Effect of ensiled or fresh Golden Apple Snails (*Pomacea spp)* on pig growth performance and production economics

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Abstract

An experiment was carried out to study the effect of replacing fish meal by ensiled (EGAS) and fresh Golden Apple Snail (FGAS) on pig growth performance and production economics. Eighteen individually housed, castrated crossbred pigs (Mong Cai x Large White) with an average live weight of 30 kg were allocated to a Completely Randomized Design, including three treatments and six replicates per treatment. The feeding trial included two periods, a growing (30-50kg) and finishing period (50-70 kg). There were three dietary treatments, designated: C, a basal diet consisting of conventional cereal feedstuffs, salt, a mineral-vitamin premix and fish meal as protein source; diets E and F consisted of the basal diet but with the fish meal replaced by EGAS and FGAS, respectively, to give equal contents of CP in the three diets. Daily DM intake was highest in diet C and decreased when EGAS and FGAS replaced fish meal in diets E and F ($P<0.01$). In the first period DM intake was 1.61 kg/day in diet C, which was higher ($P<0.01$) than in the other two diets (1.51 and 1.45 kg/day for diet F and E, respectively). In the fattening period the DM intake was 2.38 kg/day for diet C, which was higher than for diets E (2.22 kg/day) and F (2.20 kg/day) ($P<0.01$). Daily weight gain (ADG), feed conversion ratio (FCR) and back fat thickness were not different ($P>0.05$) among treatments for both growing and finishing periods, and overall. Over the whole experimental period ADG was 610, 622 and 566 g, and FCR 3.15, 2.89 and 3.22 kg DM/kg gain for diets C, E and F, respectively. Back fat thickness ranged from 3.3 cm for treatment E and F to 4.1 cm for treatment C. Feed cost per kg weight gain, including labor cost (Kip/kg gain), was lowest in diet E (6,008) compared to C (8,331) and F (8,389).

Ensiled and fresh GAS flesh, included in the diets as a protein feed resource replacing fish meal had no negative effects on the growth performance of fattening pigs, and resulted in similar feed conversion ratios. Feed cost/kg live weight gain was over 2000 Kip lower for the diet containing ensiled Golden Apple Snail, and if the snails can be collected from the fields at no cost both fresh and ensiled snails can replace fish meal and give higher economic benefits for smallholder pig producers.

Key words: Growing F1 pigs, ensiled Golden Apple snail, fresh Golden Apple snail, feed cost, feed intake, fish meal, feed cost, back fat thickness daily weight gain.

1. Introduction

Feed cost is the largest component of total production costs of pig production. Expensive high-protein feed resources such as fish meal are often used in pig diets, and if they can be replaced by cheap local feeds the cost of production can be reduced. In 1981 the Golden Apple Snail *(Pomacea Spp)* (GAS) was introduced into Taiwan from Argentina as a food for human consumption and was subsequently introduced into other Asian countries, including Laos (Naylor, 1994).

Presently, GAS is an ecological disaster in the wetlands of Laos, due to its high reproduction rate, fast growth rate and lack of natural enemies (Nilson, 2003). A female snail lays some 300 eggs a week, and snail-invaded wetlands may contain up to ten snails per square meter. However, it is a source of food for low income earners and the poor, so one strategy to control it without damaging the environment is to collect the snails and convert them to animal feed as way of decreasing the numbers (Carlson, 2002). Golden Apple Snail (GAS) (*Pomacea canaliculata*) thus is a potentially valuable high-protein, non-conventional feed resource that abounds in rice paddies in South East Asia (FAO, 1997). The use of processed snail flesh as a protein supplement to animals can increase its feeding value (FAO, 2005).

The aim of the present study was to determine the effect of replacing fish meal by ensiled and fresh GAS flesh on pig growth performance, as well as evaluating the economic efficiency of using GAS in pig diets.

2. Materials and methods

2.1. Location

The experiment was conducted in the ecological farm of the Faculty of Agriculture of the National University of Laos (NUOL), Vientiane, Laos, from July to September, 2004. The mean temperature in the area at the time of the experiment was about 28 ºC (range 24-33 ºC).

