Effect of Brewery Waste Replacement of Concentrate on the Performance of Local and Crossbred Growing Muscovy Ducks

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ABSTRACT : Two experiments were carried out to evaluate the effects of brewery waste (BW) replacement of concentrate (C) in growing duck diets. In Exp. 1, which was carried out on-station, 300 ducklings were allocated in a 2×5 factorial experiment: Two breeds (local Muscovy and crosses of French and local Muscovy)×5 levels of C and with BW offered *ad libitum*. Concentrate only *ad libitum* as the control diet (C100), and levels of 75% (C75), 50% (C50), 25% (C25) and 0% (C0) of the amount of the control diet consumed, and with BW *ad libitum*. In Exp. 2, 200 ducklings were allocated in a 2×2 factorial experiment on five smallholdings: two breeds (local and crossbred Muscovy ducks)×2 diets (the C100 and C50 diets from Exp.1). In Exp.1 total dry matter (DM), BW, crude fiber (CF) and crude protein (CP) intakes were highest on the C0 diet and ME and lysine intakes lowest ($p<0.001$). Daily live weight gains were higher for the crossbred ducks than for the local Muscovies ($p<0.05$) and were highest for treatments C100 and C50, and lowest for treatment C0 ($p<0.05$). Weights of breast muscle, liver and abdominal fat were significantly higher for the crossbred ducks. Breast and thigh muscle and abdominal fat weights were significantly higher for the C100, C75 and C50 diets, while gizzard weights were highest for the C25 and C0 treatments. Net profits were higher for the crosses, and for treatments C50 and C25. In Exp. 2 total DM, CF and CP intakes were significantly higher for the C50 diet, and ME intakes lower ($p<0.001$). Daily gains of the crosses were significantly higher than those of the local Muscovy ducks, and were similar for the C100 and C50 diets. The highest net profits were from the crosses and ducks fed the C50 diet. It was concluded that BW can replace 50% of the concentrate in growing Muscovy duck diets without reducing daily live weight gains and with improved economic benefits. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 10 : 1510-1517)***

Key Words : Brewery Waste, Growth Rate, Muscovy Ducks, Feed Intake, Profits

INTRODUCTION

Duck production plays an important role in providing meat and eggs in the diet of the people in the Mekong Delta, where over 10 million ducks are reared annually for egg and meat production. In recent years Muscovy ducks have been introduced and are especially popular and profitable for producers around the cities, but are also reared in the rural areas. The population of Muscovy ducks is about 20% of the total number of ducks raised in the Mekong Delta (Phuoc et al., 1994), and crosses between male French Muscovy and female local Muscovy ducks are popular. Muscovy ducks are easy to raise because they are more resistant to diseases and efficiently consume various low quality local feeds to produce meaty carcasses that are sold at higher prices than local common ducks, as the dark, flavorous lean meat is particularly liked by consumers in the Mekong Delta. To meet the increasing consumer demand, there is a growing interest in confinement of Muscovy ducks given locally available feeds. In addition to conventional feeds (cereals, soybeans, fish meal etc.) and agricultural by–products, other locally available feed resources, for example the by–products of food processing, have contributed considerably to duck production in the Mekong Delta, especially brewery waste (BW), which is quite plentiful and cheap in the area. Large quantities of BW are produced daily almost all the year round. According to Göhl (1981), it is a good feed resource for livestock, with a reasonably high protein content of between 23-28% CP (DM basis), and some vitamins, but is relatively low in ME, due to its high crude fiber content. Other studies have indicated that BW improved the growth rate and feed conversion, and increased fertility and hatchability in poultry (Thornton and McPherron, 1962 and Kieholz, 1967), possibly due to unidentified factors (Göhl, 1981).

The main objectives of the experiments were, in on-station and subsequent on-farm trials, to determine the optimum level of BW as replacement for concentrate in diets for growing Muscovy ducks, to compare the effect of BW on the performance of local and crossbred Muscovy ducks, and to evaluate the resulting economic benefits.

