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Use of Duckweed (*Lemna perpusilla*) as a Protein Source Feed Item in the Diet of Semi-Scavenging Jinding Layer Ducks

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An experiment was conducted for a period of 75 days at farmers house to investigate the effect of feeding duckweed (*Lemna perpusilla*) that replaced conventional protein supplement mustard oil cake (MOC) in the diets for Jinding ducks. The experiment included a total of 84 laying ducks with four treatments and three replicates and seven ducks per replicate. The diets were based on rice by products where soybean meal and mustard oil cake as protein source. The control diet A contained 15% MOC and 5, 10 and 15% MOC was replaced with dry duckweed in diets B, C and D respectively. The birds were raised under extensive system and feeds were supplied two times daily before and after herded. The replacement of MOC by duckweed non-significantly depressed live weight gain ($P>0.05$), egg weight ($P>0.05$) and feed conversion efficiency ($P>0.05$) but significantly increased egg production ($P<0.01$) and profitability ($P<0.01$) through reducing production cost of feeding. Body weight gain and egg productivity showed a linear declining trend as the proportion of duckweed in the diet was increased. Considering economic benefit it may be recommended to replace MOC by duckweed up to 15% level in the diet of laying duck.

Key words: duckweed, egg production, jinding duck, mustard oil cake, weight gain

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Introduction

In Bangladesh ducks are generally reared in rural areas under scavenging system predominantly in the regions which are prone to seasonal inundation. The vast areas of haors, canals, bills, ponds and low-lying water reservoirs considered to be the breeding grounds for a number of biotic structures to support the duck rearing of the country. The total duck population in the country is estimated to be 33 millions (FAO, 2001), which ranked the 2nd place as the supplier of eggs and meat (Salah Uddin *et al.,* 1991). Egg production of scavenging ducks increases normally during crop harvesting season and soon decline when feed supply becomes scarce (Huque and Ukil, 1998). The potential for increasing duck production under the existing scavenging system of rearing is closely related with the development of better feeding system using locally available protein sources.

The chronic scarcity and high cost of animal protein supplements has increased interest to seek alternative protein source for feeding ducks. There are certain unconventional feed resources which can effectively be used as feed for ducks. As protein source for poultry, attempts have been made into the use of local cheap feed such as aquatic plants. Especially, duckweed which is a water plant, may supply protein as the alternative feeds. Duckweed protein has a better array of essential amino acids than most vegetable proteins and more closely resembles to animal protein (Hillaman and Culley, 1978). In addition to protein benefit, it has also been shown to be a good source of vitamin and minerals for grow-

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ing ducks (Becerra *et al.,* 1997; Men *et al.,* 2001). Duckweeds are tiny free-floating vascular plants with worldwide distribution. They are very common throughout Bangladesh and grow very well on stagnant water and low lying paddy fields without any agronomic care. Duckweed, available in natural habitats, used to be foraged by scavenging ducks. But fluctuations in availability and nutrient content often affect its potentials as duck feeding. Duckweeds are very rich in protein content (34.8%; Vangyke and Sutton, 1977 and 36.7%; Khan *et al.,* 2002a). The amino acid profile of duckweed is very similar to that of soybean (Rusoff *et al.,* 1980) and are very rich in β-carotene and xanthophyll concentration (Journey *et al.,* 1993). Dried duckweed meal contains 40% CP and can be compared with soybean meal as a source of plant protein (Porath *et al.,* 1979). Johri and Sharma (1979) reported that dried *Lemna* could be used in broiler ration at a level of 100 g/kg diet without affecting weight gain and feed efficiency.

At present in Bangladesh 90 to 95% of the ducks reared by village farmers are of Deshi (native) type, which are vary poor in egg production (Ahmed, 1986). Therefore, it is necessary to explore a suitable breed of high yielding duck for our country. Jinding is a breed of ducks originated from southeast coast of China and has recently introduced in Bangladesh. The preliminary studies showed that it is a medium sized egg laying breed having potentials to survive well and giving very good production (Zhang *et al.,* 1989). But limited information is available on the performance of their egg production in relation to feed supplement under scavenging system of rearing. The main objectives of the experiment were to determine the optimum level of duckweed as replacement of costly conventional protein source mustard oil cake in the diets for Jinding layer ducks and to evaluate the effects on egg production and economic benefits.

