Use of Duckweed as a Protein Supplement for Breeding Ducks

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ABSTRACT : An experiment was conducted at the experimental duck farm of Cantho University to determine the effects of feeding duckweed *(Lemna minor)* that replaced commercial protein supplements in diets for local and Cherry Valley breeding ducks. The experiment included a total of 180 ducks, with five treatments and three replicates and six breeding ducks (one male plus five females together) per replicate, for both local and exotic Cherry Valley ducks. The five diets were fed *ad libitum* and were based on rice by-products supplemented with roasted soya bean meal plus dried fishmeal at levels of 100% (SF100, control), 75 (SF75), 50 (SF50), 25 (SF25) or zero (SF0) % of the protein in the control diet, corresponding to 18, 15, 13, 10 and 8% CP in the diets for both breeds, respectively. Fresh duckweed was supplied *ad libitum* for all treatments. These diets were fed to local breeding ducks from 7 to 12 months of age, and to exotic breeding ducks (Cherry Valley) from 8 to 13 months of age. Total mean daily dry matter (DM) intakes were 183, 178, 176, 177 and 174 g ($p<0.05$) for the local ducks, and 221, 208, 215, 219 and 210 g ($p<0.01$) for the exotic ducks for the SF100 (control), SF75, SF50, SF25 and SF0 diets, respectively. Laying rates of the local ducks were 66.5, 65.2, 62.9, 63.1 and 62.3%, and of the Cherry Valley ducks 61.9, 58.4, 58.9, 59.1 and 53.5% ($p<0.001$) for the control (SF100), SF75, SF50, SF25 and SF0 treatments, respectively. Fertile egg rates were 95.6, 95.6, 97.8, 97.8 and 92.2%, and hatchabilities 89.4, 80.6, 87.2, 88.6 and 77.8% ($p<0.05$) for the local breed, and 97.8, 97.8, 91.1, 92.2 and 90.0% ($p<0.05$) and 72.8, 74.7, 75.0, 74.3 and 76.7% for the Cherry Valley ducks for diets SF100, SF75, SF50, SF25 and SF0, respectively. Corresponding feed conversion ratios (dry matter basis) were 3.83, 3.82, 3.89, 4.01 and 3.96 kg feed per kg egg mass for the local ducks and 4.52, 4.56, 4.58, 4.73 and 5.02 kg feed per kg egg mass for the Cherry Valley ducks for the SF100, SF75, SF50, SF25 and SF0 treatments, respectively. Replacement of 100% of the protein supplement by fresh duckweed in the diets of the local laying ducks decreased the feed costs by 25% compared to the control diet. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 6 : 866-871)***

Key Words : Breeding Ducks, Duckweed, Intake, Feed Conversion Ratio, Laying Rate

INTRODUCTION

Pig and duck raising are the most important livestock enterprises in the Mekong Delta of Vietnam, with more than 95% of total production from smallholder farmers (Quac, 1990). Unlike in the Western countries, duck egg and meat consumption are expanding in Vietnam and they provide inexpensive and nutritious foods for people in both cities and rural areas, especially for poor farmers in the remote regions. Small flocks of ducks are commonly allowed to scavenge in the rice fields and backyards or gardens of households, receiving water plants, household waste or rice to supplement what they obtain by scavenging. However, the scavenging system has recently been experiencing problems due to the spread of fast-maturing, high yielding rice varieties, which limits the time available for the duck flocks to scavenge. Also, the price of feeds, especially protein supplements, has increased considerably, which pushes the cost of inputs higher (Men et al., 2001a).

It has been shown that duckweed (*Lemna minor*) can replace conventional protein sources in layer diets up to 25% of total dry matter without jeopardising production (Haustein et al., 1990). Duckweed has been traditionally used in Vietnam to feed fish and poultry, and recently as a plant protein source to replace commercial protein supplements in diets of growing ducks. Cultivated fresh duckweed can completely replace soybean meal and a vitamin-mineral premix in broken rice based diets for growing crossbred ducks without reduction in growth performance or carcass traits, and if the duckweed is grown on farm, and managed and harvested by household labour, the saving over purchased protein supplements is up to 48% (Men et al., 2001a).

The main objectives of the experiment were to determine the optimum level of duckweed as replacement of a protein supplement in diets for local and exotic breeding ducks, and to evaluate the effects of duckweed on reproductive performance. In addition, the economic benefits obtained by the use of duckweed in diets for breeding ducks were evaluated.