METHODS AND MATERIALS

Experimental design and birds

Expt. 1 was carried out using crossbred and local Muscovy ducks at the duck farm of Cantho University in the Mekong Delta. The experimental period was from April to July, in the early rainy season. A total of 300 crossbred

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Table 1. Chemical composition and range of the dietary ingredients, Expt. 1 (% of DM)

Item	Feed ingredient		
	Concentrate	Brewery waste	Dukweed
DM	88.0 (87.7-88.2)	25.0 (23.0-26.5)	5.40 (5.33-5.64)
CP	18.8 (17.0-22.2)	23.6 (23.0-28.1)	30.1 (29.8-30.4)
EE	6.40 (6.1-6.7)	10.6 (5.8-11.9)	5.6 (5.5-5.7)
CF	3.33 (3.3-3.4)	14.5 (11.7-16.6)	18.0 (17.5-18.5)
NFE	64.8 (61.3-67.1)	47.9 (41.2-48.1)	22.2 (21.9-22.4)
NDF, %	-	50.9 (50.6-56.2)	-
ADF, %	-	17.5 (17.3-22.5)	-
Ash, %	6.6 (6.2-8.9)	3.5 (3.1-3.5)	24.0 (23.6-25.2)
Ca, %	1.51	0.29	3.31
P, total, %	1.41	0.48	0.49
ME, MJ/kg	12.9	7.3	9.2

(male French Muscovy crossed with local female Muscovy ducks) and local Muscovy ducks at four weeks of age were used. One-day-old ducklings were selected from a few small holder breeding flocks and fed a commercial diet *ad libitum* from 1 to 28 days of age at the experimental farm. The birds were identified and then all were individually weighed (average initial live weights were around 810 g) each week and at slaughter for each experimental unit. All birds were vaccinated with Duck Plague vaccine and FC3 (pasteurellosis vaccine) at three and four weeks and given antibiotics to prevent common diseases.

The experimental design was factorial with 2 factors: breed, including local and crossbred ducks (male French Muscovy crossed with female local Muscovy) and diet, including five different levels of concentrate (C) and BW offered *ad libitum*: concentrate only as control diet (C100), and levels of 75% (C75), 50% (C50), 25% (C25) and 0% (C0) of the intake of the control diet, and with BW *ad libitum*. There were thus ten treatments and three replicates, with ten birds per replicate (5 males and 5 females). Fresh duckweed was also supplied at the same level of 50-90 g fresh weight per bird per day to supply vitamins and trace minerals.

Expt. 2 was carried out on small holdings in the suburbs of Cantho City where Muscovy ducks are commonly raised on a small scale. Two hundred four-week old Muscovy ducklings (100 males and 100 females) were allocated in a 2×2 factorial experiment with five households as blocks. The first factor was breed (local Muscovy and the crossbreed of local and French Muscovy ducks) and the second factor diet, including concentrate only as the control treatment (C100) and a restricted amount of 50% of the intake of the control diet (C50) and with BW given *ad libitum*. The C50 diet was selected as this was the optimum diet in terms of economic and biological performance determined by Expt 1. Fresh duckweed was supplied at the same level for all birds on each farm to supply vitamins and trace minerals. The experimental birds were identified and then individually weighed initially, weekly and at slaughter at 84 days of age.

Diets and feeding

In the preliminary period (from day 1 to day 28 after hatching) the ducklings were fed a commercial starter diet *ad libitum*, which contained 12.2 MJ ME/kg DM and 19.5% CP (DM basis). The ducks were kept in groups of 10 (5 males and 5 females) from 28 to 84 days in both Expt. 1 and 2.

Concentrate. The ducks in Expt. 1 were fed concentrate only as the control diet (C100), and levels of 75% (C75), 50% (C50), 25% (C25) and 0% (C0) of the amount of the control diet consumed, adjusted daily. The levels of CP in the concentrate given in the starter and finisher periods were formulated from suggested nutrient concentrations in practical diets for meat-type ducks (Yeong, 1992). The concentrate consisted of 52% broken rice, 33% rice bran, 14% fish meal and 1% bone meal. The ingredient and chemical contents of the dietary components are shown in Table 1. The ducks in Expt. 2 were offered concentrate and BW from different sources, and therefore the content of CP in the overall diet (in DM) varied between households. The experimental diet (C50) consisted of restricted amounts of concentrate (50% of control intake), adjusted daily and BW given ad libitum, and with concentrate only as the control diet (C100).

