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Ensiled and Dry Cassava Leaves, and Sweet Potato Vines as a Protein Source in Diets for Growing Vietnamese Large White×Mong Cai Pigs

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ABSTRACT : The aim of the present study was to evaluate the effects of replacing 70% of the protein from fish meal by protein from ensiled or dry cassava leaves and sweet potato vines on the performance and carcass characters of growing F1 (Large White×Mong Cai) pigs in Central Vietnam. Twenty-five crossbred pigs (Large White×Mong Cai) with an initial weight of 19.7 kg (SD = 0.84) were allocated randomly to five treatment groups with 5 animals per group (3 males and 2 females). Pigs were kept individually in pens (2.0×0.8 m) and fed one of five diets over 90 days. The control diet was formulated with fish meal (FM) as the protein source while the other four diets were formulated by replacing 70% of fish meal protein by protein from ensiled cassava leaves (ECL), dry cassava leaves (DCL), dry sweet potato vines (DSPV) or ensiled sweet potato vines (ESPV). Animals were fed their diets at 4% of BW. Results showed that final BW, ADG, DMI and feed conversion ratio (FCR) among the experimental treatments were not significantly different (p>0.05). ECL or DCL and ESPV reduced feed cost per unit gain by 8-17.5% compared to the fish meal diet. There were no significant differences in carcass characters among the diets (p>0.05). Lean meat percentages and protein deposition ranged 41.5-45.8% and 40.2-52.9 g/d, respectively. Using ensiled or dry cassava leaves and sweet potato vine can replace at least 70% of the protein from fish meal (or 35% of total diet CP) without significant effects on performance and carcass traits of growing (20-65 kg) pigs. Including cassava leaves and sweet potato vines could improve feed cost and therefore has economic benefits. (**Key Words :** Cassava Leaves, Carcass Characteristics, Feed Costs, Growing Pigs, Protein Deposition, Sweet Potato Vines)

INTRODUCTION

In Vietnam, pig production plays an important role at both the family and national level and at present the pig population is approximately 26.6 million heads (GSO, 2008). Normally, 4-6 pigs are kept per household and pigs are fed locally available feed resources including rice bran, cassava roots or cassava meal, maize meal and vegetables. These feed have low protein content (Pham et al., 2009), and therefore often commercial feeds or fish meal are included as a protein source. These protein supplements, however, are expensive and alternative sources are required to increase overall production efficiency of pigs raised in smallholder farms.

Cassava leaves are a rich in protein and the total essential amino acid content in the protein is higher than in soybean protein (Phuc, 2000; Montagnac et al., 2009). In addition, the CP content in the DM of sweet potato vines (vines and leaves) ranges from 16 to 29% (Dung, 2001) and the protein has a reasonable amino acid (AA) pattern (Woolfe, 1992; Ishida et al., 2000). Being readily available throughout Vietnam, these two protein sources show great promise for livestock. In a previous study, Nguyen et al. (2009) found that AAs in a practical diet for pigs, containing approximately 90% of CP from either cassava leaves and/or sweet potato vines have an apparent ileal digestibility of 0.65 to 0.75. Cassava leaves and sweet potato vines contain a number of nutritionally active factors including linamarin, oxalic acid, phytic acid, tannic acid and trypsin and chymotrypsin inhibitors (Phuc, 2000; Man and Wiktorsson, 2001; Ngudi et al., 2003; Cardoso et al., 2005). Drying or ensiling cassava leaves and sweet potato vines reduces a number of these nutritionally active factors including linamarin (Padmaja, 1989; Cardoso et al., 2005;

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Nguyen et al., 2009), trypsin and chemotrypsin inhibitors (Mosha and Gaga, 1999; Peters et al., 2005). However, additional research is required on the inclusion of cassava leaves and sweet potato vines/leaves as a protein source in practical, traditional diets for growing pigs to replace part of the protein from fish meal.

The aim of the present study was to evaluate the effects of replacing 70% of the protein from fish meal by protein from ensiled or dry cassava leaves and sweet potato vines on the performance and carcass characters of growing F1 (Large White×Mong Cai) pigs in Central Vietnam.