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MATERIALS AND METHODS

Experimental design and birds

The experiment was carried out at the experimental duck farm of Cantho University in the Mekong Delta from

March to July. A total of one hundred and eighty local and exotic type-meat ducklings were selected at start of lay. Local ducklings were selected from scavenging breeding flocks hatched at a traditional duck hatchery in a suburban area of Cantho City. One day old exotic ducklings (Cherry Valley) were selected and reared to point of lay on the university duck farm. The ducks were penned in groups as separate families, consisting of one male and five females for each family group. The groups were allocated at random to five treatments for both breeds, with three replicates and six birds (one male plus five females) per replicate.

Housing and management

The breeding ducks were housed in a shed divided into pens. The pens were mades from bamboo frames, with thatched roofs and concrete floors coverd with rice straw or dried grass for bedding, and with an average density of one duck per 0.8 m^2, and with laying nests in the corner of each pen. The ducks also had access to outside covered sand yards with an area of 2 m^2 per duck, and an adjoining canal, with an average of 1 m^2 water per duck. The temperature in the house averaged 24-25°C in the morning, 32-35°C at noon and 21-27°C at night, and mean relative humidity ranged from 58.3% at noon to 84.9% in the early morning. Natural light was used in the day time, with light from electric bulbs at night with an intensity of 5W/m^2 to maintain a total of 17 h light each day.

Feeders used for the experiment were round plastic basins 40 cm in diameter and 10 cm deep. Drinkers were 15 cm deep rectangular 30×60 cm pottery basins. They were filled intermittently with water to meet both the drinking and bathing requirements of the ducks. Both drinkers and feeders were cleaned daily in the morning.

Diets and feeding

During the rearing stage the ducklings of both breeds were fed commercial mixtures *ad libitum* up to 28 days of age and then fed restricted amounts of a grower diet up to six and seven months of age, for the local and exotic breeds, respectively. Total protein and metabolizable energy contents offered were based on the recommendations of Scott and Dean (1991), NRC (1994) and Shen (1988) for breeding ducks. All ducks were supplied *ad libitum* with fresh duckweed in addition to the experimental diets. The diets were formulated to be isocaloric, and with decreasing concentrations of a mixture of soybean meal and dried fishmeal (SF) to give 18 (SF100), 15 (SF75), 13 (SF50), 10 (SF25) and 8 (SF0) % CP for both local and Cherry Valley ducks (table 1). The broken rice and fine rice bran were from a local milling plant, and were collected and stored every two weeks during the experiment. The soya bean meal used for the trial was from whole grains that were roasted, stored and ground once or twice weekly for use throughout the experiment. The dried fish was collected at the same time, ground and stored for the whole experimental period.

Duckweed

The duckweed used in the experiment was grown on ponds enriched with nutrients from waste waters of the experimental pig farm of Cantho University and was collected twice daily in the morning and in the afternoon. After collecting it was cleaned by strong water jets and put in a large bamboo basket for one hour to drain the excess water. Fresh duckweed was offered *ad libitum* three times per day in the morning, afternoon and evening. The amounts given on each occasion depended on the intakes on the previous two occasions, to minimize spillage. The residues were gathered and weighed the following morning to calculate the actual intakes.

Measurements

Laying rates and daily intakes of the concentrate and duckweed of the local and exotic breeding ducks were recorded as means of the group (family). In addition, the proportion of fertile eggs and hatchability were calculated.

Chemical analyses

The samples of broken rice, fine rice bran, soya bean meal, fishmeal and duckweed were analysed for dry matter (DM), crude protein (N×6.25), crude fibre, ether extract, nitrogen free extract, ash, calcium, phosphorus and carotene by standard AOAC methods (AOAC, 1990) at the laboratories of Cantho University. Metabolisable energy (ME) contents of the diets were calculated from chemical analysis data using the equation of Nehring and Haenlein (1973):

$$\text{ME (kcal/kg)}=4.26X_1+9.5X_2+4.23X_3+4.23X_4$$

The calculated digestible crude protein, fat, fiber and nitrogen free extractives (g/kg feed) are represented by X_1 through X_4, and estimated digestibility coefficients for each feedstuff are according to NIAH (1992) for poultry.

