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Effects of Duckweed Meal Supplementation in Un-processed and Extruded Diets on Performance and Economics of Broilers

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ABSTRACT

A study was conducted for nutritional evaluation of duckweed meal (DWM) as an alternate protein source in broilers. DWM supplemented in un-processed and extruded diets and performance of broilers was observed. 256 IBL-80, day old commercial broiler chicks were randomly distributed into eight treatments with, four replicates each. The treatments were divided into two dietary groups: Un-processed dietary group and Extruded dietary group. Both groups were having 4 treatments. Each replicate was housing eight birds (8×4×8). Treatment T1 in both groups served as control treatment with 0% DWM, treatment T2, T3 and T4 were supplemented with 2, 4 and 6 % DWM. In both dietary groups significant differences for feed conversion ratio (FCR) was observed only during starter phase. In un-processed dietary group best FCR, protein efficiency ratio (PER) and calorie efficiency ratio (CER) was observed for 2% duckweed meal supplemented group whereas in extrusion processed dietary group the best FCR, PER and CER was observed for 4% duckweed treatment. The results indicated that duckweed meal can be safely included in the broiler ration at 2 % level without treatment and at 4% level if used in extruded form.

KEYWORDS: Calorie Efficiency Ratio, Duckweed meal, Feed Conversion Ratio, Protein Efficiency Ratio.

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INTRODUCTION

Due to rapidly growing population, increasing incomes and urbanization, the demand for animal products in India is constantly rising. Poultry sector along with livestock provide a major contribution to India's economy (Nath et al., 2012) and has a scope for quick and large profit. Mehta et al. (2003) reported that the production of agricultural crops has been growing at a rate of 1.5–2% per annum, however, that of eggs and broilers has been growing at a rate of 8–10% per annum. The shortest incubation period in harvesting the benefits and its ability to adopt in all the climates provide superiority over the other ventures. India stands 3rd in egg production and 5th in broiler production in the world with annual production of 88 billion eggs and 3.46 million tonnes broiler meat (DADF, 2018). The present per capita availability of eggs and meat is 69 and 2.5 kg per annum, respectively, is lesser than the recommendation of the nutritional advisory committee, ICMR, i.e. 180 eggs and 10.8 kg poultry meat per annum (BAHS 2017). Poultry meat is often chosen over other meat products because it is considered more hygienic, has no religious issues and is accessible all year across the country at a much lower cost than fish/mutton. Chickens represent for more than 90% of the country's overall poultry population. Broiler and layer segments make up around 65.3 and 34.7 % of the poultry industry, respectively, with monthly turnovers of 400 million chicks and 8,400 million eggs. (ICRA, 2020). Under intensive system of poultry farming, nearly 60-65%

of recurring expenditure goes for the feed itself. The availability of quality feed at a reasonable cost is a key to successful poultry operation. For sustainability of the venture, it is necessary that the resources are available locally and competition with human food should be minimal. But in rapidly developing countries like India, which are overpopulated a stiff competition exists for different feed ingredients that are common for human and livestock nutrition. In this context, one of the alternative, un-conventional and cheap source of protein that can be used in poultry nutrition is Duckweed. Duckweed is a small, monocotyledon vascular free-floating aquatic plant that belongs to the family *Lemnacea*. Duckweed morphologically is simple and it lacks specialized structures like leaves and stems. It is adapted to a wide range of ecological circumstances, allowing it to be found all over the world. There are four genera of duckweed namely *Lemna, Spirodela, Wolffia* and *Wolfiella*. Among these genera, spirodela has the potential to be a novel feed component that may be effectively employed as a protein source in broiler diet.

Nowadays different feed processing processes are employed to increase the nutritional content of the components and feed and to increase the profitability of farmers. Different feed processing procedures have different effects on parent feed. Feed processing procedures could have both positive and negative effect on digestibility and performance of animal which could affect the profitability of production. One such feed processing technique in extrusion cooking. In extrusion cooking the parent feed is exposed to high temperature and high pressure.