MATERIALS AND METHODS

Ensiling

Fresh cassava leaves were collected at the time of root harvest and spread out on the floor during 5 hours for wilting to increase the dry matter content from about 25 to 30%. The leaves were separated from the stems and petioles, chopped into small pieces (2-3 cm), mixed with 0.5% NaCl and then mixed with rice bran at 5% of the wilted weight of the cassava leaves. The cassava leaf silage was kept in sealed airtight plastic bags with a capacity of 30 kg, and was stored for at least 2 months prior to feeding. After opening the bag, it was fed for a maximum of 5 days.

Sweet potato vines were harvested at 60 days after planting, with subsequent harvests at 20-day intervals. At the time of harvest, 50% of the total branches were cut at 10 cm distance from the main stems. The vines were chopped into small 2-3 cm pieces and spread out on the floor overnight for wilting to reduce the moisture content (from 14 to 19%). Rice bran was used as additive at 10% of the wilted weight of the leaves and common salt was added at 0.5% of the wilted weight of the leaves. The silage was kept in sealed airtight plastic bags with a capacity of 30 kg, and was stored for at least 20 days prior to feeding. After opening a bag, it was fed for a maximum of 4 days.

The ensiled cassava leaves (ECL) or ensiled sweet potato vines (ESPV) were removed from the plastic bags daily and were mixed with the other dietary ingredients (rice bran, maize meal, ensiled cassava root (ECR), fish meal (FM), premix and soybean oil) at the time of feeding.

Drying

Fresh cassava leaves or sweet potato vines were collected and spread out on concrete out-doors in the sun for 2-3 days during which time the DM content of the material increased to 92-93%. The dried leaves were collected and milled through a 1 mm screen whereafter the meal was kept in plastic bags and stored in a dry place. Dry cassava leaves (DCL) and dry sweet potato vines (DSPV) were mixed with the other dietary ingredients at the time of feeding.

Animals and management

The experiment was carried out at Hue University's research farm from January 2006 to May 2006. The protocol of the experiment had been approved by the ethical committee of Hue University, Hue, Vietnam.

Twenty-five crossbred pigs (Large White×Mong Cai) with an initial weight of 19.7 kg (SD = 0.84) were used. The pigs were vaccinated against hog cholera and Pasteurellosis, and de -wormed 2 weeks before starting the experiment. All pigs were allocated randomly by sex into five groups, with each group consisting of 5 pigs (3 males and 2 females). Pigs were kept individually in pens of 2.0×0.8 m (length×width) at the experimental farm station. Animals were fed the test diets during 90 days and were then slaughtered. The feed allowance was fixed at 4% of BW, divided equally into three meals each day (7:00 h, 11:00 h and 16:00 h). The amount was reduced if refusals were observed. Water from the tap was supplied *ad libitum* and feed refusals were collected and recorded daily. Live BWs were measured in the morning before the first meal every month.

Experimental design and diets

The experiment was designed as a completely randomized design, with 5 treatments and 5 replicates. In all the experimental diets, the basal ingredients (ECR, rice bran and maize meal) provided 50% of the protein of the total diet, the remainder being supplied from either FM or cassava leaves and sweet potato vines (ensiled or dry). The protein source in the control diet originated from FM. In the four other diets, 70% of the FM protein was replaced by ECL, DCL, DSPV or ESPV. The chemical composition of ingredients and the composition of the experimental diets are presented in Table 1 and 2, respectively.

The pigs were fed one diet from 20 to below 50 kg (period 1) and another composition from 50 kg onwards to about 70 kg live weight (period 2). The nutrient requirement of the pigs followed the recommendations of the National Institute of Animal Husbandry, Vietnam (NIAH, 2001). The ME content was similar between diets and adjusted by supplementation of soybean oil to the diets (Table 2). The HCN content of the ECL and DCL diets was 43.9 and 31.5 mg per kg DM for the growing period and 41.5 and 31.0 mg per kg of DM for the finishing period. The HCN of the ECL and DCL were higher than that in FM, DSPV and DSPV diets (Table 2).