Statistical analyses

The data were analysed by analysis of variance using ANOVA General Linear Model procedure of MINITAB version 12 program statistical software (1998).

Economic analyses

Economic analyses were carried out using current prices in Vietnamese Dong (VND) to compare the feeding costs on the different treatments and to calculate feed costs for every 10 incubated eggs for both local and exotic breeding ducks.

Table 1. Ingredient and chemical composition (as fed) of the concentrate diets fed to local and exotic breeding ducks

Ingredient, %	Treatment				
	SF100	SF75	SF50	SF25	SF0
Broken rice	54.2	59.2	64.0	69.0	71.6
Rice bran	10.0	12.0	13.9	15.7	20.0
Soybean meal	20.0	15.0	10.0	5.0	-
Dried fishmeal	10.0	7.5	5.0	2.5	-
Oyster meal	4.7	4.7	4.6	4.5	4.4
Bone meal	1.1	1.7	2.4	3.1	3.7
NaCl	-	-	0.1	0.2	0.3
Nutrient					
ME, MJ/kg	12.4	12.3	12.2	12.1	11.9
CP, %	18.1	15.6	13.1	10.6	8.1
Ca, %	2.5	2.5	2.5	2.5	2.5
Available P, %	0.48	0.47	0.47	0.47	0.47
NaCl, %	0.39	0.29	0.29	0.28	0.27

RESULTS AND DISCUSSION

Chemical composition of feed ingredients and diets

The ingredient and chemical composition of the diets are given in table 1. With the exception of the crude protein levels in the SF25 and SF0 diets the nutrient concentrations met the requirements of breeding ducks (NRC, 1994): metabolizable energy (ME) 11.9-12.4 MJ/kg, calcium (Ca) 2.50%, available phosphorus 0.47-0.48% and sodium chloride (NaCl) 0.27-0.39%. Crude protein (CP) contents were 18.1, 15.6, 13.1, 10.6 and 8.1% in diets SF100, SF75, SF50, SF25 and SF0, respectively.

The duckweed used in the experiment had an average dry matter content of 5.1%. The crude protein content (38.1% of DM) was similar to that found in an earlier study done at the same location (38.6%) (Men et al., 2001a), but higher than the value found by Becerra et al. (1994) (26.3%), due to the fact that the duckweed used in our trial was grown on ponds enriched with digester effluent and waste water from the university pig farm. Also, the fibre content of the duckweed (8.9%) was lower than that reported by Becerra (1994) (11.0%). Other nutrient concentrations (% of DM) were EE, 9.8; NFE, 26.9; ash, 16.3; Ca, 1.9; available phosphorus, 0.5, and its metabolizable energy (ME) concentration was lower than the concentrates (10.1 and 13.7-14.1 MJ/kg of DM, respectively).

Feed intake

The data in table 2 and 3 show that total daily intakes of DM, concentrate and crude protein were significantly different among treatments for both local and exotic breeds. Concentrate intakes of the local ducks in the SF100 treatment were higher than those of the ducks in the treatment without any protein supplement (SF0), and daily mean concentrate intakes were 30-40 g higher for the exotic ducks compared to the local breed.

There were significant differences in duckweed intakes among treatments for both breeds. However, daily fresh duckweed intakes of the exotic ducks were around 100 g higher than for the local breed, probably as a result of their higher body weights (around 3.0 kg, compared to 2.0 kg for the local ducks), and duckweed intakes were higher than those of fattening crossbred ducks reported in studies by Men et al. (2001a) (566 g/day) and by Becerra et al. (1994) (450 g/day). Expressed as DM intake per kg of body weight the duckweed intakes of the local breeding ducks were higher than the Cherry Valley ducks (18.2 g and 14.0 g, respectively). When comparing the local breeding ducks and growing crossbred ducks in an earlier trial (Men et al., 2001a) duckweed DM intakes per kg body weight were found to be similar (18.2 and 18.1 g, respectively), but higher than the value reported by Becerra et al. (1994) (14.2 g).