Materials and Methods

Collection of Duckweed

Fresh duckweed was collected from different ponds, lakes, water reservoirs, low lying stagnant water and rice field adjacent to Bangladesh Agricultural University, Mymensingh. It was collected carefully in order to avoid contamination with foreign materials like soil, other aquatic weeds, snail etc. After washing and separation of foreign particles, collected duckweed was spread on a clean smooth concrete floor for drying in the sun. Care was taken to prevent formation of lump/cake during drying and lump formed in the semidried duckweed was crumbled for easy drying. After drying, it was ground in a hammer mill stored in air tight bags for use in the experimental diet.

Experimental Design and Birds

A total of 84 Jinding ducks between 1420 and 1450 g body weight were randomly assigned to 4 dietary treatments having 3 replications of 7 ducks. Twelve key rearers were selected from two villages under Smallholder Livestock Development Project (SLDP-2) area of Noakhali District. Key rearers are the farmers who rear duck throughout the year having training on duck rearing. The selected farmers were almost similar in socio-economic status. Each farmer was given seven Jinding ducks. The experimental ducks were reared under the existing husbandry practices conventionally followed in the village.

Diets and Feeding

Four diets (A, B, C and D) were prepared (Table 1) and were randomly allocated to 3 replicates in each group. Diet A was a standard ration (2930 kcal ME and 180 g CP per kg DM) containing 15% mustard oil cake. Diets B, C and D were prepared using 5, 10 and 15% duckweed respectively in place of mustard oil cake. Diets were prepared by using available feed ingredients from local sources. The required amount of all feed ingredients was mixed and vitamin-mineral premix was added properly to the whole feed and well mixed. Details of the formulation of the compound diets and their ingredient composition are given in Table1. Diet was supplied at 140 g per duck per day and were fed two times daily (7.0 am and 4.30 pm) dividing to equal halves in the form of wet mash for a period of 75 days.

Management of Birds and Measurements

The ducks were immunized against duck cholera by vaccination. Feeders were cleaned regularly. Droppings were removed every morning and ash was spread over the floor to maintain the floor dry condition. Strict hygienic measures were maintained throughout the experimental period of 75 days. Data on daily feed consumption, fortnightly body weight gain, daily egg production, livability

Table 1. **Ingredient composition of the experimental diets**

Ingredient (kg/100 kg)	Diets			
	A	B	C	D
Maize crushed	20	20	20	20
Rice polish	30	30	30	30
Broken rice	10	10	10	10
Soybean meal	8	8	8	8
Wheat bran	10	10	10	10
Mustard oil cake	15	10	5	—
Duckweed	—	5	10	15
Oyster shell	6.25	6.25	6.25	6.25
Salt (NaCl)	0.5	0.5	0.5	0.5
Vitamin mineral premix[#]	0.25	0.25	0.25	0.25
Total	100	100	100	100

A=15% mustard oil cake based control diet.
B=10% MOC*+5% DW*.
C=5% MOC+10% DW.
D=O% MOC+15% DW.
*MOC=Mustard oil cake.
*DW=Duckweed.
[#]Per 375 g premix (Rhone Poulenc Agrovet Bangladesh Ltd.) contained: retinal acetate 594 mg, *a*-tocopherol 0.9 mg, menaquinone 600 mg, pantothenic acid 1500 mg, cyanocobalamine 1.5 mg, folic acid 75 mg, cobalt 45 mg, copper 900 mg, iron 9000 mg, iodine 90 mg, manganese 7200 mg, zinc 6000 mg, selenium 18 mg, DL-methionine 7.5 g, choline chloride 37.5 g and BHT 7.5 g.

and production cost were recorded.