Carcass measurements

For the evaluation of carcass traits, three randomly chosen pigs (2 males and 1 female) from each treatment were slaughtered at the final BW after a growing period of 160 days. The final BWs were about 60-70 kg. The pigs were starved for 24 h, weighed and then slaughtered at the

Table 1. Chemical composition of the dietary ingredients used to formulate the experimental diets

	Ingredient[1]							
	ECR	Rice bran	Maize meal	FM	ECL	DCL	ESPV	DSPV
Organic matter (% DM)	97.5	91.0	98.4	70.5	92.0	92.2	85.5	86.6
Crude protein (% DM)	2.0	13.4	9.6	49.4	24.2	29.0	19.7	23.1
Crude fat (% DM)	0.5	13.1	4.6	5.3	7.0	6.7	6.4	5.3
Crude fiber (% DM)	2.9	9.4	2.6	ND	14.3	14.9	15.6	16.0
Neutral detergent fiber (% DM)	5.1	20.6	12.7	ND	36.5	36.9	41.5	41.4
Lysine (g/kg DM)	1.02	6.19	3.08	24.23	11.33	12.6	8.33	8.34
Methionine+cysteine (g/kg DM)	0.11	2.70	1.91	9.15	4.82	6.25	4.20	4.29
Metabolisable energy (MJ/kg DM)	12.6	11.9	14.9	12.0	10.8	10.6	9.5	9.5
Hydrogen cyanide (mg/kg DM)	25	ND	ND	ND	198	160	ND	ND

[1] ECR = Ensiled cassava root; FM = Fish meal; ECL = Ensiled cassava leaves; DCL = Dry cassava leaves; ESPV = Ensiled sweet potato vines; DSPV = Dry sweet potato vines; ND = Not determined.

slaughter house in Hue City. Carcass weights were measured according to Kauffman and Epley (2000). Hot carcass weights were measured immediately after slaughter. Carcass weights (the body without blood, hair and internal organs) were recorded and the weight of the hot carcass without head. The carcass ratio was calculated as the ratio

Table 2. Ingredient content (%), chemical composition (% of DM), calculated metabolisable energy content (MJ/kg DM) and hydrogen cyanide content (mg/kg DM) of the experimental diets for the pigs

Ingredients	Diet[1]									
	Period 1 (20 to <50 kg)					Period 2 (>50 kg)				
	FM	ECL	DCL	DSPV	ESPV	FM	ECL	DCL	DSPV	ESPV
Ensiled cassava root	30.0	17.0	20.5	16.3	12.3	40.0	27.4	31.4	27.2	25.0
Rice bran	30.5	30.0	30.0	32.5	33.8	27.5	25.0	25.0	25.7	27.6
Maize meal	25.0	28.0	28.0	24.6	23.5	20.0	26.0	25.0	23.8	20.7
Fish meal	14.0	4.5	4.5	4.4	4.4	12.0	3.6	3.6	3.6	3.5
Ensiled cassava leaves	-	20.0	-	-	-	-	17.5	-	-	-
Dry cassava leaves	-	-	16.5	-	-	-	-	14.5	-	-
Dry sweet potato vines	-	-	-	20.2	-	-	-	-	18.2	-
Ensiled sweet potato vines	-	-	-	-	23.5	-	-	-	-	21.2
Premix[2]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Soybean oil	-	-	-	1.5	2.0	-	-	-	1.0	1.5
	Calculated chemical composition									
Crude protein	14.0	14.0	14.0	14.0	14.0	12.0	12.0	12.0	12.0	12.0
Basal ingredients	7.0	7.0	7.0	7.0	7.0	6.0	6.0	6.0	6.0	6.0
Protein source	7.0	7.0	7.0	7.0	7.0	6.0	6.0	6.0	6.0	6.0
Organic matter	91.5	93.0	93.0	91.6	90.1	92.1	93.7	93.9	92.3	91.8
Crude fat	6.1	7.0	6.6	6.9	7.5	5.4	6.0	5.7	5.8	6.3
Crude fiber	4.4	6.9	6.5	7.5	8.0	4.3	6.3	6.0	6.8	7.3
Neutral detergent fiber	11.0	17.9	16.7	20.9	20.7	10.2	16.2	15.1	20.1	18.6
Lysine	0.64	0.63	0.6	0.58	0.6	0.57	0.55	0.53	0.5	0.53
Ileal digested lysine	0.49	0.46	0.44	0.42	0.45	0.42	0.41	0.39	0.37	0.39
Methionine	0.26	0.29	0.28	0.26	0.28	0.22	0.25	0.24	0.23	0.24
Ileal digested met+cys	0.20	0.21	0.20	0.19	0.21	0.20	0.19	0.18	0.17	0.18
Metabolisable energy	12.8	12.6	12.6	12.6	12.6	12.7	12.6	12.6	12.6	12.6
Hydrogen cyanide	7.5	43.9	31.5	4.1	3.1	10.0	41.5	31.0	6.9	6.4