The data in table 2 and 3 show that total daily DM and ME intakes were fairly similar among the duckweed treatments for both the local and exotic ducks, but were highest for the SF100 treatment. Mean daily CP intakes for both breeds decreased significantly ($p<0.001$) as the soya bean and fish meal levels in the diets were progressively reduced, and CP as proportion of DM intake decreased from 24.1% on the SF100 diet to only 15.2% on the SF0 treatment. It is interesting to note that the ducks on the SF100 diet still consumed very high amounts of duckweed, even though the crude protein content of the concentrate they were given was adequate. The probable explanation is that duckweed is extremely palatable to ducks, and it is also likely that the birds consumed significant quantities in order to meet their requirements for trace nutrients. However the high moisture content and bulkiness of duckweed do eventually limit intake, which explains why the ducks given concentrates with inadequate protein levels were unable to

Table 2. Total daily intakes of local breeding ducks

Parameter	Treatment					P value
	SF100	SF75	SF50	SF25	SF0	
Concentrate, g	167	159	157	160	156	0.001
Fresh duckweed, g	701[b]	711[ab]	709[ab]	711[ab]	722[a]	0.019
Duckweed, DM/kg BW	17.9	18.2	18.1	18.2	18.5	-
Total DM, g	183	177	174	177	174	0.001
ME, MJ	2.4	2.3	2.3	2.3	2.2	0.127
CP, g	43.9[a]	38.8[b]	34.4[c]	30.9[d]	26.8[e]	0.001
CP, % of DM	24.1[a]	22.0[b]	19.8[c]	17.4[d]	15.5[e]	0.001

Table 3. Total daily intakes of CherryValley breeding ducks given duckweed *ad libitum*

Parameter	Treatment					P value
	SF100	SF75	SF50	SF25	SF0	
Concentrate, g	204[a]	189[b]	197[ab]	201[ab]	190[b]	0.001
Fresh duckweed, g	806[c]	823[b]	810[bc]	832[a]	834[a]	0.001
Duckweed, DM/kg BW	13.7	14.0	13.8	14.2	14.2	-
Total DM, g	221[a]	208[b]	215[ab]	219[ab]	210[ab]	0.001
ME, MJ	2.9	2.7	2.8	2.8	2.7	0.004
CP, g	52.7[a]	45.7[b]	41.7[c]	37.5[d]	31.8[e]	0.001
CP, % of DM	23.9[a]	21.9[b]	19.4[c]	17.1[d]	15.2[e]	0.001

eat sufficient duckweed to meet their protein requirements.

Ducks, like other poultry species, are able to adjust their ME intakes to meet requirements (Dean, 1986), and the higher energy intakes of the exotic breed are probably a result of their higher maintenance requirements, as their mean live weight during the trial was about 1,000 g higher than the local breed.

Reproductive performance

The reproductive performance of the local and exotic ducks for the 5 months of the experiment is presented in table 4 and 5. The data show that the average laying rates of the local ducks were higher than those of the Cherry Valley ducks and that the mean laying rates of the Cherry Valley ducks fed the diet without any protein supplement (SF0) were significantly lower than for the other treatments, probably because the crude protein intake on the SF0 treatment (15.2% of DM) was below the recommended requirement for Cherry Valley layers (20% of DM, Cherry Valley, 1994). However, there were no significant

Table 4. Reproductive performance of local breeding ducks fed fresh duckweed as part replacement for a protein supplement

Parameter, %	Treatment					SE	P value
	SF100	SF75	SF50	SF25	SF0		
Laying rate	66.5	65.2	62.9	63.1	62.3	1.6	0.303
Fertile egg rate*	95.6	95.6	97.8	97.8	92.2	1.9	0.237
Hatchability**	89.4[a]	80.6[ab]	87.2[ab]	88.6[ab]	77.8[b]	4.9	0.034

* Proportion of fertile eggs of incubated eggs.

** Proportion of hatched eggs of fertile eggs.

Table 5. Reproductive performance of Cherry Valley breeding ducks fed fresh duckweed as part replacement for a protein supplement

Parameter, %	Treatment					SE	P value
	SF100	SF75	SF50	SF25	SF0		
Laying rate	61.9[a]	58.4[ab]	58.9[ab]	59.1[ab]	53.5[b]	1.4	0.001
Fertile egg rate*	97.8[a]	97.8[a]	91.1[b]	92.2[b]	90.0[b]	2.3	0.044
Hatchability**	72.8	74.7	75.0	74.3	76.7	6.3	0.993

* Proportion of fertile eggs of incubated eggs.

