Effects of Replacing Fish Meal With Ensiled Shrimp By-Product on the Performance and Carcass Characteristics of Growing Pigs

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ABSTRACT : A feeding trial was conducted to evaluate the effects of replacing fish meal (FM) with ensiled shrimp by-product (ESB) in a cassava root meal and rice bran-based diet on the performance and carcass characteristics of growing pigs. Thirty six crossbred (Large White × Mong Cai) pigs, with an average initial BW of 19.4 kg, were randomly allocated to one of three different dietary treatments in which the crude protein of the FM was replaced with 0, 50 or 100% ESB. The animals were fed restrictedly and at the end of the experiment at a BW of about 90 kg, 6 representative animals in each treatment group were slaughtered for carcass quality evaluation. Animal growth performance and daily feed intake were significantly reduced ($p<0.05$) by the inclusion of shrimp by-products in the diets, whereas feed conversion ratios and carcass measurements were not significantly affected ($p>0.05$). Daily weight gains of the pigs fed the 100% FM diet and 50% ESB diet were significantly ($p<0.05$) higher than those of pigs fed the 100% ESB diet. In conclusion, from an economical as well as performance point of view, ESB can replace 50% of the crude protein of FM in cassava root meal and rice bran-based diets for growing pigs with a low genetic growth potential. *(Asian-Aust. J. Anim. Sci. 2001. Vol. 14, No. 1 : 82-87)*

Key Words : Ensiled Shrimp By-Product, Performance, Carcass Characteristics, Growing Pigs

INTRODUCTION

In Vietnam pig production plays a very important role at both the family and national level, and currently the pig population is estimated at 18 million animals (General Statistical Office, 1999). The majority of the pigs for slaughter are produced on small-scale farms, where the animals are mainly fed using cheap local materials and unconventional feed sources in order to increase profit margins. Generally, conventional protein supplements (e.g. soybean meal and fish meal) for pigs are relatively expensive.

Shrimp production has increased by around 10% annually in the period from 1990 to 1998, and is an important export product in Vietnam. Therefore, the quantities of shrimp by-products (SBP) are increasing, and the total output was estimated to be over 80 thousand tons in 1998 (General Statistical Office, 1999). The increase in shrimp production without a parallel development of an appropriate technology for utilizing the extra SBP has resulted in local pollution problems. Currently, SBP are sun-dried and ground to obtain shrimp meal, which may be effectively used in the feed industry. Unfortunately, sun-drying is not always feasible, especially during the rainy reason.

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In a previous study, Ngoan et al. (2000) found that SBP could successfully be preserved for at least 8 weeks by ensiling with either molasses or cassava root meal. However, there are contradictory reports as to the maximum levels of shrimp meal in diets for pigs, with Göhl (1998) and Lien et al. (1994) recommending no more than 5%, while Tuan (1996) reported that 75% of the crude protein of fish meal could be replaced by ensiled shrimp by-product.

The high contents of chitin and calcium and the low content of methionine have been pointed out as limiting factors in the utilization of SBP for monogastric animal species (Ngoan et al., 2000). Few studies on the effects of inclusion of SBP on carcass characteristics have been carried out (Mohan and Sivaraman, 1993).

The present study aimed at evaluating the effects of replacing fish meal by increasing levels of shrimp by-product ensiled with molasses on the performance and carcass traits of growing pigs with a low genetic growth potential.

MATERIALS AND METHODS

Shrimp by-product silage

For this experiment, shrimp by-product was supplied on five occasions from August to December 1999 by the Seafood Processing Factory in Hue City in Central Vietnam. The by-product originated from two shrimp species (Penaeus monodon and Penaeus semisulcatus), and was immediately ground and mixed with molasses at a ratio of 3:1 (wet weight). This ratio was found to be optimum with respect to silage quality in an earlier study (Ngoan et al., 2000). The mixture was placed into plastic bags of 40 L volume and sealed to prevent air contamination. The bags were stored at room temperature (27-33℃) and the ensiled shrimp by-product (ESB) was used after 3 weeks of ensiling.