Brewery waste : The BW used in both experiments was bought every day at local breweries located near to Cantho University, and consisted of approximately 30% barley grains residues, 50% broken rice residues and 20% germinated rice residues, with yeast. It was preserved anaerobically in plastic sacks for up to two weeks before feeding. The ducks were supplied with feed twice a day, at 08:30 h and 15:30 h. The refusals, spilled and remaining in the basins, were collected and weighed daily in the morning to calculate the feed intake, and samples were taken for analysis of chemical composition. The concentrate feed, BW and duckweed used were analysed weekly from the start of the experiments.

Duckweed (Lemna spp.) : In Expt. 1 the duckweed was cultivated on ponds enriched with nutrients from pig manure and waste water from the duck farm of Cantho University. The duckweed in Expt. 2 was grown on ponds belonging to the farmers, with nutrients from home waste water, and was harvested daily in the early morning. After collection it was put into bamboo baskets and cleaned by a strong water jet and then left for one hour to drain the excess water. Fresh duckweed was supplemented once per day at 11:00 h (after the concentrate and brewery waste had been given) with the amounts given being around 500-900 g/10 ducks/day fresh weight.

Table 2. Essential amino acid composition of feed components and ideal protein, Expt. 1

Item	Feed ingredient			
	Concentrate*	Brewery waste*	Dukweed	Ideal protein**
Lysine	100	100	100	100
Isoleucine	79	103	83	77
Leucine	151	212	141	130
Methionine	38	51	35	75 (Met+Cys)
Threonine	73	92	123	66
Valine	106	150	110	89

* Analyzed values (lysine as 100). ** Ideal protein for growing ducks, Rose (1997). Absolute values of lysine were 1.28, 0.99 and 0.98% in DM for concentrate, brewery waste and duckweed, respectively.

Housing and management

In Expt. 1 the ducks were confined in divided pens constructed from bamboo, with thatched roofs and concrete floors covered with rice straw for bedding, with an average density of 3-4 birds per m^2. Also there were concrete yards scaffolded with palm leaves to provide shade, and with an average yard area one m^2 per duck The temperature in the house averaged 25-32°C, with a maximum of 37°C. Natural light was used in the day and electric bulbs at night to allow eating as well as to deter mice. The duck yards were cleaned daily in the morning and the duck manure was removed every two weeks. Rectangular 15 cm deep pottery basins were used as drinkers and for bathing and were cleaned twice a day before feeding. The feeders were round plastic basins, 40 cm in diameter and 10 cm deep, which were cleaned daily in the morning.

In Expt. 2 the ducks were housed in thatched sheds built in covered gardens or back yards with a sand surface and partial rice straw cover for bedding, with an average density of three ducks per m^2. They also had access to outside sand yards, averaging 0.5 m^2 per duck. They were raised on wire floors on two farms, with a density sufficient for eating, drinking and resting but without an exercise yard. Round plastic basins were used as drinkers and feeders, and were 30 cm in diameter and 12 cm deep. All were cleaned daily in the morning. Small electric bulbs were used at night during the experimental stage to allow eating as well as discouraging mice.

Chemical analysis

The concentrate, BW and duckweed for both experiments were analyzed for DM, CP (N×6.25), crude fiber (CF), ether extract (EE), and ash by standard AOAC methods (AOAC, 1990). Analyses of neutral detergent fiber (NDF) and acid detergent fiber (ADF) of BW were also done, following the procedure of Goering and Van Soest (1991). The feeds were also analyzed for GE, and ME contents were calculated from these (ME=GE, MJ/kg analyzed×coefficient ME/GE) according to the Standard Tables of Feed Composition in Japan (1995), and Titus and Fritz (1971) for BW. Representative samples of BW, concentrate and duckweed were analyzed for macro- and micro minerals, and essential amino acids.

Measurements

At the beginning of the experiments all ten ducks per experimental unit were weighed individually and then weekly and at the end of the experiment. Daily feed intakes were calculated according to the total feed consumption of the 10 ducks in each pen. At the end of Exp. 1, one representative female and one male bird from each pen were slaughtered for evaluation of carcass and internal organs. Breast muscles were removed and analyzed for DM, CP, EE, and ash.

