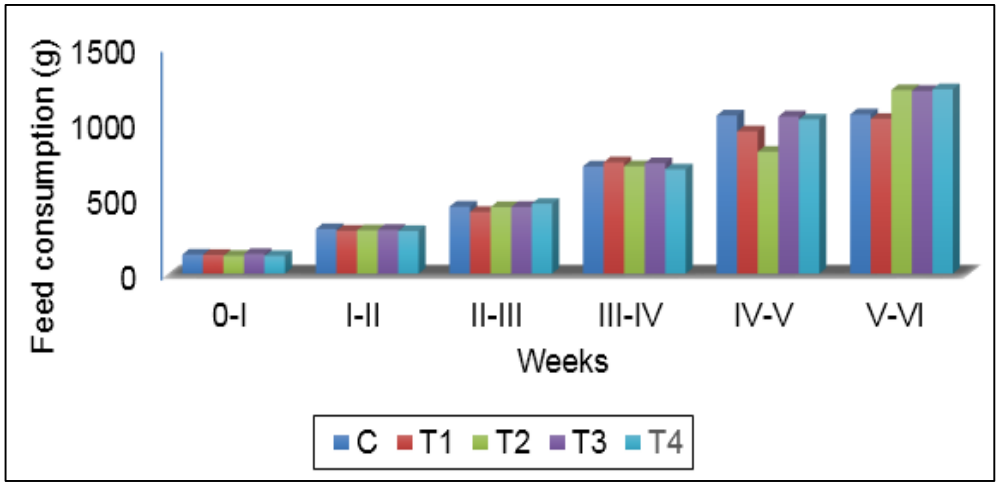

Fig 4: Effect of feeding Azolla pinnata on feed consumption at different weeks

3.5 Feed conversion ratio (FCR)

Feed conversion ratios obtained in different treatments are shown in Table 5 as well as in figure 5. There was significant ($P<0.01$) difference between the groups in I, III and V weeks. At I week significantly lower and better FCR was recorded in treatment groups than control group. At III week lowest FCR was observed in T_2 which was significantly lower than T_4 but comparable with other treatment groups and control. At V week significantly lower FCR was reported in T_2, FCR of control was higher than other treatment groups but comparable with T_4. On observing overall FCR from day one to end of experiment lowest FCR was recorded in T_2 which was though comparable with T1 but significantly lower than C, T_3 and T_4. C had highest FCR which had no-significant differences from T_3 and T_4. The result obtained in present study fall in line with the findings of Basak *et al*. (2002) [3] Naghshi *et al*. (2014), Saikia *et al*. (2014) recorded improvement in FCR with inclusion of Azolla as feed supplement in the diet of broilers.

Table 5: Effect of feeding Azolla (*Azolla pinnata*) on feed conversion ratio (FCR) at different weeks

Main effects	Periods (week)						
	I	II	III	IV	V	VI	I-VI
C	1.31^{d}	1.45	1.47^{ab}	1.68	2.15^{d}	2.19	1.84^{b}
T_1	1.16^{b}	1.43	1.40^{a}	1.71	1.91^{b}	1.98	1.72^{a}
T_2	1.15^{b}	1.44	1.38^{a}	1.62	1.58^{a}	2.16	1.67^{a}
T_3	1.28^{c}	1.44	1.42^{a}	1.67	1.97^{bc}	2.14	1.79^{b}
T_4	1.09^{a}	1.41	1.53^{b}	1.60	2.08^{cd}	2.16	1.81^{b}
SEM	0.0061	0.01944	0.0228	0.02305	0.02967	0.04566	0.01331
Significance	S**	NS	S**	NS	S**	NS	S**

a, *b* - Means superscripted with different letters within a column differ significantly from each other. SEM: Standard error of means; NS: Non significant; S**: Highly significant ($P<0.01$); S*: Significant ($P<0.05$)