Animals and management

Eighteen female and eighteen castrate crossbred pigs (Large White×Mong Cai) from 6 litters with an initial BW of 19.4 kg were housed in 9 concrete pens. During the experiment the average temperature was 25.8±2.5℃ and humidity 86.7±5.3%. The animals were vaccinated against hog cholera and *Pasteurellosis*, and de-wormed 2 weeks before starting the experiment. The pigs were randomly allocated to three treatment groups based on initial BW, litter and sex, and were weighed monthly. The experiment lasted for 124 days for the control group, and 134 and 141 days for the FM-ESB and ESB groups, respectively.

Experimental design, diets and feeding

The experiment was a completely randomized design with three treatments and three replicates, and 4 pigs per replicate (two females and two castrates). The control diet consisted of maize meal, cassava root meal and rice bran, and was supplemented with fish meal (FM) as the sole protein source (table 1). The test diets were based on the control diet with replacement of 50 or 100% of the FM (on a crude protein basis) by ESB, and denoted FM-ESB and ESB, respectively. The diets were formulated according to the two growing phases of the animals, 20-50 kg (phase 1) and 50-90 kg (phase 2). The diets were fed according to a restricted feed allowance (NRC, 1988) and were distributed equally into 3 meals per day at 7:00, 12:00 and 17:00 h. Refusals were collected the following morning before the first meal. Drinking water was available *ad libitum*.

Carcass measurements

For the evaluation of carcass traits, 18 representative pigs of about 90 kg BW were starved for 24 hours and weighed prior to slaughter. Carcass traits were measured according to Kaufman and Epley (1996). Hot carcass weight was measured immediately after slaughter. The P2 backfat thickness was measured on the partitioned carcass 10 cm from the midline behind the 10th rib using a tracer paper and a ruler, and the loin area was measured by tracer paper at slaughter. Lean percentage was calculated as the ratio of lean mass to hot carcass weight: Lean mass=7.231+(hot carcass weight, lb×0.437+(loin area, In^2×3.877)-(P2 backfat thickness, In×18.746) (Kaufman and Epley, 1996).

Muscle samples from the longissimus dorsi were taken at the 10th rib, minced and stored at -20℃ prior to DM and fat analyses. Iodine value was determined in backfat samples, which were taken at the 10th rib, minced and gently rendered, and then stored at 20℃.

Chemical analysis

Samples of dietary ingredients were taken from each batch, homogenized, ground on 1 mm sieves and dried at 60℃ prior to chemical analysis. The chemical composition of dietary ingredients and muscle samples were determined according to standard methods (AOAC, 1984). Dry matter (DM) was measured by drying fresh samples at 100℃ for 24 hours. Total nitrogen (N) was determined on fresh samples by the macro Kjeldahl method and CP was calculated from total nitrogen (N*6.25). Ether extract (EE) was determined by Soxhlet extraction without acid hydrolysis. Calcium and phosphorous were determined according to AOAC (1984) using the dry method and the alkalimetric ammonium molybdophosphate method, respectively. Amino acids were analysed according to Spackman et al. (1958) on an ion-exchange column using an HPLC. Samples were hydrolyzed for 24 hours at 110℃ with 6 mol/l HCl containing 2 g/l reagent grade phenol and 5000 nmol norleucine (internal standard) in evacuated and sealed ignition tubes. Half-cystine and methionine were determined as cysteic acid and methionine sulphone, respectively, with separate samples hydrolyzed for 24 hours as described above following oxidation with performic acid overnight at 0℃ (Moore, 1963). Iodine values were analyzed according to AOCS (1991) using Wijs method. All samples were analyzed in duplicate.

Statistical analysis

Analysis of variance was performed using the general linear model (GLM) procedure of Minitab Version 12 (1998). Pairwise comparisons with confidence levels of 95 were used to determine the effects of dietary treatments between treatment groups. Final BW, daily weight gain (DWG), daily feed intake (DFI) and feed conversion ratios (FCR) were covariated by the initial BW, and carcass length, backfat thickness and loin muscle area were covariated by the BW at slaughter. Results are presented as least squares means with the pooled standard error of the means.