Chemical Analysis

The proximate composition of feed and egg samples were determined following the methods AOAC (2000). True metabolizable energy (TME) contents of the diets were calculated from chemical analysis data using the following equation (Wiseman,1987).

True ME (Kcal/kg DM)=3951+54.4 EE−88.7 CF−40.8 Ash

Where, EE=ether extract (%)
CF=crude fiber (%)
Ash=ash (%)

Statistical Analysis

Data were analyzed statistically using analysis of variance technique for a completely randomized design and significant differences among the treatment means were identified by Duncan's Multiple Range Test (Steel and Torrie, 1980).

Economic Analysis

Economic analysis were carried out using market prices of feed ingredients to compare the feeding costs on different treatments and to calculate feed costs for eggs.

Results and Discussion

Nutrient Content of Test Ingredients

The nutrient composition of duckweed, mustard oil cake and different diets is presented in Table 2. Duckweed used in the present experiment contained 29.20% crude protein, which was 6% lower than that of mustard oil cake (35.26%). The crude protein concentration of duckweed used in the present experiment is in well agreement with the crude protein level found by Vandeyke and Sutton (1977). However, some researchers (Culley and Epps, 1973; Hillman and Culley, 1978) reported a higher CP content of duckweed ranged from 30 to 40% collected from agricultural and municipal waste lagoon. From the literature it is evident that CP content of duckweed is quite variable depending on the season, location, environment and nutrient content of water, where it is grown (Gerloff *et al.,* 1965). Due to high protein content and availability as natural water plants, Abdulayef (1969) recommended duckweed as a great potential proteinous feed for poultry. The crude fiber content of duckweed was higher compared to that of mustard oil cake (10.4 vs 8.5%). Similar crude fiber content in duckweed was observed by Zaher *et al.* (1995), which was 11.08%. Mbagwu and Adeniji (1988) demonstrated that duckweed grown under ideal condition and harvested regularly might have fiber content between 5 and 15%.

Ether extract content of duckweed was 5.06% which was 9.4% lower than that in mustard oil cake (14.47%). The value found in the present study for duckweed is 2 times higher than that of previous reports (Dudley *et al.,* 1975; Khan *et al.,* 2002a). They found the ether extract content of *Lemna spp* varied between 1.8 and 2.4% but a higher value of 6 percent for ether extract was also reported by Culley (1976).

Total ash or mineral matter content of duckweed found in the present experiment was 28.24%, which was higher than the values reported by Dudley *et al.,* 1975 (24.8%) and Khan *et al.,* 2002b (26.4%). The high ash content of duckweed may be due to large quantities of silt, which accumulated on the plants and not removed by washing. Much of the ash in duckweed is $CaCO_3$ deposited on the plant surface (Welch, 1952).

Nitrogen free extract (NFE) content of duck-

Table 2. **Nutrient composition of feed ingredients and composite diets (g/100 g DM)**

Nutrients	MOC*	DW**	Diets			
			A	B	C	D
Dry matter	88.94	88.07	88.93	89.36	89.29	89.12
Crude protein	35.26	29.20	18.08	17.78	17.48	17.18
Crude fiber	8.50	10.48	5.84	6.20	6.35	6.56
Ether extract	14.47	5.06	4.53	4.20	3.92	3.90
Nitrogen free extract	34.94	26.96	53.19	53.17	53.30	53.31
Ash	16.83	28.24	18.36	18.65	18.95	19.05
Calculated Value						
ME (kcal/kg DM)	3297	2144	2930	2869	2828	2804
Calcium (Ca%)	0.89	2.39	2.05	2.70	2.74	2.80
Phosphorus (P%)	1.78	0.71	0.65	0.82	0.76	0.70
Methionine (g/100 g CP)	0.92	1.40	0.21	0.28	0.30	0.31
Lysine (g/100 g CP)	1.13	4.70	0.54	0.56	0.55	0.54

