Complete Replacement of Dietary Fish Meal by Duckweed and Soybean Meal on The Performance of Broilers

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ABSTRACT : An experimant was conducted to investigate the effects of equiprotein replacement of dietary fish meal (FM) with duckweed (DW) and soybean meal (SBM) on the performance of broilers. A total of 112 seven-day-old as hatched broilers were fed on 4 different iso-energetic (2,818 kcal/kg) and iso-nitrogeneous (20.2% CP) diets up to 56 days of age. Diet A was control with 12% FM. In diets B (3% DW + 13.5% SBM), C (6% DW + 11.5% SBM) and D (9% DW + 10% SBM). All FM protein of control diet was replaced by DW and SBM. The replacement of dietary FM by DW and SBM depressed feed intake, live weight gain and feed conversion efficiency and increased production cost and thus affected profitability. All those growth parameters had a linear declining trend as the proportion of DW in the diet was increased. It may be concluded that complete replacement of dietary FM by DW and SBM should not be recommended for raising broilers.
(**Key Words:** Duckweed, Soybean Meal, Fish Meal, Broiler, Dressing Yield, Carcass Composition)

INTRODUCTION

The profit of a poultry enterprise mainly depends on economic feeding (contribute 70% of total production cost) of balanced ration concomitant with greater yields of meat and eggs. The chronic scarcity and high cost of animal protein supplements particularly fish meal has increased interest to seek alternative protein source for feeding poultry. There are certain unconventional feed resources which can effectively be used as feed for poultry. For example, *Lemna minor* (duckweed), an aquatic weed grown abundantly in Bangladesh with almost no agronomic care. If grown under ideal condition and harvested regularly may have a fibre content of 5 to 15 per cent and a protein content of 35 percent, depending on the species involved (Mbagwu and Adeniji, 1988). Its protein has higher concentration of the essential amino acids, lysine and methionine than in most plant protein and more closely resembles animal protein in this respect (Journey et. al., 1993). Furthermore, lysine and methionine have been recognized as critical amino acids for broilers.

Previous studies (Muztar et al., 1976 ; Shahjahan et al., 1981) on the prospects of utilizing aquatic weeds (e.g. spirodella, azolla, lemna etc.) in poultry feeding have given encouraging results. Jhori and Sharma (1979) reported that dried *Lemma minor* could be used in chick starter or broiler ration at a level of 100 g/kg diet without affecting weight gain and feed efficiency. Ali et al. (1993) concluded that soybean meal can be used as a good substitute of animal protein (fish meal and blood meal) in broiler ration. Waldroup and Cotton (1974) concluded from their study that full fat soybean meal can be incorporated up to 25 percent in broiler mash. Aletor et al. (1989) reported that chicks when given equiprotein diets with fish meal replaced by soybean meal at 0, 20, 40, 60, 80 and 100 percent levels did not affect carcass characteristics. Dried duckweed meal which contains up to 400 g CP per kg DM can be compared with soybean meal as a source of plant protein (Porath et al., 1979).

Soybean meal contains low level of methionine (0.66 g per 100 g protein). On the otherhand, duckweed contains high amount of lysine (5.40 g per 100 g protein) and methionine (1.39 g per 100 g protein). Therefore, formulation of diets for broilers containing duckweed and soybean meal instead of fish may have balanced concentrations of lysine and methionine. The present study was designed to investigate whether a suitable

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combination of duckweed and soybean meal could replace the conventional fish meal protein of broiler diet.

MATERIALS AND METHODS

Fresh duckweed was collected from low-lying stagnant water, rice field and ponds. It was dried in the sun to a whole meal with a residual moisture content of 10 percent and was ground for use in the experimental diet.