Statistical analysis

The data were subjected to ANOVA using the General Linear Model (GLM) of MINITAB Reference Manual Release 12 (1998).

Economic analysis

Economic analyses were done using current prices in Vietnamese Dong (VND) to calculate the treatment and breed effects on total income and total expenses (including feeds, ducklings, labour, vaccines and medicines).

RESULTS AND DISCUSSION

Experiment 1

Chemical composition of feed stuffs : The chemical composition of the concentrate, BW and duckweed is shown in Table 1. The levels of CP and ME for a concentrate based diet are consistent with the recommendations of Siregar et al. (1982a) for growing meat-type ducks (12.70 MJ/ME/kg and 16-19% CP). According to Dean (1985), there was no significant effect on weight gain of varying the energy density of the diet from 9.20 to 12.97 MJ/ME/kg.

Analysis of amino acids showed that the most important essential amino acid concentrations in BW are higher than those of the ideal protein reported by Rose (1997) (Table 2). However, it should be pointed out that the digestibilities of the amino acids in BW are probably rather low due to the high fiber content.

The CP content of the duckweed used in the trial was midway in the range of values reported from two earlier studies in Vietnam (Becerra, 1994 and Men, 1996). The variability was found to be high and would have been affected by the nutrient concentrations in the water and season of cultivation.

Feed and nutrient intakes : Daily intakes of dietary ingredients are shown in Table 3. Daily intakes of

Table 3. Daily intakes (g/day) of dietary ingredients by local Muscovy (LM) and crossbred Muscovy (CM) ducks, Expt. 1 (DM)

Item	Beed (B)		Diet (D)					P value	
	LM	CM	C100	C75	C50	C25	C0	B	D
Total DM	115	119	103^{a}	118b	120^{b}	121^{cd}	125^{d}	***	***
Concentrate	49.4	51.1	97.7^{a}	76.5^{b}	51.2^{c}	25.7^{d}	0.0	***	***
Brewery waste	60.7	63.3	0.0	36.1^{a}	63.4^{b}	90.5^{c}	120^{d}	***	***
Duckweed	5.0	5.1	5.1	5.1	5.0	5.0	5.1	ns	ns
Total CP	25.1	26.0	19.8^{a}	24.4^{b}	26.0^{c}	27.6^{d}	29.8^{e}	***	***
Total CF	11.3	11.8	4.16^{a}	8.7^{b}	11.8^{c}	14.9^{d}	18.4^{e}	***	***
ME, MJ	1.13	1.17	1.31^{a}	1.30^{a}	1.17^{b}	1.04^{c}	0.92^{d}	***	***
CP/ME, g/MJ	23.0	23.1	15.2^{a}	18.8^{b}	22.3^{c}	26.6^{d}	32.3^{e}	ns	***

*** Significantly different ($p<0.001$).Values in rows with different superscript letters are significantly different ($p<0.05$).

Table 4. Daily intakes (g/day) of macro mineral and amino acids by local Muscovy (LM) and crossbred Muscovy (CM) ducks, Expt. 1 (DM)

Item	Beed (B)		Diet (D)					P value	
	LM	CM	C100	C75	C50	C25	C0	B	D
Calcium	0.92	0.96	1.64^{a}	1.33^{b}	0.96^{c}	0.58^{d}	0.20^{e}	***	***
Phosphorus	1.01	1.05	1.41^{a}	1.28^{b}	1.05^{c}	0.82^{d}	0.60^{e}	***	***
Arginine	2.00	2.07	1.81^{a}	2.06^{b}	2.08^{c}	2.09^{d}	2.14^{e}	***	***
Leucine	2.30	2.38	1.95^{a}	2.30^{b}	2.39^{c}	2.47^{d}	2.59^{e}	***	***
Lysine	1.28	1.33	1.30^{a}	1.39^{b}	1.33^{c}	1.27^{d}	1.24^{e}	***	***
Methionine	0.57	0.60	0.50^{a}	0.58^{b}	0.60^{c}	0.61^{d}	0.64^{e}	***	***
Threonine	1.07	1.11	0.97^{a}	1.10^{b}	1.11^{b}	1.12^{b}	1.15^{c}	***	***