2.2. Experimental animals and design

Eighteen castrated crossbred pigs (Mong Cai x Large White), with an average live weight of 30 kg were randomly allocated in a growth performance trial according to a Completely Randomized design. There were three treatments and six replicates (animals) per treatment. The pigs were housed in individual pens of 1.0 m x 1.5 m. The pens had a concrete floor with wooden walls and each pen had a feeder and drinking nipple. The pigs were vaccinated against Swine cholera and de-wormed, and were adapted to the dietary treatments for a 14 day period before starting the experiment.

2.3. Snails and experimental diets

There were three dietary treatments applied: C, a basal diet, consisting of broken rice, rice bran, maize meal, fish meal, salt and a mineral-vitamin premix. The basal diet was formulated to meet requirements according to tropical conditions for F1 fattening pigs from 20-50 kg and 50-70 kg live weight (NIAH, 1995). The pigs in the other two treatments were fed the basal diet, but with the fish meal replaced by ensiled (EGAS) or fresh Golden Apple Snail (FGAS) to give equal contents of crude protein (CP), and designated E and F, respectively. The ingredient and chemical composition of the diets for pigs of 20-50 kg and 50-70 kg is shown in Table 2. The pigs were fed at 5 % of body weight

(DM basis) in equal amounts twice daily at 09:00h and 18:00h. Clean water was supplied *ad-libitum* through nipple drinkers.

The GAS were purchased from farmers every five days, and were kept in hessian sacks and left under shade. Each day water was poured onto them to keep them alive. FGAS preparation: before each feeding occasion, the shell and cover of the snail were removed and then the flesh washed and drained. The flesh was then chopped and ground by a meat grinder into small pieces of 0.5-1 cm in size, and was immediately mixed with the basal diet. Around 50% of the chopped FGAS was taken for making silage, with a ratio of 2 kg of FGAS to 1 kg of additive mixture (90% rice bran and 10 % molasses on a fresh basis, as shown in Table 1).

Table 1. Ratio of DM of snail to additive mixture, as fed

	Ratio *	DM, g/kg	Ratio (a) to (b) DM basis
FGAS (a)	2	181	0.4
Additive mixture (b)			
Rice bran	0.9	916	0.8
Molasses	0.1	713	0.1

* Wet weight, kg

Then the mixture was put into sealed plastic bags and air was removed to avoid contamination. After 21 days of ensiling, the EGAS was fed to the pigs after mixing with the basal diet. The proportions of the body components of the snails are shown in Table 2.

Table 2. Proportions of Golden Apple Snail components, g/kg in fresh basis

	Shell	Flesh	DM of flesh
Golden Apple Snail	319	360	181

2.4. Measurements

The pigs were weighed every 14 days. Individual daily weight gains were calculated by regressing live weight in kg on time in days. Feed intake was recorded daily by weighing the fresh material offered minus refusals that were collected and weighed the next morning. Feed conversion ratios were calculated from individual daily DM intakes and live weight gains. Samples of feed offered and refused were collected daily. Sub-samples were stored in a refrigerator at 4ºC, and were pooled on a weekly basis and analyzed for DM and N (AOAC, 1990).

Amino acids in the GAS flesh were analysed by the method of Spackman *et al* (1958).

2.5. Statistical analysis

The data were analyzed using the General Linear Model procedure of ANOVA in MINITAB 13.31 program (2000) to determine between treatment differences.

3. Results

3.1. Ingredient and chemical composition of the ingredients and diets

The flesh of the fresh and ensiled snails had DM contents of 181 and 453 g/kg, respectively, and 621 and 368 g/kg of CP on a DM basis, respectively (Table 3).

Table 3. Analyzed chemical composition of the feed

ingredients (g/kg, DM basis)

Ingredient	Parameter		
	DM	CP	Ash
Broken rice	852	77	
Maize meal	862	94	11
Rice bran	879	130	59
EGAS*	453	368	53
FGAS**	181	621	149
Fish meal	901	620	
Salt	941		
Premix	970		

* EGAS=Ensiled Golden Apple Snail flesh.
** FGAS=Fresh Golden Apple Snail flesh.
The ingredient and chemical composition of the diets is shown in Table 4.