MATERIALS AND METHODS

To study the above mentioned objectives, an experiment was conducted in poultry farm of Department of Animal Nutrition, GADVASU, Ludhiana using total of 256 IBL-80, day old broiler chicks, which were procured from GADVAU hatchery. On day one chicks were grouped on the basis of their weight and were randomly distributed into eight treatments. These eight treatments were then divided into two dietary groups: - un-processed dietary group and extruded dietary group. Chicks of un-processed dietary group were given raw mash diet and those of extrusion processed dietary group were given extrusion cooked diets. Both dietary groups contained four treatments, containing graded levels of duckweed meal (0%, 2%, 4% and 6%). T1 of both groups served as control diet, T2 contained 2% DWM, T3 contained 4% DWM and T4 contained 6% DWM. The various experimental diets of starter, grower and finisher phase were prepared according to nutritional requirements of ICAR (2013).Birds of each replicate of experimental treatment were offered pre -weighed amount of feed two times a day. The amount of residue left was collected and weighed on weekly basis to calculate actual feed intake and nutrient utilization by birds. The average intake of feed for birds of different replicates and different treatments was then calculated by subtracting the residue left from the total feed offered and then the actual feed intake was divided by the number of broiler birds to determine the actual feed intake of an individual bird. All the chicks were weighed after every week to record their weight gain.

T1 (0% duckweed)
T2 (2% duckweed) } Un-processed diets
T3 (4% duckweed)
T4 (6% duckweed)

T1 (0% duckweed)
T2 (2% duckweed) } Extruded diets
T3 (4% duckweed)
T4 (6% duckweed)

Nutritional profile of feed ingredients

Duckweed was collected from ponds of college of Fisheries, GADVASU and was then sundried for

7 days in Department of Animal Nutrition. The dried duckweed was then ground before incorporating it at different levels in different dietary treatments. Duckweed and all the feed ingredients required for formulation of experimental diets (Maize, ground nut extract, Soybean meal, duckweed meal, Di-calcium Phosphate and Lime Stone Powder) were analyzed for various proximate principles such as Crude Protein, Ether Extract, Crude Fibre, Total Ash and Acid Insoluble Ash, phosphorus (AOAC 2005) and calcium (Talpatra et al., 1940) content.

All eight iso-caloric and iso-nitrogenous experimental diets containing graded levels of duckweed meal prepared for feeding chicks at different phases were analyzed for various proximate principles, calcium (Talpatra et al., 1940) and phosphorus (AOAC 2005) content.

Calculations

Feed Conversion Ratio (FCR) of birds in different phases of growth was computed as grams of total amount of feed consumed by bird per grams of increase in body weight of that particular bird. It's calculated on growth phase basis and week basis. Mortality, if any is also taken into account. Protein efficiency ratio is parameter that describes efficiency by which protein utilization occurs in birds. It is determined as grams of increase in body weight per gram of protein utilized by birds. Calorie Efficiency Ratio is parameter that describes efficiency by which calorie utilization occurs in birds. It is determined as grams of increase in body weight per kilo calories consumed.

Statistical Analysis

Numerical data obtained from different observations and chemical assessments was analyzed with a social science software tool (SPSS Version 24.0). The significant variance between different treatments (Pd 0.05) was determined using Duncan's Multiple Ranged Test at a 5% level.

RESULTS AND DISCUSSION

Eight treatments under two dietary groups were designed in present study. The results for Feed Conversion ratio, Calorie Efficiency Ratio, Protein Efficiency Ratio and Economics are discussed below.

Feed Conversion Ratio (FCR)

During starter phase (0-14 days), the feed conversion ratio of birds given un-processed diet supplemented with 2% duckweed was significantly (Pd 0.05) lower than the birds fed with diet supplemented with 6% duckweed. FCR of control treatment was numerically lower than that of 4% supplemented treatment. During grower phase (15-21 days),finisher phase (22-42 days) and over all phase (0-42 days) non-significant effect were seen on feed conversion ratio of birds due to supplementation of duckweed meal at different levels in un processed diets. During grower and finisher phase FCR was numerically lowest for 6% duckweed treatment and during overall phase numerically lowest FCR was observed for 2% duckweed treatment (Table 1).