** Proportion of hatched eggs of fertile eggs.

differences in laying rates among treatments for the local ducks, which have lower protein requirements (around 18% of DM) than exotic breeds. While there were no treatment effects on hatchability for the Cherry Valley ducks the hatchability of the local breed eggs was significantly lower on the SF0 treatment. However, the hatchability of the eggs from the local breed was higher than for the Cherry Valley ducks on all treatments. There were no between treatment differences in the proportion of fertile eggs for the local breed, although the proportion of fertile eggs for the Cherry Valley ducks was higher on the SF100 and SF75 treatments.

Feed conversion ratios and production costs

Results for FCRs are presented in table 6 and 7. The mean feed conversion ratios and protein consumption per kg egg-mass of the Cherry Valley ducks were significantly higher than those of the local ducks. Each kg of eggs produced by the local ducks required on average 780 g less feed DM and 139 g less protein than the Cherry Valley ducks. One possible explanation for this is that the local duck has evolved in scavenging systems where the feeds normally consumed have high levels of fibre, and therefore they are able to digest fibrous feeds more efficiently than the Cherry Valley ducks. When expressed as feed DM intakes per 10 eggs produced the FCRs of the Cherry Valley ducks were lower than those reported in a study of Minh et al. (1995) in north Vietnam (3.73 vs 4.13 kg feed/10 eggs, respectively).

The cost of feed for 10 eggs based on the price of feeds and eggs at the time of the trial gradually decreased in order from treatment SF100 to SF0 for both the local and Cherry Valley ducks (table 8). The replacement of 100% of the protein supplement by fresh duckweed thus resulted in the lowest feed costs.

IMPLICATIONS

The results of the experiment lead to the conclusion that fresh duckweed can replace protein supplements in the diets of local laying ducks without affecting reproductive performance, except for a reduction in hatchability in diets in which duckweed was the major source of protein. However, replacement of the soya bean and fishmeal by duckweed in the diets of Cherry Valley laying ducks significantly decreased laying rate and the proportion of fertile eggs. Fed the same diets local breeding ducks had higher rates of lay and hatchability than the Cherry Valley ducks. As total dry matter intakes of the CherryValley ducks were also considerably higher, the cost of feed per 10 eggs was significantly lower for the local breed on all

Table 6. Feed conversion ratio (FCR) of local breeding ducks, intake/kg egg-mass

Parameter	Treatment					SE	P value
	SF100	SF75	SF50	SF25	SF0		
Total DM, kg	3.83	3.82	3.89	4.01	3.96	0.31	0.988
Total CP, kg	0.92[a]	0.84[ab]	0.77[ab]	0.70[ab]	0.61[b]	0.06	0.030
CP from duckweed, kg	0.29	0.30	0.31	0.32	0.32	0.03	0.920

Table 7. Feed conversion ratio (FCR) of Cherry Valley breeding ducks, intake/kg egg-mass

Parameter	Treatment					SE	P value
	SF100	SF75	SF50	SF25	SF0		
Total DM, kg	4.52	4.56	4.58	4.73	5.02	0.35	0.840
Total CP, kg	1.08[a]	1.00[ab]	0.89[ab]	0.81[ab]	0.76[b]	0.07	0.034
CP from duckweed, kg	0.32	0.35	0.34	0.35	0.39	0.03	0.506

Table 8. Total feed costs* for 10 eggs, Vietnamese Dong, VND (1US$=13,000VND)

Parameter	Treatment				
	SF100	SF75	SF50	SF25	SF0
Local breed					
Duckweed purchased	9,106	8,476	7,965	7,565	6,815
Duckweed grown on farm**	6,993	6,265	5,689	5,233	4,445
Cherry Valley					
Duckweed purchased*	11,842	11,167	10,344	9,777	9,499
Duckweed grown on farm**	9,127	8,305	7,590	6,923	6,323

* Based on prices in VND per kg for roasted soya beans 5,400, dried fish meal 5,000, broken rice 1,800, rice bran 1,600, oyster meal 800, bone meal 2,300, fresh duckweed 200, and salt 1,000.

** Assumes no cost of duckweed, as opportunity cost of family household labour is usually zero.

dietary treatments. Complete replacement of the protein supplement by fresh duckweed in the diets of the local laying ducks decreased the feed costs by 25% compared to the control diet, even in a situation where the duckweed was purchased. If the duckweed is grown on farm, and managed and harvested by household labour, the savings over purchased protein supplements would be even greater, up to 36%.

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