*** Significantly different ($p<0.001$).Values in rows with different superscript letters are significantly different ($p<0.05$).

concentrate of the crossbred birds were significantly ($p< 0.01$) higher than of the local Muscovy ducks. Daily intakes of BW and total DM increased significantly as the concentrate supplied was reduced, reaching a maximum level on diet C0 (BW only), indicating a high level of palatability. There was a significant difference in intake of CP between the two breeds, consumption being higher for the crossbred ducks. Intake of protein was least on the 100% concentrate diet (C100), and increased with increasing BW intakes, being highest on the BW only diet (C0) as a result of the large amount consumed ($p<0.001$). However, due to the high CF content of the BW the digestibility of the protein is likely to have been low, and in a Japanese study was reported to be only 56% (Standard Tables of Feed Composition in Japan, 1995). Intake of CF of the crossbred Muscovies was significantly higher than that of the local Muscovies, and increased with increasing BW intakes due to the high CF content of BW, the highest daily intake being on 100% BW (C0) (Table 3). This is consistent with studies which reported that ducks were able to consume and digest high fibre diets efficiently (Schubert et al., 1982). The difference between the two breeds in total daily intake of ME was significant ($p<0.001$), and was significantly reduced for both breeds with increasing intakes of BW compared to the ducks given concentrate only. This demonstrates that the ducks were attempting to adjust their feed intake in order to meet their energy requirement, although they were unable to do this as a result of the low ME content of the BW. Sauveur and Stevens (1985) showed that adult Muscovy ducks accurately regulate their feed intake according to the energy content of the diet, with an average ME intake of around 1.89 MJ/day. Daily ME intakes in our experiment (0.92 to 1.31 MJ) were lower than recommended for all treatments, especially for the C25 and C0 diets, and were also lower than those of ducks given duckweed as a replacement for soybean meal in a broken rice based diet (1.45 to 1.61 MJ), reported by Men (1996). The ratios of CP/ME increased markedly with high intakes of BW, to values exceeding the recommendations of Leclercq and Carville (1977), who reported requirements in the range of 9.6-10.3 g CP/MJ ME. However, as mentioned previously, the CP digestibility in BW was probably low.

The intake of essential amino acids was significantly different between breeds and diets (Table 4). The mean dietary concentration of lysine (1.14%) was higher than the reported requirement of 0.65% (0.54 g/MJ ME), and of methionine (0.50%) was slightly lower than the requirement of 0.59% (0.47 g/MJ ME) of Muscovy ducklings during intermediate (3-6) and late (6-10) stages of growth (Leclercq and Carville 1985), but the amino acid digestibility in BW would have been low. In the present study lysine and methionine intakes were higher than those of ducks fed duckweed as replacement for soybean meal in a broken rice based diet in an earlier trial carried out in the Mekong Delta (Men, 1996). The daily intakes of Ca and P decreased with increasing intake of BW, being lowest for ducks given no concentrate, due to the low content of the macro-minerals in BW (Table 4). Leclercq et al., (1989) reported that the Ca requirements of Muscovies were 0.46

Table 5. Effect of level of replacement of concentrate by brewery waste on live weight changes, daily gains and feed conversion ratios of local (LM) and corssbred (DM) Muscovy ducks, Expt. 1

Item	Beed (B)		Diet (D)					P value	
	LM	CM	C100	C75	C50	C25	C0	B	D
Initial weight, kg	0.76	0.92	0.83	0.84	0.85	0.84	0.84	***	ns
Final weight, kg	2.35	2.50	2.54^{a}	2.49^{a}	2.52^{a}	2.37^{b}	2.21^{c}	***	***
Daily gain, g	28.4	29.3	31.1^{a}	30.1^{b}	30.4^{ab}	28.0^{c}	25.0^{d}	***	***
Kg, feed/kg gain	4.07	4.14	3.31^{a}	3.91^{b}	3.94^{b}	4.33^{c}	5.01^{d}	ns	***
ME/gain, MJ/kg	39.4	39.7	42.1^{a}	43.1^{a}	38.5^{b}	37.1^{c}	37.0^{c}	ns	***
CP/gain, g/kg	889	907	639^{a}	811^{b}	858^{c}	989^{d}	1,194^{e}	*	***

*, **, *** Significantly different, $p<0.05$, $p<0.01$ and $p<0.001$, respectively.
Values in rows with different superscript letters are significantly different ($p<0.05$).