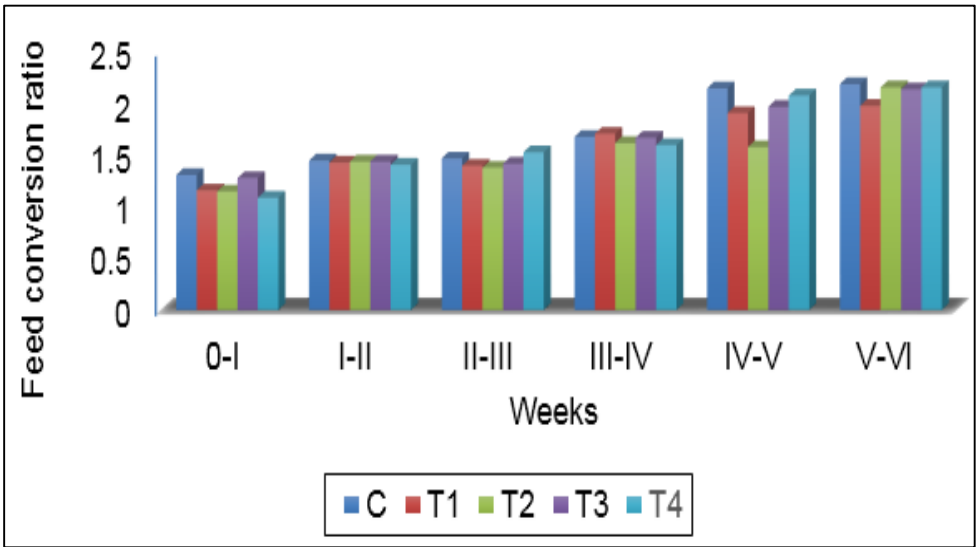

Fig 5: Effect of feeding *Azolla pinnata* on feed conversion ratio at different weeks

3.6 Performance index (PI)

Performance index obtained in different treatments are shown in Table 6 as well as in figure 6. Performance index for different groups showed significant differences at I and V weeks. Highest and lowest performance index was reported in T_4 and control group respectively. At V week highest

performance index was reported in T_2 group, lowest performance was obtained in control group which was comparable with T_1 and T_4 treatment groups. The overall mean performance index calculated for all the treatment groups for entire period of six weeks highest performance index was recorded in T_2 followed by T_3, T_1 and T_4 exhibited statistically comparable mean values but lower than T_2. C group had lowest performance index which was comparable to T_4 but lower than T_1, T_2 and T_3.

Table 6: Effect of feeding Azolla (*Azolla pinnata*) on performance index at different weeks

Main effects	Periods (weeks)						
	I	II	III	IV	V	VI	I-VI
C	78.87^{a}	145.70	211.35	256.26	228.96^{a}	226.09	1107.66^{a}
T_1	97.96^{c}	143.43	213.04	255.70	261.70^{ab}	264.01	1204.41^{b}
T_2	96.41^{c}	142.15	236.08	275.24	329.66^{c}	263.31	1299.62^{c}
T_3	85.91^{b}	144.06	222.84	266.70	270.92^{b}	266.61	1220.62^{b}
T_4	105.42^{d}	146.50	201.61	274.14	237.42^{ab}	263.83	1181.24^{ab}
SEM	0.9281	3.9878	6.5891	7.0524	8.5795	10.472	17.813
Significance	S**	NS	NS	NS	S**	NS	S**

a, b, c - Means superscripted with different letters within a column differ significantly from each other. SEM: Standard error of means; NS: Non significant; S**: Highly significant (P<0.01); S*: Significant (P<0.05)

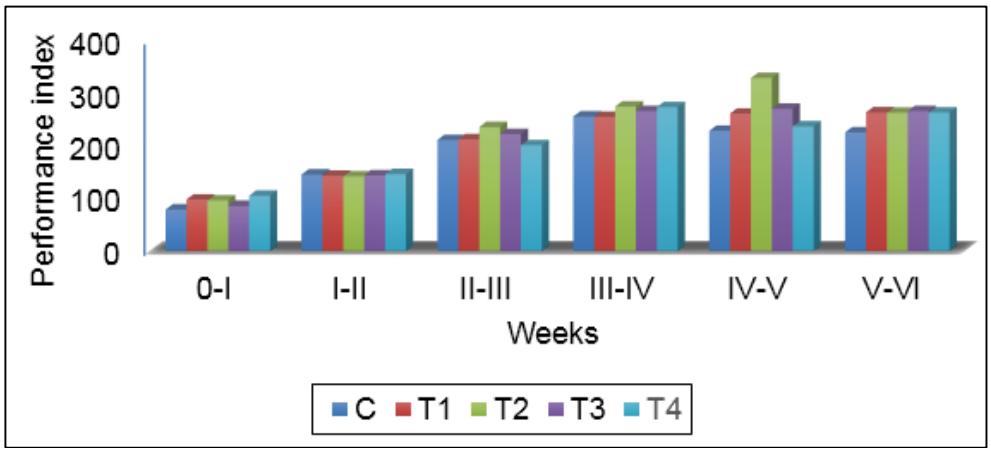

Fig 6: Effect of feeding *Azolla pinnata* on performance index at different weeks