Supplementation of duckweed meal at different levels (0%, 2%, 4%, and 6%) in extrusion processed diets of commercial broiler chicks during starter phase (0-14 days), grower phase (15-21 days),finisher phase (22-42 days) and over all phase (0-42 days) had non-significant effects on Feed Conversion Ratio (FCR) of birds. During starter phase FCR was numerically lowest for 6% duckweed treatment. But during grower phase, finisher phase and overall phase numerically lowest FCR in was observed for 4% duckweed treatment (Table 1).

Table 1.Effect of graded levels of Duckweed meal supplementation in un-processed diets and extruded diets on Feed Conversion Ratio

		Treatment				SEM	P-value
		T 1	T 2	T 3	T4		
Starter phase	Un-processed	2.43^{ab}	2.15^{a}	2.49^{ab}	2.72^{b}	0.068	0.034
(1-14 days)	Extruded	3.56	3.9	3.8	3.28	0.088	0.066
Grower phase	Un-processed	1.86	1.96	2.34	1.17	0.12	0.292
(15-21 days)	Extruded	2.26	2.15	2.12	2.15	0.052	0.78
Finisher phase	Un-processed	5.25	4.67	4.79	4.55	0.19	0.605
(22-42 days)	Extruded	4.58	4.68	4.44	4.54	0.086	0.82
Overall phase	Un-processed	2.97	2.72	3.06	2.83	0.081	0.464
(1-42 days)	Extruded	3.24	3.23	3.04	3.15	0.053	0.53

*Means with different superscripts in a column differ significantly (Pd”0.05)

FCR of birds during starter phase was significantly (Pd”0.05) highest for 6% duckweed group as compared to other groups. No significant differences were observed for FCR between different treatments during grower, finisher and overall phases (Table 2).

Table 2. Effect of graded levels of Duckweed meal supplementation on Feed Conversion Ratio, irrespective of feed processing (un-processed or extruded diets)

	Treatment				SEM	P-value
	0% DWM	2% DWM	4% DWM	6% DWM		
Starter phase (1-14 days)	2.99^{a}	3.00^{a}	3.03^{a}	3.15^{b}	0.23	0.988
Grower phase (15-21 days)	1.93	2.05	2.06	2.23	0.13	0.566
Finisher phase (22-42 days)	4.55	4.62	4.67	4.92	0.088	0.589
Overall phase (1-42 days)	2.97	2.99	3.05	3.11	0.06	0.937

*Means with different superscripts in a column differ significantly (Pd”0.05)

During starter and grower phase FCR of birds who were fed un-processed diet was significantly (Pd 0.05) lower than that of birds that were fed extruded diet. During grower, finisher and overall phase no significant difference was observed for birds of two groups. During overall phase FCR of birds who were fed Extruded diets was significantly (Pd 0.05) higher than birds that were fed of un-processed diets (Table 3).

Table 3. Effect of feed processing (Un-processed or extruded diets) on Feed Conversion Ratio (FCR), irrespective of graded levels of duckweed meal supplementation

	Diet		SEM	P- value
	Un-processed	Extruded		
Starter phase (1-14 days)	2.452[a]	3.639[b]	0.24	0.01
Grower phase (15-21 days)	1.968	2.177	0.13	0.13
Finisher phase (22-42 days)	4.820	4.564	0.088	0.088
Overall phase (1-42 days)	2.895[a]	3.170[b]	0.065	0.065

*Means with different superscripts in a column differ significantly (Pd"0.05)

Protein Efficiency Ratio

The results of our experiment revealed that during starter phase (0-14 days) protein efficiency ratio of broiler birds was significantly (Pd"0.05) higher for 2% duckweed supplementation group as compared to 6% duckweed treatment. PER of control and 4% duckweed treatment was exactly similar to each other. No significant difference was seen for PER of commercial broiler chicks between various treatment groups containing different levels of duckweed during grower phase (15-21 days),finisher phase (22-42 days) and over all phase (0-42 days). During grower phase numerically lowest PER was seen for 4% duckweed treatment and numerically highest for 6% duckweed treatment. During finishing and overall phases numerically lowest PER was seen for control treatment and numerically highest for 2% duckweed treatment(Table 4).