A=15% mustard oil cake based control diet.
B=10% MOC*+5% DW**.
C=5% MOC+10% DW.
D=O% MOC+15% DW.
* MOC=Mustard oil cake.
** DW=Duckweed.

weed and mustard oil cake were found to be 26.96 and 34.94% respectively. The NFE content of duckweed in the present experiment is lower than the observation of Khan *et al.* (2002a) who obtained 31.03% NFE in *Lemna trisulaca.*

Individual mineral and amino acid composition were not analyzed in this study. However, previous studies (Khan *et al.,* 2002b) have reported that duckweed (*L. perpusilla*) contained 2.39% calcium, 0.71% phosphorus, 1.4% methionine and 4.7% lysine. With this high concentration of minerals and amino acids *L. perpusilla* can be categorized as high quality feed.

Nutrient Composition of Different Diets

It is evident from Table 2 that crude protein concentration of the diets ranged between 17.18 and 18.08%, where highest concentration was in diet A and lowest in diet D. Crude fiber and crude fat content of different diets were almost similar. Metabolizable energy content of different diets ranged from 2804 to 2930 kcal/kg DM and the variation was very negligible. Similarly, Ca, P, methionine and lysine concentrations of the diets where almost similar.

Body Weight of Ducks

Initial and fortnightly body weight of ducks in different groups have been presented in Table 3. The body weigh of ducks at the beginning of the experiment was almost similar (1428 to 1450 g). The body weight of ducks of all the four treatment groups increased in first fortnight and thereafter the body weight of the birds were almost static which at 5 fortnight was between 1478 and 1496 g. The ducks used in this experiment were in laying condition and naturally attained their maximum body weight at the onset of the experiment. Therefore, body weight changes of the ducks during the experimental period was not significant.

Egg Production

Egg production characteristics of Jinding ducks fed different diets have been presented in Table 4. Total number of egg production during 75 days of the experiment was 923, 883, 821 and 799, respectively for dietary treatments A, B, C and D and the difference was statistically significant ($P<0.01$). Daily average egg production was highest in treatment group A (0.58) where standard ration was supplied followed by B (0.56), C (0.53) and D (0.51). The ration of ducks belonging to group A contained more protein and energy than the ducks of other groups, which resulted maximum egg production in A. The difference in egg production between the treatment groups C and D was not-significant ($P>0.05$). Duck housed egg production was 58.6, 56.0, 52.0 and 50.6% for ducks belonging to the groups A, B, C and D, respectively. The variation of egg production due to replacement of mustard oil cake by duckweed in the diets was sta-

Table 3. **Fortnightly body weight of Jinding ducks (g) on different dietary treatments**

Dietary Treatments	Fortnight						LSD Value	Level of significance
	Initial body wt.	1	2	3	4	5		
A	1428.57	1500.57	1510.50	1496.51	1498.51	1496.98	84.40	NS
B	1437.17	1495.11	1500.57	1475.57	1488.15	1489.35	45.25	NS
C	1450.28	1483.46	1490.51	1480.46	1483.46	1485.26	41.27	NS
D	1428.15	1465.34	1472.52	1460.17	1470.40	1478.39	63.54	NS

A=15% mustard oil cake based control diet.
B=10% MOC*+5% DW**.
C=5% MOC+10% DW.
D=O% MOC+15% DW.
*MOC=Mustard oil cake.
**DW=Duckweed.
NS=Non-significant.