[1] FM = Fish meal; ECL = Ensiled cassava leaves; DCL = Dry cassava leaves; DSPV = Dry sweet potato vines; ESPV = Ensiled sweet potato vines.

[2] Composition per kg premix: 2,400 mg retinol: 4.32 cholecalciferol, 15,000 mg α-tocopherol, 5,000 mg phytylmenaquirone, 2,000 mg thiamin; 15,000 mg riboflavin, 25,000 mg calcium pantothenate, 30,000 mg niacin, 30 mg cyanocobalamin, 2,000 mg folic acid, 100 mg choline, 100 mg Fe, 115 mg Zn, 40 mg Cu, 0.15 mg Co, 0.6 mg I, 0.3 mg Se.

of carcass mass to live BW after the pigs have been starved for 24 hours. The P_2 back fat thickness was measured on the partitioned carcass 10 cm from the midline behind the tenth rib using a ruler, and loin area was measured by trace paper (70 g/m^2) at slaughter. Carcass length was measured from the first rib to the pubic bone. Lean percentage was calculated as the ratio of lean mass to hot carcass weight:

$$\text{Lean mass (Ib)} = 7.231+(\text{hot carcass weight, Ib}\times 0.437) +(\text{loin area, Inch}^2\times 3.877) -(P_2 \text{ backfat thickness, Inch}\times 18.746)$$

(Kauffman and Epley, 2000).

Chemical analysis

Samples of diet ingredients were dried at 60°C overnight and ground through an 1 mm screen before analysis. DM, CP, crude fiber (CF), NDF and ash were determined in dry samples according to AOAC (1990). NDF was analyzed according to Robertson and Van Soest (1991), with addition of sodium sulfite and alpha amylase. AAs were analyzed according to Spackman et al. (1958) on an ion-exchange column using an HPLC. Samples were hydrolyzed for 24 hours at 110°C with 6 mol/HCL containing 2 g/L reagent grade phenol and 5,000 nmol norleucine (internal standard) in evacuated and sealed ignition tubes. Methionine+cysteine content were determined as methionine sulphone+cysteic acid with separate samples hydrolyzed for 24 hours as described above after oxidation with performic acid overnight at 0°C (Moore, 1963). All samples were analyzed in triplicate while amino acids with were determined in duplicate.

Data collection

Pigs were weighed at the start of the experiment and on the sixth day of each month during the experimental period at 06:00 h in morning, before the first meal. Refused feed was collected and recorded daily in order to determine daily DMI. Feed cost/kg live weight gain, and protein and fat deposition were calculated for each treatment. Feed cost was calculated by quantity of in feed eaten by each pigs and price of 1 kg DM feed. We calculated quantity of DM intake. And the cost was derived by calculating for each ingredient the market price and amount used. So only ingredient costs were included.

To calculate the approximate protein and fat deposition, the following assumptions were made: one gram of protein and fat contains 23.4 and 39.7 kJ of energy per gram, respectively (NRC, 1998) and

$$\text{ME intake} = \text{MEm}+c\times\text{protein deposition} +d\times\text{fat deposition}$$

where MEm is the amount of ME required for maintenance (460 kJ of ME per kg of metabolic BW ($BW^{0.75}$)); c and d represent the amount of ME needed for the deposition of 1 g of protein and fat, respectively. The required amount of ME per g of protein and fat deposition was assumed to be 53 and 53 kJ ME per g (NRC, 1998).