The results of our experiment revealed that during starter phase (0-14 days) protein efficiency ratio (PER) of broiler birds was significantly (Pd"0.05) higher for 6% duckweed supplementation group as compared to 2% and 4% duckweed treatment. No significant differences were observed for PER of commercial broiler chicks between various treatment groups containing different levels of duckweed during grower phase (15-21 days), finisher phase (22-42 days) and over all phase (0-42 days) (Table 4).

Table 4. Effect of graded levels of Duckweed meal supplementation in un-processed diets and extruded diets on Protein Efficiency Ratio

		Treatment				SEM	P-value
		T 1	T 2	T 3	T4		
Starter phase (1-14 days)	Un-processed	1.98[ab]	2.18[b]	1.98[ab]	1.77[a]	0.039	0.003
	Extruded	1.35[ab]	1.21[a]	1.25[a]	1.50[b]	0.028	0.001
Grower phase (15-21 days)	Un-processed	2.56	2.57	2.49	2.80	0.048	0.13
	Extruded	2.19	2.23	2.30	2.31	0.044	0.75
Finisher phase (22-42 days)	Un-processed	1.13	1.17	1.17	1.16	0.024	0.93
	Extruded	1.18	1.14	1.17	1.18	0.021	0.89
Overall phase (1-42 days)	Un-processed	1.72	1.87	1.79	1.79	0.028	0.31
	Extruded	1.59	1.56	1.65	1.64	0.023	0.53

*Means with different superscripts in a column differ significantly (Pd"0.05)

No significant differences were found for PER of birds that were fed diets containing different levels of duckweed. During grower, finisher and overall phase PER of birds of duckweed supplemented treatments was numerically higher than that of control treatment (Table 5).

Table 5. Effect of graded levels of Duckweed meal supplementation on Protein Efficiency Ratio, irrespective of feed processing (Un-processed or extruded diets).

	Treatment					
	0% DWM	2% DWM	4% DWM	6% DWM	SEM	P-value
Starter phase (1-14 days)	1.669	1.697	1.621	1.640	0.132	0.998
Grower phase (15-21 days)	2.383	2.404	2.400	2.557	0.739	0.885
Finisher phase (22-42 days)	1.160	1.160	1.175	1.172	0.0064	0.815
Overall phase (1-42 days)	1.662	1.720	1.727	1.715	0.387	0.957

*Means with different superscripts in a column differ significantly (Pd”0.05)

During starter and grower phase of growth Protein Efficiency Ratio of birds fed un-processed diets was significantly (Pd”0.05) higher than the birds those who were fed with extruded diets. Protein Efficiency Ratio of birds of both groups was almost similar during finisher phase but during overall phase Protein Efficiency Ratio of birds of un-processed diet group was numerically more than birds of extruded diet group (Table 6).

Table 6. Effect of feed processing (Un-processed or extruded diets on Protein Efficiency Ratio, irrespective of graded levels of duckweed meal supplementation.

	Diet		SEM	P-value
	Un-processed	Extruded		
Starter phase (1-14 days)	1.982[b]	1.332[a]	0.01	0.01
Grower phase (15-21 days)	2.610[b]	2.26[a]	0.003	0.003
Finisher phase (22-42 days)	1.16	1.17	0.483	0.483
Overall phase (1-42 days)	1.796	1.615	0.603	0.603

*Means with different superscripts in a column differ significantly (Pd”0.05)

Calorie Efficiency Ratio

The results of our experiment revealed that during starter phase (0-14 days) calorie efficiency ratio (CER) of broiler birds was significantly higher for 2% duckweed supplementation treatment as compared to 6% duckweed treatment. CER of control and 4% duckweed treatment was exactly similar to each other. No significant differences were observed for CER of commercial broiler chicks between various treatments containing different levels of duckweed during grower phase (15-21 days), finisher phase (22-42 days) and over all phase (0-42 days) of experiment. During grower phase numerically highest CER was seen for 6% duckweed treatment and numerically lowest for 4% duckweed treatment. During grower phase numerically highest CER was observed for 6% duckweed treatment and numerically lowest for 4% duckweed treatment. During finisher phase numerically highest CER was observed for 4% duckweed treatment and numerically lowest for control treatment. During overall phase numerically highest CER was observed for 2% duckweed treatment and numerically lowest for control treatment (Table 7).