RESULTS

The chemical composition of the ingredients, the dietary formulations and the chemical composition of the diets are shown in tables 1 and 2, respectively. The ESB used in the present experiment had a pH of 4.2, a CP content of 26.9% and a chitin content of

10.7% (on a DM basis). It contained 6.5% calcium (table 1), which resulted in the highest calcium content in the ESB diet (table 2).

The experiment was carried out without any problems concerning diseases. Significantly higher final BW in the FM and FM-ESB groups was found than in the ESB group ($p<0.05$). The number of days on experiment was lower for pigs on the FM diet than for the other two treatment groups ($p<0.05$), and the difference in days on experiment between the two ESB groups was not significant ($p=0.67$). Compared with the FM diet, replacement of 50% and 100% of the FM protein by ESB reduced DWG by around 10% ($p=0.11$) and 20% ($p<0.05$), respectively. A significant decrease in daily feed intake ($p<0.001$) with increasing level of ESB in the diet was found, and daily DM intakes were reduced by 15% for the FM-ESB diet and 24% for the ESB diet compared with the FM treatment group. Feed conversion ratios were not significantly different among treatments ($p>0.05$).

No significant treatment effects were found for any of the carcass traits or meat and fat quality ($p>0.05$; table 4). However, backfat thickness and leaf fat weight tended to decrease with increasing levels of ESB, but not significantly ($p>0.05$). Fat concentration

Table 1. Chemical composition of the dietary ingredients (% of dry matter)

	Dry matter	Crude protein	Ether extract	Ash	Calcium	Phosphorus	Lysine	Methionine
Ensiled shrimp by product	28.0	26.9	2.8	21.0	6.5	1.0	1.6	0.7
Fish meal	89.0	43.9	6.4	31.3	5.5	2.5	2.7	1.0
Rice bran	90.3	11.5	12.0	8.4	0.2	1.7	0.6	0.3
Cassava root meal	91.1	2.9	0.6	2.4	0.7	0.1	0.2	
Maize	90.3	8.9	4.4	1.4	0.2	0.3	0.3	0.2

Table 2. Ingredient (% of dry matter) and chemical composition of the experimental diets

	Diet					
	Phase 1 (20-50 kg)			Phase 2 (50-90 kg)		
	FM	FM-ESB	ESB	FM	FM-ESB	ESB
Ingredients						
Rice bran	51.0	54.0	36.0	41.0	44.0	46.0
Maize meal	2.8	2.4	29.0	6.8	5.9	5.0
Cassava root meal	31.3	25.7	13.0	38.3	33.4	28.6
Ensiled shrimp by-product	-	10.8	21.7	-	10.1	20.1
Fish meal	13.6	6.8	-	12.6	6.3	-
Mineral and vitamin premix[1]	0.3	0.3	0.3	0.3	0.3	0.3
Limestone	1.0	-	-	1.0	-	-
Chemical composition, %						
Crude protein (CP)	13.0	13.1	12.3	12.0	12.0	11.9
Calculated digestible CP[2]	10.5	9.8	9.7	9.7	9.0	9.0
Ether extract	7.3	7.5	6.3	6.3	6.4	6.5
Ash	10.3	10.6	9.3	9.4	9.7	8.8
Calcium	1.35	1.35	1.62	1.34	1.32	1.59
Phosphorus	1.21	1.19	0.90	1.03	1.02	0.98
Lysine	0.8(0.6)[3]	0.7(0.6)	0.7(0.5)	0.7(0.6)	0.7(0.6)	0.7(0.6)
Methionine	0.3(0.2)	0.3(0.2)	0.3(0.2)	0.3(0.2)	0.3(0.2)	0.3(0.2)
Gross energy, MJ/kg DM	13.7	13.7	13.1	13.9	13.9	13.8
Calculated DE, MJ/kg DM[2]	12.5	11.8	11.5	12.6	11.9	11.3

[1] Supplied per kilogram of diet: 6,000 IU vitamin A; 1,150 IU vitamin D_3; 0.4 IU vitamin E; 0.3 mg thiamin; 0.15 mg riboflavin; 2 mg vitamin B5; 0.6 mg vitamin B6; 0.35 mg folic acid; 1 mg vitamin C; 20 mcg biotin; 100 mg iron; 135 mg zinc; 40 mg copper; 67.5 mg manganese; 0.9 mg iodine; 0.1 mg cobalt; 0.06 mg selenium; 7.5 mg lysine; 10 mg methionine.