Table 4. **Production performance of Jinding ducks fed on different diets**

Parameters	Treatments				LSD Value	Level of significance
	A	B	C	D		
Total number of egg production	923[a]	883[b]	821[c]	799[d]	13.90	**
Average egg production	0.58[a]	0.56[b]	0.52[c]	0.51[c]	0.02	**
Average egg weight (g/egg)	60.03	59.69	59.56	59.31	0.76	NS
Total egg mass production (kg)	55.41[a]	52.71[b]	48.90[c]	47.39[d]	1.23	**
Egg mass production (g/bird/d)	35.18[a]	33.6[b]	31.05[c]	30.08[c]	1.01	**
FCR (feed: egg mass)	3.98	4.18	4.50	4.65	0.76	NS
Duck housed egg production (%)	58.66[a]	56.00[a]	52.00[b]	50.66[b]	3.74	**

A=15% mustard oil cake based control diet.
B=10% MOC+5% DW.
C=5% MOC+10% DW.
D=O% MOC+15% DW.
MOC=Mustard oil cake.
DW=Duckweed.
**=Significant at 1% level.
NS=Non significant.
[a, b, c, d] Values having common superscripts in the same row did not differ significantly ($P<0.05$).

tistically significant ($P<0.01$). Average fortnightly egg production of duck fed different diets are presented in Fig. 1. It is evident that egg production of ducks in all treatment groups decreased linearly with the advancement of age, which is normal trend of egg production in ducks as reported by XianJun *et al.* (1999) and Das *et al.* (2000). The production performance of the Jinding ducks in the present experiment was higher than that of Khaki Campbell (51.33%) and Indian Runner (47.23%) as reported by Hamid *et al.* (1993).

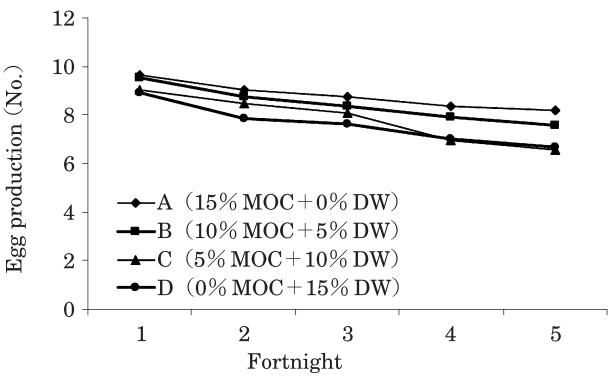

Fig. 1. **Fortnightly egg production of ducks**

Egg Weight

The average egg weight was almost similar in all the dietary treatment groups (Table 4) and the difference was non-significant ($P>0.05$). This result agrees with Fanimo (1996) who found no effect of dietary protein on egg weight. However, ducks on diets A had higher egg weight than those on diets

Table 5. **Chemical composition of eggs (g/100 g DM) in different treatment groups**

Parameters	Variable	Treatments				LSD Value	Level of significance
		A	B	C	D		
Dry matter	Albumen	19.37[a]	16.34[ab]	15.53[b]	15.33[b]	1.440	*
	Yolk	46.04	45.86	45.44	44.98	3.543	NS
Crude protein	Albumen	61.88[a]	60.98[b]	59.63[c]	59.34[d]	0.188	**

A=15% mustard oil cake based control diet.
B=10% MOC+5% DW.
C=5% MOC+10% DW.
D=O% MOC+15% DW.
MOC=Mustard oil cake.
DW=Duckweed.
*=Significant at 5% level.
**=Significant at 1% level.
NS=Non significant.
[a, b, c, d] Values having common superscripts in the same row did not differ significantly ($P<0.05$).

B, C and D. Egg weight of ducks increased with the advancement of age. In fact, egg weight decreased with the inclusion of increased proportion of duckweed in the diets. This may be due to lower biological value of duckweed.

Feed Conversion Ratio

For the production of 1 kg egg it required 3.98, 4.18, 4.50 and 4.65 kg feed for the ducks of treatment groups A, B, C and D, respectively. Feed conversion efficiency was superior in ducks fed standard diet and inferior in diet where 15% mustard oil cake was replaced by duckweed. In an experiment with Khaki Campbell duck, Das and Hoq (2000) found feed efficiency 3.98 which corresponds well with the findings of the present experiment. It is observed that egg production and feed conversion rate decreased with the inclusion of increased proportion duckweed in place of mustard oil cake in the diets. Lower nutrient concentration mainly protein and energy of the duckweed based diet resulted in lower egg production and feed conversion efficiency of the ducks belonging to the groups B, and D may be due to physical form of duckweed with higher fiber and ash content which might depressed bioavailability of nutrients.