The results of our experiment revealed that during starter phase (0-14 days) calorie efficiency ratio (CER) of broiler birds was significantly (Pd"0.05) higher for 6% duckweed treatment as compared to 2% and 4% duckweed treatments. CER of control group was at par. But no significant differences were observed for CER of commercial broiler chicks between various treatments containing different levels of duckweed during grower phase (15-21 days),finisher phase (22-42 days) and over all phase (0-42 days). During grower phase numerically highest CER was observed for 6% duckweed treatment and numerically lowest for 4% duckweed treatment. During finisher phase numerically highest CER was observed for 6% duckweed treatment and numerically lowest for 2% duckweed treatment. During overall phase numerically highest CER was observed for 2% duckweed treatment and numerically lowest for control treatment (Table 7).

Table 7. Effect of graded levels of Duckweed meal supplementation in un-processed diets and extruded diets on Calorie Efficiency Ratio

		Treatment				SEM	P-value
		T 1	T 2	T 3	T4		
Starter phase (1-14 days)	Un-processed	0.145^{ab}	0.160^{b}	0.145^{ab}	0.130^{a}	0.003	0.003
	Extruded	0.099^{ab}	0.088^{a}	0.092^{a}	0.110^{b}	0.002	0.001
Grower phase (15-21 days)	Un-processed	0.181	0.182	0.175	0.197	0.003	0.14
	Extruded	0.155	0.157	0.162	0.163	0.003	0.75
Finisher phase (22-42 days)	Un-processed	0.0714	0.0739	0.074	0.0729	0.001	0.93
	Extruded	0.0745	0.0719	0.0738	0.0744	0.001	0.89
Overall phase (1-42 days)	Un-processed	0.112	0.122	0.117	0.116	0.002	0.30
	Extruded	1.59	1.56	1.65	1.64	0.023	0.53

*Means with different superscripts in a column differ significantly (Pd"0.05)

Although no significant effect was seen on Calorie Efficiency Ratio of birds when they were fed diets containing graded levels of duckweed during all the phases of growth. But during grower and overall phase supplementing duckweed meal in diet of birds numerically improved the Calorie Efficiency Ratio of birds as compared to that of birds of control group (Table 8).

Table 8. Effect of graded levels of Duckweed meal supplementation on Calorie Efficiency Ratio (CER), irrespective of feed processing (Un-processed or extruded diets)

	Treatment				SEM	P-value
	0% DWM	2% DWM	4% DWM	6% DWM		
Starter phase (1-14 days)	0.122	0.124	0.119	0.120	0.009	0.99
Grower phase (15-21 days)	0.168	0.169	0.169	0.180	0.005	0.89
Finisher phase (22-42 days)	0.073	0.073	0.074	0.074	0.0004	0.85
Overall phase (1-42 days)	0.109	0.113	0.113	0.112	0.0023	0.94

*Means with different superscripts in a column differ significantly (Pd"0.05)

During starter, grower and over all phases calorie efficiency ratio of birds of un-processed diet group was significantly (Pd"0.05) higher than the birds of extruded diet group. During finisher phase calorie efficiency ratio of birds of un-processed diet group was numerically higher than the birds of extruded diet group (Table 9).

Table 9. Effect of feed processing (Un-processed or extruded diets) on Calorie Efficiency Ratio (CER), irrespective of graded levels of duckweed meal supplementation

	Diet Un-processed diet	 Extruded diet	S.E.M	P-value
Starter phase (1-14 days)	0.145^{b}	0.098^{a}	0.001	0.001
Grower phase (15-21 days)	0.184^{b}	0.159^{a}	0.003	0.003
Finisher phase (22-42 days)	0.073	0.001	0.508	0.508
Overall phase (1-42 days)	0.117^{b}	0.002^{a}	0.004	0.004

*Means with different superscripts in a column differ significantly (Pd"0.05)

Economics

As the amount of duckweed kept on increasing in diets the cost of un-processed feed was reduced during all the phases of growth. Extruded feed was more expensive than un-processed feed due to addition of charges of extrusion.