A total of 112 seven-day-old Starbro broilers were randomly divided into 4 groups with 4 replicates of 7 birds in each replicate. Four iso-energetic (2,818 kcal ME/kg) and iso-nitrogeneous (20.2% CP) diets (A, B, C and D) were prepared (table 1 and 2) and were randomly allocated to 4 replicates in each group. Diet A was a commercial broiler ration and acted as control contained 12% fish meal (FM) without duckweed (DW) and soybean meal (SBM). In diet B, 3% DW + 13.5% SBM replaced all FM protein. Diet C had 6% DW and 11.5% SBM in lieu of FM and in diet D, 9% DW and 10% SBM replaced all dietary FM protein. Data on daily feed consumption, weekly body weight gain, water consumption, livability and production cost were recorded. At the end of feeding trial, 2 birds (1 male and 1 female) from each replicate were randomly selected and slaughtered to determine the dressing yield. Representative samples of breast muscle were taken to analyse their chemical composition. The proximate composition of feed and meat samples were determined using the methods of AOAC (1980). Data were analysed statistically using analysis of variance technique for a completely randomised design and significant differences among the treatment means were identified by Duncan's Multiple Range Test (Steel and Torrie, 1980).

Table 1. Chemical composition of feed ingredients

Ingredients	Composition (g/100 g air dry sample)										
	DM	CP	CF	EE	Ash	NFE	Lysine[1]	Meth[1]	Ca[2]	P	ME (kcal/kg)[3]
Wheat (crushed)	90.10	12.95	2.30	1.20	2.31	71.34	0.34	0.16	0.07	0.37	3,139
Wheat bran	90.23	16.40	8.20	2.30	4.50	58.83	0.50	0.14	0.17	1.00	2,058
Rice polish	89.65	16.90	7.50	13.16	9.10	42.99	0.37	0.35	0.25	1.26	3,097
Sesame oil cake	90.49	31.33	5.30	8.26	12.57	33.03	1.94	0.76	2.23	1.29	1,984
Fish meal	87.31	44.52	3.30	8.38	27.88	3.23	2.82	1.12	6.72	1.57	2,216
Duckweed	90.10	20.27	12.07	2.00	31.00	24.76	1.40	0.32	2.58	0.17	1,302
Soybean meal	90.46	35.43	6.50	22.10	6.09	20.34	2.08	0.46	0.32	0.81	2,874
Soybean oil	–	–	–	99.50	–	–	–	–	–	–	8,900
Oyster shell	92.00	–	–	–	38.00	–	–	–	38.00	–	–

[1,2] Adapted from Banerjee (1986) for all ingredients and from Porath et al. (1979) and Linn et al. (1975) for duckweed.
[3] Estimated for all ingredients (Janssen and Terpstra, 1972) and for duckweed (Khan, 1995; personal communication).

RESULTS AND DISCUSSION

The results on feed consumption, weight gain, feed conversion ratio, carcass weight and dressing percentage are given in table 3. Significant differences were observed for average feed consumption, weight gain and feed conversion ratio. The broilers on diet A (control) ate more feed, gained higher liveweight and utilised feed more efficiently ($p < 0.01$) for growth than those on other diets.

The chicks on diet B and C were similar and superior to those on diet D in terms of feed intake, liveweight gain and feed conversion efficiency. The chick survivability percentages were similar on all diets ($p > 0.05$). In respect of growth, diet A seemed to be the best followed by B, C and D, respectively.

The average carcass weight of birds fed on diet A was significantly ($p < 0.05$) higher compared to those on diets B, C and D and ran almost in parallel to growth rate. The dressing yields were similar ($p > 0.05$) for all dietary groups. However, dressing yields tended to be decreased as the proportion of DW and SBM in the diet increased.