On the basis of literature review of Kotarbinska and Kielanowski (1969) it can be assumed that about 10% of weight gain is gut fill and ash, thus, 0.9×ADG = water+protein+fat.

The deposition rate of protein and fat in the empty body of the two genotypes were calculated base on the two following equations:

$$0.9\times\text{ADG} = F+P/0.21$$

where ADG is average rate of gain (g/d), 0.21 is protein/(protein+water), F is the amount of fat deposited (g/d); P is the amount of protein deposited (g/d) and

$$\text{MEp} = F\times 53+P\times 53$$

Where MEp is the metabolizable energy used for fat and protein deposition, F is the amount of fat deposited and P is amount of protein deposited.

Statistical analysis

Analyses of variance was conducted using the following model:

$$Y_{ij} = \mu+T_i+e_{ij}$$

where Y is the dependent variable, μ is the overall mean, T_i is the treatment effect (i = 1, 2, 3, 4, 5) and e_{ij} is the random error.

Data collected were analyzed by ANOVA using the General Linear Model (GLM) of the Minitab Statistical Software Version 14 (2004). Tukey pair-wise comparison was used to determine differences between treatment means at $p<0.05$.

RESULTS

There were no significant differences in the final BW, ADG, DMI and FCR of the pigs fed the various experimental diets ($p>0.05$; Table 3).

The final BW and ADG of the pigs were not different among dietary treatments ($p>0.05$). DMI of the pigs was the highest for the FM and lowest for the DSPV diet but again no significant differences were observed between treatments ($p>0.05$). FCR tended to be different among treatments with pigs fed the DSPV diet having higher values than those fed the FM, ECL or ESPV diets (p =

Table 3. Effect of dietary protein source on the performance of F1 crossbred (Large White×Mong Cai) pigs

Parameter	Diet[1]					SEM	p-value
	FM	ECL	DCL	DSPV	ESPV		
Number of pigs	5	5	5	5	5	-	-
Initial BW (kg)	19.3	19.7	20	19.8	19.7	0.40	0.81
Final BW (kg)	61.8	60.5	59.3	55.5	61.5	3.14	0.63
ADG (g/d)	470	456	436	394	464	34.8	0.55
DMI (kg DM/d)	1.46	1.41	1.42	1.34	1.42	0.08	0.88
FCR (kg DM/kg gain)	3.1	3.1	3.3	3.4	3.1	0.09	0.057
Feed cost (VND/kg gain)[2]	11,636[ab]	9,763[b]	11,057[ab]	11,702[a]	10,698[ab]	318	0.002

[1] FM = Fish meal; ECL = Ensiled cassava leaves; DCL = Dry cassava leaves; DSPV = Dry sweet potato vines; ESPV = Ensiled sweet potato vines; FCR = Feed conversion ratio.

[2] Price of fresh feed in Hue at the time of the study (Viet Nam Dong, VND/kg): ECR, 600; rice bran, 3,100; maize, 3,000; fish meal, 8,500; ECL, 550; DCL, 2,800; ESPV, 550; DSPV, 2,500; premix, 30,000; soybean oil, 12,000. At the time of the study: 1 USD = 16,000 VND.

[a,b] Values within rows with differing superscript letters are significantly different ($p<0.05$).

0.057). Calculating the feed cost per kg of live weight gain showed a significantly difference among the experimental diets (p = 0.002). The feed cost per kg of live weight gained was higher for the DSPV diet than for the ECL diet. Although not significant, compared to the control diet (FM), the DSPV was equally as expensive while the diets containing ECL, DCL and ESPV as a protein source were 16.1, 5.0 and 8.1% less expensive.

No significant dietary treatment effects were found for any of the carcass traits ($p>0.05$, Table 4). The 3 pigs randomly chosen for carcass evaluation (2 males and 1 female) had a somewhat higher BW than the mean values presented in Table 3.

None of the carcass parameters measured were found to be significant between treatments. Loin muscle area and lean meat percentage were numerically higher for the pigs fed the DCL and DSPV diets. Carcasses of pigs fed the DCL and DSPV diets had a numerical higher lean meat percentage than pigs on the other diets.