Table 10. Cost of feed prepared during different phases of growth

	Cost of feed/kg		
	Starter (Rs)	Grower (Rs)	Finisher (Rs)
T1 (un-processed)	27.48	27.9	26.5
T2 (un-processed)	26.95	27.55	26.2
T3 (un-processed)	26.42	2706	25.5
T4 (un-processed)	25.88	26.58	24.91
T1 (extruded)	32.48	32.9	31.5
T2 (extruded)	31.95	32.55	31.2
T3 (extruded)	31.42	32.06	30.5
T4 (extruded)	30.88	31.58	29.91

Table 11. Cost of feed consumed by birds during different phases of growth

	Cost of feed consumed by birds			
	Starter (Rs)	Grower (Rs)	Finisher (Rs)	Overall (Rs)
T1 (un-processed)	12.83	10.68	60.68	73.51
T2 (un-processed)	12.58	12.78	62.88	88.24
T3 (un-processed)	12.62	12.90	60.69	86.22
T4 (un-processed)	12.91	11.53	60.28	84.73
T1 (extruded)	15.68	12.99	73.71	102.39
T2 (extruded)	16.10	14.77	74.56	105.44
T3 (extruded)	15.80	14.04	71.06	100.91
T4 (extruded)	15.31	14.14	72.98	102.44

When broiler birds were reared on un-processed diets best profit margin was seen on control group due to less amount of feed intake and numerically higher metabolizability of nutrients. Although final body weight achieved was more in duckweed supplemented group but feed intake of birds of those group was also higher. Higher feed intake in duckweed supplemented group could be due to specific aroma of duckweed which was appealing to broilers. The feed intake of birds that were fed extruded diets were more and weight gain was less because of less metabolizability of nutrients and due to high cost of extrusion processing.

Table 12. Cost economics of Experiment

	T1 (un-processed)	T2 (un-processed)	T3 (un-processed)	T4 (un-processed)	T1 (extruded)	T2 (extruded)	T3 (extruded)	T4 (extruded)
Total feed cost	73.51	88.24	86.22	84.73	102.39	105.44	100.91	102.44
Finisher body weight(Kg)	1.127	1.296	1.235	1.244	1.072	1.094	1.127	1.159
Selling price @75/kg	84.525	97.2	92.625	93.3	80.4	82.05	84.525	86.925
Profit /loss	11.015	8.96	6.405	8.57	-21.99	-23.39	-16.38	-15.51

CONCLUSION

During starter phase, the FCR of birds of un-processed dietary group, supplemented with 2% duckweed was significantly (Pd"0.05) lower than the birds fed with diet supplemented with 6% duckweed. During grower phase, finisher phase and over all phase non-significant effect were seen. Whereas in extrusion dietary group supplementation of duckweed meal at graded levels during starter phase, grower phase, finisher phase and over all phase had non-significant effects on FCR of birds. Protein Efficiency Ratio (PER) of chicks of un-processed dietary group was significantly (Pd"0.05) higher for 2% duckweed supplementation group as compared to 6% duckweed treatment. PER of control and 4% duckweed treatment was exactly similar to each other. No significant difference was seen for PER between various treatment groups during grower phase, finisher phase and over all phase. In extrusion processed dietary, during starter phase (0-14 days) protein efficiency ratio (PER) of broiler birds who were fed extruded diets was significantly (Pd”0.05) higher for 6% duckweed supplementation group as compared to 2% and 4% duckweed treatment.

Calorie Efficiency Ratio (CER) of chicks during starter phase of un-processed dietary group was significantly higher for 2% duckweed supplementation treatment as compared to 6% duckweed treatment. CER of control and 4% duckweed treatment was exactly similar to each other. No significant differences were observed for CER during grower phase, finisher phase and over all phase. During starter phase CER of chicks of extruded dietary group was significantly (Pd”0.05) higher for 6% duckweed treatment as compared to 2% and 4% duckweed treatments. But no significant differences were observed for CER during grower phase, finisher phase and over all phase. Rearing chicks of un-processed dietary group was profitable, whereas rearing chicks of extruded dietary group unprofitable and loss making due to high cost of extrusion cooking.

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