Table 2. Ingredient and chemical composition of the experimental diets

	Diets[#]					Diets[#]			
	A	B	C	D		A	B	C	D
Ingredients (%)					Calculated Composition (g/100 g diet)				
Wheat (crushed)	46.0	41.0	41.0	42.0	DM	88.90	89.40	89.30	88.50
Wheat bran	14.0	10.0	4.0	3.0	CP	20.20	20.20	20.20	20.20
Rice polish	12.0	12.0	15.0	10.0	CF	4.18	4.66	4.84	4.81
Sesame oil cake	14.5	18.5	20.5	23.0	EE	5.60	7.82	7.85	8.07
Fish meal	12.0	–	–	–	NFE	51.40	49.90	48.60	47.90
Duckweed	–	3.0	6.0	9.0	Ash	7.94	7.04	8.10	8.78
Soybean meal	–	13.5	11.5	10.0	Ca	1.20	0.99	0.91	1.03
Soybean oil	1.0	1.0	1.0	2.0	P	0.84	0.76	0.75	0.70
Oyster shell	–	0.5	0.5	0.5	Methionine	0.40	0.34	0.35	0.36
Embavit B[1]	0.25	0.25	0.25	0.25	Lysine	0.89	0.89	0.94	0.97
Common salt	0.25	0.25	0.25	0.25	ME (kcal/kg)	2,816	2,820	2,833	2,802
					Cost (Tk/kg feed)*	10.7	9.72	9.34	9.68

[1] Embavit B (per 2.5 kg): Vit. A 12,500,000 IU, D_3 2,500,000 IU, E 20,000 IU, K_3 4.0 g, B_1, 2.5 g, B_2, 5.0 g, B_6 4.0 g, Nicotinic Acid 40.0 g, Pantothenic Acid 12.5 g, B_{12} 12.0^6 mg, Folic Acid 0.8 g, Biotin 0.1 g, Cobalt 0.4 g, Copper 10.0 g, Iron 60.0 g, Iodine 0.4 g, Manganese 60.0 g, Zinc 50.0 g, Selenium 0.15 g, DL-Methionine 100.0 g, Choline Chloride 300.0 g, Spiramycin 5.0 g, B. H. T. 50.0 g.
* 1 US Dollar = 42.5 BD Taka.
[#] A = 12% fish meal.
B = 3% duckweed + 13% soybean meal.
C = 6% duckweed + 11.5% soybean meal.
D = 9% duckweed + 10% soybean meal.

Table 3. Effect of complete repplacement of fish meal by different combinations of duckweed and soybean meal on growth performance of broiler chicks (7 - 56 days of age)

Parameters	Dietary groups[#]				SED	Significance
	A	B	C	D		
Initial live weight (at day 7) (g/bird)	72	73	72	71	0.615	NS
Total live weight gain (kg/bird)	1.455^a	1.239^b	1.180^b	1.006^c	0.039	**
Total feed consumption (kg/bird)	3.563^a	3.100^b	3.162^b	2.700^c	0.105	**
Feed conversion ratio (intake/weight gain)	2.45^a	2.50^{ab}	2.68^{bc}	2.70^c	0.059	**
Carcass weight (kg/bird)	1.266^a	1.038^b	0.996^b	0.903^b	0.095	*
Dressing yield (%)	72.8	71.3	69.3	69.9	1.670	NS
Survivability (%)	100	96.4	92.8	92.8	2.86	NS
					(Chi-square value)	

[NS] $p > 0.05$; * $p < 0.05$; ** $p < 0.01$.
[a,b,c] Means in the same row with different superscripts are significantly different ($p < 0.05$).
[#] A = 12% fish meal.
B = 3% duckweed + 13% soybean meal.
C = 6% duckweed + 11.5% soybean meal.
D = 9% duckweed + 10% soybean meal.

The chemical composition of breast meat sample is given in table 4. The dry matter, crude protein, ether extract and total ash contents of breast meat of broilers were not influenced significantly ($p > 0.05$) by the substitution of total dietary FM with different combinations of DW and SBM in the diet.