Chemical Composition of Eggs

The average value of dry matter and protein contents of egg sample (egg yolk and egg albumen) is given in Table 5. Although significant difference was observed for dry matter ($P<0.05$) and protein ($P<0.01$) contents of egg albumen of ducks fed on different diets, but no significant difference was recorded for dry matter of egg yolk. Dry matter as well as protein content of eggs on dietary treatment A was highest compared to the eggs on other treatment groups B, C and D. Dry matter and crude protein content decreased with the higher levels of duckweed inclusion replacing mustard oil cake in the diets on B, C and D.

Economic Assessment

The cost of duck rearing on different rations is given in Table 6. The price of feed was highest for diet A followed by diets B, C and D, respectively. The results indicated that total cost of duck rearing tended to decrease linearly with a corresponding increase of duckweed in the diets of ducks belonging to groups B, C and D, respectively. Production cost calculation involved cost of feed, ducks, medicine and others. Table 6 showed that production cost was higher in group A than other treatment groups. As duckweed is an unconventional feed and price involved only collection cost which stands Tk. 2.00 only per kg is 12.5% of the price of mustard oil cake (Tk.16.00/kg). That is why the feed cost was less in duckweed fed group which was Tk. 10.35, 9.66, 8.96 and 8.26 per kg feed in groups A, B, C and D, respectively. Egg production was highest in A group where standard ration was supplied, consequently total income was highest in this group which stands Tk. 212.00 followed by Tk. 206.00, 197.00 and 194.00 in B, C and D groups respectively. Average profit margin for one duck during 75 days of rearing period stands Tk. 7.22, 8.57, 9.92 and 11.27, respectively for treatment groups A, B, C and D which

Table 6. **Cost of production and profit margin in different treatment groups for 75 days (Taka*)**

Variable	Treatments				LSD Value	Level of significance
	A	B	C	D		
Cost of duck	90.00	90.00	90.00	90.00	—	
Feed cost#	108.78[a]	101.43[b]	94.08[c]	86.73[d]	4.61	**
Cost of feed (kg)	10.35[a]	9.66[b]	8.96[b]	8.26[c]	0.47	**
Medicine and other	6.00	6.00	6.00	6.00	—	—
Total cost (b)	204.78[a]	197.43[ab]	190.08[bc]	182.73[c]	10.48	**
Spent duck	80.00	80.00	80.00	80.00	—	
Egg sold##	132.00[a]	126.00[ab]	117.00[bc]	114.00[c]	9.64	**
Total income (a)	212.00[a]	206.00a[b]	200.00[bc]	194.00[c]	87.47	**
Profit margin (a-b)	+7.22[a]	+8.57[ab]	+9.92[bc]	+11.27[c]	1.36	**

A=15% mustard oil cake based control diet.
B=10% MOC+5% DW.
C=5% MOC+10% DW.
D=O% MOC+15% DW.
MOC=Mustard oil cake.
DW=Duckweed.
**=Significant at 1% level.
NS=Non significant.
[a, b, c, d] means values having common superscripts in the same row did not differ significantly ($P<0.05$).
* Taka 67.00=1 U$.
#=Feed cost was calculated multiplying the feed intake (kg) by cost of per kg feed.
##=Egg sold price was calculated multiplying the eggs produced (no) by price of egg @Tk3.00 per egg.

differed significantly ($P<0.01$). Although egg production was lower in duckweed fed groups but due to low cost of feed the profit margin was higher in these groups. The profit margin increased linearly with the increased level of mustard oil cake replacement by duckweed in the diet. Duckweed may be considered as a source of protein in the diet of laying duck and that such ingredient may be incorporated in the diets up to 150g/kg replacing mustard oil cake or other vegetable protein sources without any adverse effect on body weight, egg weight and egg production performance.

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