Table 6. Effect of level of replacement of concentrate by brewery waste on carcass traits[1] and weights of internal organs[1] of local (LM) Muscovy ducks, Expt. 1

Item	Beed (B)		Diet (D)					P value	
	LM	CM	C100	C75	C50	C25	C0	B	D
Carcass weight, kg	1.55	1.74	1.80^{a}	1.74^{a}	1.73^{a}	1.73^{a}	1.40^{c}	***	***
Carcass %	66.5	66.9	68.5	68.4	66.3	66.3	64.5	ns	ns
Breast muscle, g	301	326	356^{a}	341^{a}	327^{ab}	327^{ab}	249^{c}	**	***
Thigh muscle, g	223	219	237^{a}	228^{a}	239^{a}	239^{a}	193^{b}	ns	**
Liver, g	44.9	60.8	55.0	51.3	5.34	53.4	49.1	***	ns
Gizzard, g	74.3	72.4	56.2^{a}	66.4^{a}	77.4^{b}	77.4^{b}	84.0^{b}	ns	***
Abdominal fat, g	14.2	21.9	25.6^{a}	20.7^{a}	20.9^{a}	19.9^{a}	9.23^{b}	**	ns

[1] Mean of males and females. *, **, *** Significantly different, $p<0.05$, $p<0.01$ and $p<0.001$, respectively.
Values in rows with different superscript letters are significantly different ($p<0.05$).

and 0.42 percent of the diet for the age periods of 3 to 8, and 8 to 12 weeks, respectively, which implies a Ca deficiency on the C0 diet. However P intakes were higher than reported requirements, which implies low Ca:P ratios for all treatments.

Daily weight gains and feed conversion ratios : In Expt. 1 the rates of live weight gain and final live weights of the crossbred Muscovy ducks were significantly higher than those of the local birds, and were similar to those of purebred Muscovy ducks fed concentrates in a previous on-station trial (Lien, 1997). The effect of treatment was significant, with the highest daily gains on the C100, C75 and C50 diets, and the lowest on C0 ($p<0.001$) (Table 5). Rate of gain, therefore, was significantly depressed as BW intakes increased, probably due to the high concentration of fiber in BW, which would have reduced nutrient and energy digestibility. However, daily gain was not significantly reduced when 50% of the concentrate was replaced by BW, and at over 30 g/day was higher than results from similar trials in the Mekong Delta with growing Muscovy ducks given diets based on locally available feed resources such as paddy rice, oysters and water plants (Dong and Ogle, 1995), and duckweed and broken rice (Men, 1996). Studies carried out on brewers' dried grains (BDG) in diets of growing chickens (Lopez and Carmona, 1981) showed significant decreases ($p<0.05$) in the weight gain of birds when the inclusion of BDG was 20% or more, whereas in the present studies up to 50% BW could be included in the diet DM without any decrease in daily weight gains, which implies that ducks can digest high fiber diets more efficiently than chickens, as suggested by Schubert et al. (1982).

Feed conversion ratio was significantly ($p<0.001$) lower for the group fed concentrate only (C100) and increased with increasing intakes of BW, being highest when no concentrate was given (C0) (Table 5). These results are in agreement with reports of Siregar et al., (1982b), Dean (1985) and Yeong (1985) which showed that feed conversion ratios decreased with increases in dietary energy concentration. The regression equation for the relationship between feed conversion ratio and total daily BW intake is as follows:

$Y=3.29+0.013X$, $r^2 = 0.90$
Where Y=feed conversion ratio (kg feed/kg weight gain) and X=BW intake (g/day).