There were no significant treatment effects for the estimated fat and protein deposition of the F1 pigs ($p>0.05$, Table 5).

Protein deposition of the pigs was numerically higher when fed the FM, ECL and ESPV diets compared to the DCL and DSPV diets.

DISCUSSION

Cassava leaves are rich sources of protein with a total essential AA content higher than soybean protein (Eggum,

Table 4. Effect of dietary protein source on the carcass characteristics of F1 crossbred (Large White×Mong Cai) pigs

Parameter	Diet[1]					SEM	p-value
	FM[2]	ECL	DCL	DSPV	ESPV		
Number of pigs	3	3	3	3	3	-	-
Live weight at slaughter (kg)	63.7	62.7	61.8	57.2	61.8	3.82	0.785
Headless hot carcass weight (kg)	43.7	42.3	43.2	39.5	43.2	2.95	0.857
Dressing percentage (%)	68.5	67.4	69.8	69.0	69.9	0.81	0.274
Carcass length (cm)	76.8	79.0	80.0	74.7	78.0	2.81	0.711
Loin muscle area (cm^2)	24.4	23.7	26.2	25.6	24.8	1.19	0.633
Back fat thickness P_2 (cm)	3.1	3.2	2.9	2.9	3.1	0.13	0.388
Lean meat (%)	43.1	41.5	45.8	45.2	43.0	1.49	0.301

[1] FM = Fish meal; ECL = Ensiled cassava leaves; DCL = Dry cassava leaves; DSPV = Dry sweet potato vines; ESPV = Ensiled sweet potato vines.

Table 5. Effect of dietary protein source on the fat and protein deposition of F1 crossbred (Large White×Mong Cai) pigs between 20-65 kg

Deposition	Diet[1]					SEM	p-value
	FM	ECL	DCL	DSPV	ESPV		
Fat (g/d)	182.4	165.3	175.4	164.9	166.1	13.8	0.214
Protein (g/d)	50.8	51.0	45.5	40.2	52.9	4.1	0.214

[1] FM = Fish meal; ECL = Ensiled cassava leaves; DCL = Dry cassava leaves; DSPV = Dry sweet potato vines; ESPV = Ensiled sweet potato vines.

1970; Phuc, 2000; Montagnac et al., 2009). The CP content in the DM of sweet potato vines (vines and leaves) ranges from 16 to 29% (Farrell et al., 2000; Hartemink et al., 2000; Dung, 2001). Cassava leaves and sweet potato leaves have been used as a protein supplement for feeding pigs and can, at least partly, replace FM, soybean meal and groundnut cake in pig diets (Phuc, 2000; Phuc et al., 2001; An et al., 2005). There is limited information on the performance of pigs fed diets where traditional protein sources are replaced by ensiled or dry cassava leaves and sweet potato vines. Van An et al. (2005) reported that the daily weight gain of F1 (Large White×Mong Cai) pig was 542 g/d when fed diets containing FM protein, while the daily BW gain of F1 was only 482 g/d when the protein source came from sweet potato leaves. In the present study, we found that there were no significant differences in the final BW, ADG, DMI, FCR and carcass traits among the experimental diets. These results demonstrated that 70% of the CP from FM in diets for pigs can come from cassava leaves and sweet potato vines in either ensiled or dried form without reducing performance.

Fresh cassava leaves have a high HCN content and drying or ensiling of cassava leaves and roots can markedly reduce the HCN content (Phuc, 2000; Ngudi et al., 2003, Borin et al., 2005). Cassava leaves can be preserved up to 3 months by common ensiling methods which improves the nutritional quality by reducing the HCN content up to 80% of the original concentrations found in the leaves (Nguyen et al., 2009). The HCN concentration of the cassava leaves diets (ECL and DCL) was higher than in the other FM, DSPV and ESPV diets. No indication of cyanide toxicity was observed in any of the pigs fed the diets containing HCN in the present study. Growth performance of the animals on the various diets was not significantly different indicating that the pigs fed the HCN containing diets did not have a reduction in growth. In animals, the lethal dose of HCN is generally reported to be between 0.66 and 15 mg/kg BW for various species (WHO, 1965; Leng, 2005). Tewe (1992) reported a toxicity level of HCN for pigs of 3.5 mg/kg BW. The pigs in the present study fed the ECL and DCL diets ingested approximately 1.02 and 0.75 mg HCN per kg BW or about 1/3 of the reported levels which are considered toxic.