Table 4. Ingredient and chemical composition of diets (DM basis) for growing (30–50 kg) and finishing pigs (50-70 kg) (g/kg)

	Dietary treatment					
	(30-50 kg)			(50-70 kg)		
	C	E	F	C	E	F
Ingredient composition						
Broken rice	306	215	306	326	250	335
Rice bran	274	330	274	274	315	270
Maize meal	320	290	320	330	330	330
Fish meal	90	-	-	60	-	-
FGAS	-	-	90	-	-	55
EGAS	-	155	-	-	95	-
Salt	5	5	5	5	5	5
Premix	5	5	5	5	5	5
Total	1000	1000	1000	1000	1000	1000
Chemical composition						
DM	868	673	557	869	676	557
CP *	145	144	145	129	126	126

* Calculated from ingredient composition
FGAS=Fresh Golden Apple Snail flesh;
EGAS=Ensiled Golden Apple Snail flesh
C= Control (basal) diet; E= Ensiled GAS diet and F=Fresh GAS diet.

The EGAS and FGAS contents in diets E and F were 155 and 90 g/kg of DM in the growing phase (30-50 kg), respectively, and 95 and 55 g/kg in the finishing phase (50-70 kg), respectively. DM content was much higher in diet C (868 g/kg DM) compared to diets E (670 g/kg DM) and F (557 g/kg DM). For the growing period (30-50 kg) CP content in the diets was around 145 g/kg DM and in the finishing period 127 g/kg DM. The requirement for protein and lysine and methionine + cystine (% of diet DM) for growing F1 pigs (NIAH, 1995) is shown in Table 5, and the amino acid content in fresh Golden Apple Snail flesh is presented in Table 6.

Table 5. Requirement for protein and lysine and methionine+cystine(% of diet DM) for growing F1 pigs (NIAH, 1995)

	Live weight of pigs		
	15-30 kg	**30-50 kg**	**>50 kg**
CP	16.0	14.5	12.0
Lysine	0.90	0.70	0.60
Methionine + cystine	0.45	0.35	0.30

Table 6. Amino acid content in fresh Golden Apple Snail flesh (% of DM)

Amino acid	**% of DM**
Histidine	5.08
Threonine	9.00
Arginine	13.82
Valine	9.23
Methionine	3.48
Phenylalanine	7.10
Isoleucine	8.19
Leucine	15.20
Lysine	4.18

3.2. Feed and nutrient intake

Feed and nutrient intakes are presented in Table 7. Daily DM intake was highest in diet C and decreased when EGAS and FGAS replaced fish meal in diets E and F, respectively (P<0.001). In the growing period (30-50kg) DM intake was highest in diet C (1.61 kg/day), which was higher (P<0.001) than in the other two diets (1.51 and 1.45 kg/day for diet F and E, respectively). In the finishing period the highest DM intake was 2.38 kg/day for diet C, which was higher than diets E (2.22 kg/day) and F (2.20 kg/day) (P<0.001). The mean DM intake over the whole experimental period was 1.93, 1.77 and 1.80 kg/day for diet C, E and F, respectively (P<0.001). The CP intake was higher in treatments E and F than treatment C in both growing and finishing periods (P<0.001) (Table 7).

Table 7. Effect of replacing fish meal by fresh and ensiled Golden Apple Snail on daily feed and nutrient intakes of F1 (Mong Cai x Large White) growing pigs

Parameter	Dietary treatment *			SE	P
	C	E	F		
No of pigs	6	6	6		
Growing period					

(30-50 kg)					
DM, kg	1.61[a]	1.45[b]	1.51[b]	0.022	0.000
CP, kg	230[a]	207[b]	217[b]	3.368	0.000
Finishing period					
(50-70 kg)					
DM, kg	2.38[a]	2.22[b]	2.20[b]	0.037	0.001
CP, g	307[a]	278[b]	275[b]	4.959	0.000
Overall, 30-70 kg					
DM, kg	1.93[a]	1.77[b]	1.80[b]	0.027	0.000
CP, g	262[a]	236[b]	241[b]	3.298	0.000