[2] Calculated DE=GE×digestibility of organic matter of the control diet (91%) and of other diets (86%); and calculated CP=CP×digestibility of the FM diet (81%) and of the other diets (75%) (Ngoan et al., 2000).

[3] Number in brackets is g per 16 g N.

Table 3. Effects of ensiled shrimp by-product on performance of fattening pigs

Parameter	Diet				
	FM	FM-ESB	ESB	SEM	p
Initial live weight, kg	19.7	19.1	19.7	1.33	0.920
Final live weight, kg	91.6^{a}	89.2^{a}	85.0^{b}	1.26	0.009
Days on experiment	124^{a}	134^{ab}	141^{b}	5.02	0.026
Daily weight gain, kg	0.58^{a}	0.52^{a}	0.46^{b}	0.03	0.019
Feed intake, day^{-1}					
kg DM	2.49^{a}	2.11^{b}	1.88^{c}	0.04	0.001
Calculated DE, MJ	31.20^{a}	25.13^{b}	21.43^{c}	5.23	0.004
Calculated digestible CP, g	238.5^{a}	198.9^{b}	175.5^{c}	14.2	0.023
Feed conversion ratios, kg DM kg^{-1} BW gain	4.29	4.03	4.05	0.24	0.779

^{a,b,c} Means with different superscripts within rows are significantly different ($p<0.05$).

Table 4. Effects of ensiled shrimp by-product on carcass characteristics and quality of fattening pigs

Parameter	Diet				
	FM	FM-ESB	ESB	SEM	p
Live weight at slaughter, kg	87.3^{a}	84.3^{ab}	81.8^{b}	1.86	0.04
Weight of hot carcass without head, kg	64.9	63.0	60.1	1.06	0.10
Dressing percentage	74.4	74.8	73.4	2.32	0.35
Carcass length, cm	86.0	91.4	91.1	1.78	0.12
Loin muscle area, cm^{2}	23.27	23.95	24.84	0.89	0.65
Backfat thickness, mm	30.8	29.4	26.4	2.42	0.49
Leaf fat including kidney, kg	2.55	2.21	2.00	0.24	0.33
Dry matter in loin, %	26.9	26.2	27.0	0.52	0.50
Dry matter in backfat, %	94.3	94.9	94.4	0.37	0.89
Fat in loin, %	10.7	10.6	9.3	0.74	0.17
Calculated lean, %	40.2	39.5	39.4	0.42	0.41
Iodine index	63.8	62.7	63.7	1.89	0.56

^{a,b} Means with different superscripts within rows are significantly different ($p<0.05$).

in loin muscle ranged from 9.3 to 10.7% and iodine values of the backfat from 62.7 to 63.8.

DISCUSSION

The chemical composition of shrimp by-products (SBP) used in the present study was (DM basis): crude protein 40%, ether extract 6.7%, chitin 16.2%, ash 26.7% and calcium 9.3%. The values are comparable to the results of various authors (Watkins et al., 1982; Bolagun and Akegbejo-Samsons, 1992; Evers and Carroll, 1996), who reported that the chemical composition of SBP varies widely (DM basis): crude protein 30-55%, ether extract 5-7%, chitin 14-20%, ash 20-40% and calcium 10-15%.