Several studies which used forages in diets for growing pigs indicate that forages can partly replace cereals without affecting performance. Scipioni and Martelli (2001) included ensiled sugar beet pulp at 10% of DM diet without affecting the growth performance of fattening pigs while increasing the level to 20% of DM diet reduced feed intake but made no difference to the carcass quality of the pigs. Differences in lean meat content in our study were not significant different between treatments. There was however a significant difference in feed cost among the experimental diets. The ECL, DCL and ESPV diets of growing pigs had a lower cost compared to the control diet (FM) indicating that profitability is better using these diets. Recently, Hoanh et al. (2006) found that using ESPV in diets of growing pigs improved daily BW gain by 13% and feed cost by 17.7% compared to diets using fresh sweet potato vines. In the study here, the ECL diet was the most economical to use.

Feed conversion ratio for FM, ECL and ESPV treatments, tended to be lower than for the pigs fed the DCL and DSPV diets. This finding is in accordance with a number of studies where cassava leaves or sweet potato leaves have been used as protein source in diet of pigs (Phuc et al., 2000; Nguyen et al., 2004; Van An et al, 2005). Differences in lean meat content were not significantly different between the treatments. This result is in good agreement with Van An et al. (2005) who also reported similar values for carcass traits of F1 (Large White×Mong cai). These authors reported that lean meat percentage of F1 pigs were 43.6, 42.5, 42.6 and 43.4% when protein from FM, groundnut cake, ensiled sweet potato leaves or ensiled sweet potato leaves, respectively were used with added lysine. These authors also concluded that sweet potato leaves can replace FM and groundnut cake in traditional Vietnamese diets for growing pigs. Ngoan et al. (2001) found that the lean meat content was a 40.2% when using FM as a protein source in addition to cassava root meal and rice bran in the diet of F1 (Large White×Mong cai) pig.

Fat and protein deposition of the F1 pigs were not significantly affected by the dietary treatment in the present study. There were no significant differences in the intake with regard to ME, CP, lysine or methionine among diets. In a recent study into the ileal digestibility of AAs of cassava leaves and sweet potato vines both in silage and in dry form in diets for pigs, we found that AAs from cassava leaves and sweet potato vines have an ileal digestibility of 0.65 to 0.75 (Nguyen et al., 2009). The pigs in the present study received similar amounts of ileal digestible methionine+ cysteine as well as similar amounts of metabolisable energy. However, the ADG of pigs fed the FM diet (470 g/d) tended to be higher than the pigs fed the cassava leaves and sweet potato vines diets. Data in Table 5 shows that the estimates of fat and protein deposition in pigs fed the FM diet was slightly higher for fat and similar to the other treatments. Table 5 also shows that protein depositions of the pigs fed the FM, ECL and ESPV diets were numerically higher than the pigs fed the DCL and DSPV diets. These results can be explained by the ileal digested methionine+cysteine and lysine content of the diet which was strongly correlated with the protein deposition. Protein deposition and indirectly fat deposition are dependant on the first limiting AAs. It is well known that methionine is the most limiting amino acid in cassava leaves (Eggum, 1970; Phuc, 2000;

Montagnac et al., 2009) and lysine is the most limiting AA in sweet potato vines (Woolfe, 1992; An et al., 2003).

CONCLUSION

Using ensiled or dry cassava leaves and sweet potato vines replacing 70% of the CP from FM in diets and providing 35% of the total CP had no effect on the performance and carcass traits of the Large White×Mong Cai pigs. Cassava leaves and sweet potato vines can be used as a protein supplement for feeding pigs at a relatively high inclusion level without negative effects on performance if HCN concentrations are below levels known to be toxic to pigs. Higher returns are possible if ensiled or dry cassava leaves and sweet potato vines are used in diets for pigs.