[a,b] mean values within rows with different superscript letters are significantly different (P<0.001); * See Table 4

3.3. Pig performance

The data for initial weight, final weight, daily weight gain (ADG), feed conversion ratio (FCR) and back fat thickness are shown in Table 8. The final weight and ADG of treatments C, E and F were similar, (P>0.05) in both growing (30-50 kg) and finishing period (50-70 kg). FCR was not significantly different among treatments in both periods and overall (P>0.05). The FCR for diets C, E and F were 2.57, 2.19 and 2.70 kg feed / kg gain (P>0.05), respectively, for the growing period (30-50 kg) and in the finishing period (50-70 kg) 3.76, 4.01 and 3.89 for diets C, E and F, respectively (P>0.05). The back fat thickness was 3.3 cm on diets E and F, and 4.1 cm on diet C (P>0.05).

Table 8. Effect of replacing fish meal by fresh and ensiled Golden Apple Snail on growth performance, feed conversion ratio and back fat thickness of F1 (Mong Cai x Large White) growing pigs.

Parameter	Dietary treatment *			SE	P
	C	E	F		
No of pigs	6	6	6		
Growing period					
(30-50 kg)					
Initial weight, kg	30.1	28.0	32.5	1.501	0.140
Final weight, kg	55.8	55.5	55.9	2.378	0.991
Days	41	41	41		
ADG, g	628	671	572	33.34	0.142
FCR	2.57	2.19	2.70	0.145	0.066
CP, g/kg gain	367	312	387	21.421	0.063
Finishing period					
(50-70 kg)					
Final weight, kg	72.8	71.5	72.1	2.962	0.954
Days	29	29	29		

ADG, g	605	572	578	34.07	0.760
FCR	3.76	4.01	3.89	0.332	0.844
CP, g/kg gain	476	504	485	37.786	0.866
Overall, 30-70 kg					
ADG, g	610	622	566	29.022	0.382
FCR	3.15	2.89	3.22	0.184	0.420
CP, g/kg gain	428	386	432	25.006	0.387
Back fat thickness, cm	4.1	3.3	3.3	2.36	0.176

3.4. Economic analysis

Ingredient and diet costs and an economic analysis of the effect of dietary treatment for the experimental period are shown in Table 9, 10 and 11. Diet costs for C and F were similar for both periods, and were 2,791 and 2,177 Kip/kg DM for the growing period and 2,829 and 2,485 Kip/kg DM for the finishing period, respectively. The cost of diet E was lower, at 2,049 and 2,462 Kip/kg in the growing and finishing period, respectively. The feed cost per kg weight gain, including labor cost, was lowest in diet E (6,008 Kip/kg) compared to C (8,331 Kip/kg) and F (8,389 Kip/kg).

Table 9. Feed cost (Kip/kg DM).

Feed ingredients	Cost, Kip/kg DM
Broken rice	2,113
Rice bran	1,137
Maize meal	1,856
Molasses	1,403
Fish meal	12,215
FGAS	12,640
EGAS	3,374
Salt	2,122
Premix	25,773

1 USD = 10,500 Kip

Table 10. Diet cost (Kip/kg DM)

Diet *	Live weight of pigs	
	30-50 kg	50-70 kg
C	2,791	2,485
E	2,177	2,049
F	2,829	2,462

1 USD= 10,500 Kip ; * See Table 4

Table 11. Economic analysis of dietary treatments (Kip)

	Treatment *

	C	E	F
Growing period (30-50 kg)			
Total feed cost/pig	184,218	129,450	175,143
Finishing period (50-70 kg)			
Total feed cost/pig	171,523	131,920	157,067
Overall (30-70 kg)			
Total feed cost/pig	355,741	261,370	332,210
Weight gain, kg	43	44	40
Feed cost/kg weight gain	8,331	6,008	8,389