The present results clearly demonstrate that feed refusals increased as the level of ESB increased, thus lowering the daily intake of digestible energy by 19 and 31% for the FM-ESB and the ESB treatment groups, respectively, as compared with the FM treatment group. The ESB contributed 10 and 21% of the DM of the two diets, respectively. Adverse effects on daily feed intake in growing pigs by admixing dried shrimp waste meal (Mohan and Sivaraman, 1993) and shrimp head and animal blood ensiled with molasses (Lien et al., 1994) have been reported previously, supporting our findings. These results indicate acceptability or palatability problems when including even relatively low levels of shrimp waste. In the hot humid conditions of Central Vietnam feed refusals, particularly of the diets containing the moist SBP paste, would be likely to quickly develop unpleasant odors, and the practice of removing feed refusals only once daily would have had severe consequences for the ESB silage, which being moist would have deteriorated more quickly. Moreover, low energy density diets may contribute to the problem of heat dissipation in pigs by raising the heat increment and consequently lowering voluntary feed intake (King, 1987). The hot and humid conditions under which the present experiment was performed would have further worsened the heat dissipation problem.

Reduced DWG of pigs fed ESB as compared with FM as the main protein source has been reported previously by Lien et al. (1994), who found that inclusion of 10% shrimp head and blood ensiled with molasses significantly reduced the growth rate of pigs. Similarly, Mohan and Sivaraman (1993) reported that the inclusion of 6 and 12% of dry prawn waste meal replacing groundnut meal and FM dramatically lowered growth performance of growing pigs by 45 and 53%, respectively. Watkins et al. (1982) reported the dietary inclusion of 8.8% of shrimp meal reduced daily gains of both male and female mink. However, the inclusion of up to 12% krill meal, a shrimp meal like product, did not affected the growth performance of pigs (Tolokonnikov et al., 1976).

The adverse effect of ESB inclusion on daily feed intake for the FM-ESB and the ESB treatment groups, which were reduced by 19 and 31%, respectively compared to the FM group, can be explained mainly by the reduced intake of digestible energy. However, the corresponding daily gains were only 10 and 20%, respectively, lower than for the FM diet. Thus, DWG did not respond linearly to the change in daily intake of digestible energy, probably as a result of the tendency towards more limited energy deposition in backfat, leaf fat and fat in loin with increasing level of ESB compared to the FM group.

The similar feed conversion ratios found for the all diets was unexpected in view of the longer period on the experiment for pigs on the two ensiled shrimp by-product diets, which would result in higher maintenance requirements and feed conversion ratios. However, the higher digestible energy density of the FM diet resulted in carcasses with a higher fat content, which would tend to increase feed conversion ratios and cancel out the effect of the lower maintenance requirement of the FM pigs.

Carcass measurements, color of the longisimus dorsi muscle and fat quality were not significantly affected by dietary treatment in the present study, findings which are supported by the results of Gawecki et al. (1980), who reported that the inclusion of 16.5% of krill meal in the diet of growing pigs did not affect carcass traits. Similarly, Tibbetts et al. (1981) and Kjos and Overland (1999) were unable to find differences in carcass traits of pigs fed up to 9% fish silage in the diet. However, Mohan and Sivaraman (1993) reported that pigs fed 12% dried prawn waste meal had a lower dressing percentage, backfat thickness and eye muscle area. Smith (1977) found that feeding diets with herring offal silage resulted in unacceptable carcasses and tainted meat, but this was not found in our study.

Loin muscle area was low and backfat thickness high compared to existing data (Gawecki et al., 1980), mainly due to the low genetic potential of the pigs used in the present investigation. Also, the low calculated lean percentage of about 40% has to be questioned with respect to the appropriateness of the equation used for the lean percentage calculations (Kaufman and Epley, 1996), which was developed for pigs with a very different body conformation.

Finally, an evaluation of ESB as a protein source for growing pigs has to take into consideration economical calculations under farm conditions. With increasing dietary levels of ESB, the cost per kg weight gain of the pigs decreased as a result of the very low price of the shrimp by-product as compared with FM under Vietnamese conditions. The highest feed cost per kg weight gain was found in the FM group (0.86 USD), followed by the FM-ESB (0.75 USD) and ESB groups (0.72 USD).

IMPLICATIONS

High levels of inclusion of around 20% of the ensiled shrimp by-product in growing pig diets reduced body weight gain and daily feed intake. However, reducing the feeding intensity and quickly removing refusals would limit the negative effect of ensiled shrimp by-product on feed intake. At current prices in Vietnam around 50% of the fish meal in conventional diets for pigs with a low genetic growth potential may be replaced by ensiled shrimp by-product.

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