The significant ($p < 0.01$) lower intakes of diets were noted for the birds where dietary FM was replaced by DW and SBM with a tendency to decline in feed intake as the proportion of DW in the diet was increased. The differences in feed intake as influenced by changes in dietary ingredients is supported by Isshiki and Nakahiro (1989). They suggested that passage rate and feed intake changed based on type of feed used in formulating diets. The probable reason for inferior feed conversion efficiency may be due to less feed intake of DW based diets which inturn may be influenced by the physical form of duckweed i. e. dustiness and loose in texture. Such an assumption is consistent with the observation of Church (1986), who indicated that broiler chicks gained more live weight and improved efficiency of feed conversion when fed pelleted feed, crumbles or reground crumbles as compared to performance of birds on mash. Furthermore, addition of SBM in the diet might contain trypsin and chymotrypsin inhibitors which may be attributed to depression of protein digestion, destruction of methionine and excretion of N and S (Church, 1986; McDonald et al., 1988). This inturn may have resulted in retardation of broiler growth. In addition, inclusion of increased amount of sesame oil cake in the experimental diets may have a supplementary effect to hinder feed conversion efficiency (Church, 1986). The use of plant sources (sesame oil cake, SBM and DW) in lieu of fish meal (animal source) obviously increased phytate content in the experimental diets which might have reduced the availability of Ca and P and ultimately subjected to reduce the feed conversion efficiency. The associative effects of various feed ingredients might have also affected the availability of nutrients from formulated rations (Hoover and Miller, 1992). Probable reason behind less live weight gain for DW diets (B, C and D) were the combined effect of lower feed intake and feed conversion efficiency as discussed above.

Table 4. Effect of complete replacement of fish meal by different combinations of duckweed and soybean meal on chemical composition of breast meat sample

Parameters	Dietary groups[#]				SED	Significance
	A	B	C	D		
Composition (g/100 g sample)						
Dry matter	27.69	26.72	27.32	26.76	1.205	NS
Crude protein	22.17	21.30	20.18	20.36	0.967	NS
Ether extract	2.91	2.93	2.94	2.79	0.055	NS
Total ash	0.96	1.04	0.99	1.01	0.217	NS

[NS] $p > 0.05$.
[#] A = 12% fish meal.
B = 3% duckweed + 13% soybean meal.
C = 6% duckweed + 11.5% soybean meal.
D = 9% duckweed + 10% soybean meal.

The cost of production and profits are presented in table 5. Feed costs per kg live weight gain and dressed yield were not significantly different among the dietary treatments. However, production cost based on chicks and feed costs indicated significant differences among the groups for producing each kg live broiler ($p < 0.05$) or each kg dressed broiler ($p < 0.01$). Higher production cost was recorded for chicks raised on diet D compared to those given other diets. Thus, reduced profit was accounted with the incorporation of increased proportion of DW in the diet. The differences in production costs and therefore, reduced profits were due to differences in growth rates of chicks on different diets.

Considering the above findings, it can be concluded that duckweed (*Lemna minor*) along with soybean meal may be used up to 9% of broiler ration without any adverse effect on the performance of chicks. However, from commercial point of view, total replacement of fish meal with duckweed and soybean meal may not be advisable.

Table 5. Cost of production of broiler fed on different diets

Parameters	Dietary groups[#]				SED	Significance
	A	B	C	D		
Feed cost (Tk/kg LWG)	26.18	24.30	25.04	26.09	0.998	NS
Feed cost (Tk/kg dressed yield)	35.94	34.05	36.12	37.33	1.430	NS
[1]Cost of production (feed+chick) (Tk/kg LWG)	37.87	38.03	39.45	43.08	1.577	*
[1]Cost of production (feed+chick) (Tk/kg dressed yield)	51.99	53.30	56.91	61.65	2.306	**
[2]Profit (Tk/kg LWG)	27.14	26.97	25.56	21.92	1.577	*
[3]Profit (Tk/kg dressed yield)	33.01	31.70	28.09	23.35	2.306	**

[NS] $p > 0.05$; * $p < 0.05$; ** $p < 0.01$.
[a,b,c]Means in the same row with different superscripts are significantly different ($p < 0.05$).
[1] Calculating chick cost (Tk. 17/bird)
[2,3] Assuming sale revenue (Tk. 65/kg Live weight and Tk. 85/kg dressed weight)
1 US Doller = 42.5 BD Taka.
[#] A = 12% fish meal.
B = 3% duckweed + 13% soybean meal.
C = 6% duckweed + 11.5% soybean meal.
D = 9% duckweed + 10% soybean meal.

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