1 USD = 10,500 Kip. * See Table 4

4. Discussion

The DM intake was highest for treatment C and decreased by 8 and 7 % in treatment E and F, respectively, which indicated that the presence of EGAS and FGAS in the diets had a negative effect on DM intake. This is in agreement with Ngoan *et al* (2000), who reported that the daily DM feed intake was reduced by 24 % when ensiled shrimp by-product (ESB) replaced fish meal in diets for growing pigs, due to the fact that feed refusals increased as the level of ESB in the diet increased. Also Lien *et al.* (1994) found that inclusion of 10% of a silage made from shrimp heads, blood and molasses, replacing fish meal in growing pig diets, reduced DM intake, but 5% replacement had no effect on intake. Cervantes (1979) showed that the daily DM feed intake was reduced when 100% of the fish meal in the diet was replaced by fish waste silage. Mohan and Sivaraman (1993) also concluded that there were adverse effects on daily DM feed intake in growing pigs by admixing dried shrimp waste meal in the diet. In the present study the inclusion level of EGAS in the growing phase was quite high (155 g /kg), but it is unreasonable to compare the palatability of silages made from different animal protein sources such as GAS, and shrimp and fish waste. In addition to the possible palatability effects, the high moisture content of EGAS and FGAS could also have reduced daily DM feed intake due to bulkiness. Moreover, feed refusals increased when EGAS and FGAS replaced fish meal possibly because of the high environmental temperatures (mean daily temperatures ranged from 24-33 ºC during the experiment), because when heat stressed pigs reduce their heat production during the digestion and metabolism of food by eating less (McDonald *et al.*, 2002). Diets E and F contained high levels of moisture, and would quickly have developed unpleasant odors as a result of the high temperatures, and the practice of removing feed refusals only once daily could have had consequences for the EGAS and FGAS diets, which being moist would have deteriorated more quickly. In addition it is possible that the low pH content in the EGAS diet could have resulted in reduced intake (McDonald *et al.*, 2002).

Lien *et al.* (1994) reported that the ADG of pigs was not different when the pigs were fed a silage of shrimp heads, animal blood and molasses as replacement for fish meal in a cereal-based diet at levels of up to 5 % of diet DM. Ngoan *et al* (2000) also found that when ensiled shrimp by-product replaced 50 % of the fish meal in pig diets this did not affect pig performance. Tolokonnikov *et al* (1976) reported that including krill meal at levels of up to 12% of the diet did not affect the growth performance of pigs. Similarly, feeding diets with raw fish did not affect swine performance according to FAO (2005) As pointed out previously in the present study the inclusion level of EGAS in the growing phase, at 15.5 % in diet DM, was quite high compared to these other studies.

Finally, an evaluation of EGAS and FGAS as a protein source for growing pigs has to take into consideration economical calculations under farm conditions. When replacing fish meal by EGAS, the cost per kg gain of the pigs decreased compared with the fish meal and FGAS diets due to the fact that

fish meal is very expensive in Laos as it is imported, mainly from Thailand. FGAS also was expensive because it was purchased from farmers, and the price includes the labor cost for removing the shell and chopping (labor cost was estimated at 27% of total diet cost). The GAS for ensiling however were collected at a time in the rainy season when the snails were very numerous and the cost low. The result was a similar cost per kg gain for FGAS and the control diet, and a lower cost for the EGAS diet. However, GAS is a locally available feed resource, and if the farmers collect and process the snails themselves, then they can get higher economic benefits from pig production, as well as higher rice yields.

5. Conclusions

- Ensiled and fresh Golden Apple Snail (GAS) flesh as replacement for fish meal had no negative effects for fattening pigs in terms of daily weight gains and feed conversion ratios. However, feed dry matter intakes were lower when EGAS and FGAS replaced fish meal.
- The cost of the diet with ensiled GAS flesh was lower than of the diets with fish meal and fresh GAS, including the labor cost of processing the snails.
- It can be concluded that including the snails in fresh or ensiled form in diets for growing pigs can be profitable if the farmers collect and process the snails themselves, and there should be an additional benefit of higher rice yields.

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