Carcass evaluation : Mean carcass yields of the two breeds, as well as between diets, were significantly different ($p<0.001$) (Table 6). The weights of breast and thigh muscle were significantly higher on the control, C75 and C50% diets than on the C0 diet with only BW ($p<0.001$ and $p<0.01$, respectively). There were no significant differences in weights of the components of the digestive tract, except that the weight of the gizzard increased with increased consumption of BW, probably, due to the large amounts of CF consumed. This result is consistent with a report showing that gizzard weights for both ducks and chickens increased with increasing amounts of fiber in the diet

Table 7. Economic analysis of the effects of breed and replacement of concentrate by brewery waste, Exp. 1 ('000 VND/10 birds; 14,000 VND=1 USD)

Item	Beed (B)		Diet (D)				
	LM	CM	C100	C75	C50	C25	C0
Total feed cost	153	159	190	182	159	135	114
Total expenses*	241	252	280	273	249	226	204
Total income	383	413	419	411	415	392	353
Net profit	141	161	139	139	166	166	148

* Includes feed, medicines, labor and ducking costs.

Based on prices per kg: concentrate 3,000 VND; brewery waste 400 VND; duckweed 200 VND; 5,000 VND/local Muscovy duking and 6,000 VND/crossbred Muscovy ducking.

Table 8. Daily intakes (g/bird) of dietary ingredients and nutrients by local (LM) and crossbred (CM) Muscovy ducks, Expt. 2 (DM basis)

Item	Beed (B)		Diet (D)		P value	
	LM	CM	C100	C50	B	D
Total DM	112	116	103	125	ns	***
Concentrate	75.4	78.0	101	52.4	**	***
Brewery waste	35.6	35.9	0.0	70.5	ns	***
CP	24.3	25.2	19.8	29.7	ns	***
CF	8.09	8.40	3.68	12.8	ns	***
ME (MJ)	1.25	1.29	1.33	1.21	*	***
CP/ME, g/MJ	25.3	27.1	25.3	27.1	*	*

*, **, *** Significantly different. $p<0.05$. $p<0.01$ and $p<0.001$. respectively.

(Siregar et al., 1982c), and the findings of a study on Muscovy ducks fed a high CF diet based on rice bran supplemented with 30% Azolla, which indicated that gizzard weights were significantly higher compared to ducks fed a concentrate diet (Viet, 1994). The effect of total daily CF intake on gizzard weight is illustrated by the following equation: $Y=49.3+2.08X$, $r^2=0.69$. Where Y=gizzard weight (g) and X=CF intake (g/day).

The weight of abdominal fat of the crossbred ducks was higher than that of the local ducks, and for both breeds decreased gradually as the ducks consumed more BW ($p<0.001$) (Table 6).

Health status and economic analysis : Overall mortality was only 1.3%, and throughout the experiment all ducks remained healthy, with no symptoms observed of toxicity or malnutrition, even on the diet that consisted of BW only with a small daily supplement of duckweed.

The economic analysis summarised in Table 7 shows that it is possible to replace 100% of the concentrate by BW supplied *ad libitum*, with feed costs decreasing in proportion to the amount of concentrate replaced, reaching a minimum on the C0 diet on which ducks were only given BW. The net profits from the crossbred ducks were 14% higher than from the local ducks. The highest net benefits were for the C50 and C25 diets, and ducks on the C50 diet produced an optimum carcass weight for consumers. The lowest net profit from ducks on diet C100 was a result of the high cost of the concentrate. Therefore, at current prices there would appear to be marked economic benefits to producers from using cheap BW to replace around 50% of the concentrate in diets for growing Muscovy ducks.

Table 9. Effect of brewery waste as replacement for concentrate on live weights, daily gains and feed conversion ratios of local (LM) and crossbred (CM) Muscovy ducks, Expt. 2

Item	Beed (B)		Diet (D)		P value	
	LM	CM	C100	C50	B	D
Live weight, kg						
Initial	0.74	0.83	0.78	0.79	***	ns
Final	2.48	2.76	2.62	2.61	***	ns
Daily gain, g	30.9	34.3	32.8	32.6	***	ns
FCR	3.73	3.46	3.25	3.94	***	***
ME/gain MJ/kg	40.3	37.8	40.7	37.5	**	**
CP/gain, g/kg	787	738	607	918	*	***

*, **, *** Significantly different. $p<0.05$. $p<0.01$ and $p<0.001$. respectively.