3.7 Protein efficiency ratio (PER)

Protein efficiency ratios obtained in different treatments are shown in Table 7 as well as in figure 7. PER in any week, except the II week and VI week, differ significantly between groups. Highly significant (P<0.01) effect for I and V weeks and significant effect (P<0.05) for III and IV weeks was recorded. At I week highest and lowest PER was obtained in T_4 and control group respectively. At III week highest PER was recorded in T_2 group which was comparable with T_1 and T_3 but higher than T_4 and control. At IV week it was highest in T_4 group which was comparable with T_2 and T_3 but higher than T1 and control. At V week PER was lowest in control which was at par with T_4 group whereas it was highest in T_2 group. On observing mean values highest PER was recorded for T_2 which had no-significant differences from C and T_3 but higher than T_1 and T_4 exhibited non-significant differences from each other. C i.e. control group had Lowest PER. These results obtained in study in text corroborate well with the findings of Basak *et al*., (2002) [3] also recorded significant effect on PER due to incorporation of Azolla in the diet of broilers and recorded highest PER at 5% level of inclusion of Azolla in broiler diet.

Table 7: Effect of feeding Azolla (*Azolla pinnata*) on protein efficiency ratio at different weeks

Main effects	Periods (weeks)						
	I	II	III	IV	V	VI	I-VI
C	3.79^{a}	3.44	3.39^{a}	3.41^{a}	2.66^{a}	2.63	2.93^{b}
T_1	4.30^{c}	3.50	3.57^{ab}	3.36^{a}	3.01^{c}	2.90	3.22^{a}
T_2	4.38^{c}	3.49	3.65^{b}	3.56^{ab}	3.65^{d}	2.67	3.33^{b}
T_3	3.97^{b}	3.51	3.56^{ab}	3.47^{ab}	2.93^{bc}	2.70	3.13^{b}
T_4	4.65^{d}	3.61	3.33^{a}	3.63^{b}	2.78^{ab}	2.68	3.11^{a}
SEM	0.0206	0.0489	0.0532	0.04903	0.0582	0.1397	0.0206
Significance	S**	NS	S*	S*	S**	NS	S**

a, b - Means superscripted with different letters within a column differ significantly from each other. SEM: Standard error of means; NS: Non significant; S**: Highly significant (P<0.01); S*: Significant (P<0.05)S*: Significant (P<0.05)

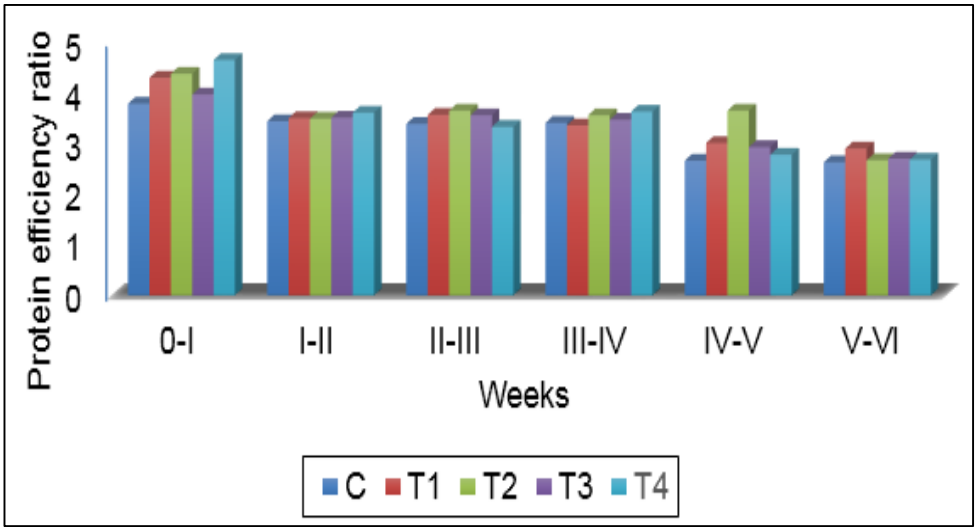

Fig 7: Effect of feeding *Azolla pinnata* on protein efficiency ratio at different weeks

3.8 Survivability

None of the birds died in any treatments during the experimental period. The present study indicated that the inclusion of AZM up to 10 per cent in broiler diets has no influence on livability of birds. The results are similar with Basak *et al*. (2002) [3] Parthasarathy *et al*. (2002), Balaji *et al*. (2009) and Dhumal *et al.* (2009) [2] who also found no toxic effect of dietary azolla**.**

4. Conclusion

The optimum performance, feed and protein utilization of broiler chicks is observed at the 5% inclusion level of *Azolla pinnata* however on looking to the performance of broilers i.e. growth parameters and ultimately production in terms of live body weight gain suggested that inclusion of *Azolla pinnata* up to 7.5% level is quite effective and could be a viable proposition for profitable rearing of broilers for meat production.

5. Acknowledgement

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6. References

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