Experiment 2

Feed and nutrient intakes : Daily concentrate intakes of the local Muscovy ducks, and therefore ME intakes, (Table 8) were significantly lower than those of the crossbred ducks ($p<0.01$) and were similar to those of the birds fed the corresponding diets in Expt. 1. The intakes of CF and CP were also approximately similar to the corresponding diets in Expt. 1, and increased significantly when the ducks were given BW on the C50 diet compared to birds fed concentrate only (C100).

Daily weight gains and feed conversion ratios : The final live weights, mean daily weight gains and FCR of the growing ducks are shown in Table 9. The mean daily weight gain of the crossbred Muscovy ducks was significantly higher than that of the local Muscovy ducks ($p<0.001$). probably due to the higher growth potential of the French Muscovies and the heterosis effect. Experimental observations also indicated that the crossbreds had better appetites. The live weight gains were higher than in a previous study in the same village (Dong, 1996) where local and crossbred Muscovy ducks under scavenging conditions were given paddy rice supplemented with fish waste and water plants. Although the between diet difference was not significant ($p>0.05$) there were considerable differences between farms, due to different nutrient concentrations in the concentrates, BW and duckweed used, as well as different management systems. The daily weight gains and final mean live weights in the on-farm trial were slightly higher than those in the on-station trial reported in Expt. 1, possibly due to different sources of ducklings and better management. In spite of higher DM intakes, feed conversion ratio and ME/gain (MJ/kg) were significantly better for the crossbred birds than for the local ducks (Table 9), because of their higher daily weight gains, and was significantly poorer for the group supplemented with BW (C50) compared to the

Table 10. Economic analysis of the effect of using brewery waste as replacement for concentrate for growing local (LM) and crossbred (CM) Muscovy ducks, Expt. 2 ('000 VND/10 bird; 14,000 VND=1 USD)

Item	Breed		Diet	
	LM	CM	C100	C50
Total feed cost	184	190	200	173
Total expenses*	247	253	264	236
Total income	409	455	433	431
Net profit	162	202	169	195

* Includes feed, medicine and duckling costs.
Based on prices per kg: concentrate 3,000 VND; brewery waste 400 VND; duckweed 200 VND; 5.000 VND/local Muscovy duckling and 6.000 VND/crossbred Muscovy duckling.

control diet (C100), due to the higher intake of total DM. FCR were significantly different between farms, and were approximately equal to those of ducks given the corresponding diets in Expt. 1.

Health status and economic analysis : Based on information from the farmers, mortality in the traditional system is normally around 5-10%. However, in the five farms involved in the trial overall mortality was only approximately 3%, probably due to better feeding and management.

The economic analysis given in Table 10 indicates that when up to 50% of concentrate was replaced by BW ad libitum feed costs decreased in proportion to the amount of concentrate replaced, without any reduction in growth performance. The poorer feed conversion on the diet containing BW had no economic significance, and therefore the net profit was considerably higher for ducks supplemented with BW than for ducks fed concentrate only. It was also noted that the net profit varied considerably among farms due to differences in management and feeding methods. Because of their higher growth rate, the net benefits from the crossbred ducks were about 25% higher than from the local birds.

In both experiments the deep orange-yellow colour of the skin and body fat of all ducks, due to the high carotene content in duckweed (1,025 mg/kg of DM), made them more attractive for consumers, and the birds were therefore easier to sell in the market.

CONCLUSIONS AND IMPLICATIONS

It may be concluded from both the on-station and on-farm trials that BW can replace up to 100% of the concentrate in diets for growing local and crossbred Muscovy ducks, but with reduced growth performance and net economic benefits. However, a level of 50% concentrate replaced by BW significantly reduced feed costs, did not depress growth performance or affect carcass traits, and gave the best economic returns. The crossbred Muscovies had better performance and gave higher net profits than the local Muscovy ducks. The results of the trials were received positively by peri-urban producers as well as local government officials, as it was realized that more efficient utilization of the BW would contribute to reducing environmental pollution in the city.

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