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REFERENCES

An, L. V. 2004. Sweet potato leaves for growing pigs. Doctoral thesis. Swedish University of Agricultural Sciences Uppsala, Sweden.

An, L. V., B. E. F. Lindberg and J.E. Lindberg. 2003. Effect of harvesting interval and defoliation on yield and chemical composition of leaves, stems and tubers of sweet potato (*Ipomoea batatas* L (Lam.)) plant parts. Field Crops Res. 82: 49-58.

AOAC. 1990. Official methods of analysis. 15 th edn. Association of Official Analytical Chemists, Arlington, Virginia.

Bolhuis, G. G. 1954. The toxicity of cassava root. J. Agric. Sci. 2: 176-185.

Borin, K., J. E. Lindberg and R. B. Ogle. 2005. Effect of variety and preservation method of cassava leaves on diet digestibility by indigenous and improved pigs. Anim. Sci. 80:319-324.

Cardoso, A. P., M. Mirione, M. Ernesto, F. Massaza, J. Cliff, M. Haque and H. Bradbury. 2005. Processing of cassava roots to remove cyaogens. J. Food Compost. Anal. 18:451-460.

Dung, N. N. X. 2001. Evaluation of green plants and by-products from the Mekong Delta with emphasi on fibre utilization by pigs. Ph.D. Thesis, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Eggum, B. O. 1970. The protein quality of cassava leaves. Br. J. Nutr. 24:761-769.

GSO (General Statistical Office). 2008. Statistical Publishing House, Hanoi, Vietnam.

Farrell, D. J., H. Jibril, P. Maldonada and P. F. Manion. 2000. A note on a compassion of the feeding value of sweet potato vines and lucerne meal for broiler chickens. Anim. Feed Sci. Technol. 85:145-150.

Hartemink, A. E., S. Poloma, M. Maino, K. S.Powell, J. Egenae and J. N. O'Sullivan. 2000. Yield decline of sweet potato in the humid lowlands of Papua New Guinea. Agric. Ecosyst. Environ. 79:259-269.

Hoanh, M. T., D. Peters and N. T. Tinh. 2006. Use of ensiled sweet potato roots and vines for pig feed in Vietnam. Acta Hortic. 703:133-140.

Ishida, H., H. Suzuno, N. Sugiyama, S. Innami, T. Tadokoro and A. Meakawa. 2000. Nutritive value on chemical components of leaves, stalks and stems of sweet potato (*Ipomoea batatas* Poir). Food Chem. 68:359-367.

Kauffman, R. G. and R. J. Epley. 2000. Pork industry handbook. U.S. Grain Council Agricultural Publishing House, Ha noi. pp. 913-938.

Kotarbinska, M. and J. Kielanowski. 1969. Energy balance studies with growing pigs by the comparative slaughter technique 4th symposium on energy metabolism Warsaw EAAP publish 12: 299-310.

Man, N. V. and H. Wiktorsson. 2001. Cassava tops ensiled with or without molasses as additive effects on quality, feed intake and digestibility by heifers. Asian- Aust. J. Anim. Sci. 14:624-630.

McDonald, P., R. A. Edwards, J. F. D. Greenhalgh and C. A. Morgan. 1995. Animal nutrition. Fifth edition. Longman Scientific and Technical, Harlow, Essex, England.

Mintab Reference Manual. 2004. Release 14 for Windows. Minitab Inc., USA.

Moore, S. 1963. On the determination of cystine as cysteic acid. J. Biol. Chem. 238:235-237.

Montagnac, A. J., R. D. Christopher and S. A. Tanumihardjo. 2009. Nutritional value of cassava for use as a staple food and recent advances for improvement. Compr. Rev. Food Sci. Food Saf. 8:186-194.

Mosha, T. C. and H. E. Gaga. 1999. Nutritive value and effect of blanching on the trypsin and chymotrysin inhibitor activities of selected leafy vegetables. Plant Foods Hum. Nutr. 54:217-283.

National Institute of Animal Husbandry (NIAH). 2001. Composition and nutritive value of animal feeds in Vietnam. Agriculture Publishing House, Hanoi. p. 391.

Ngudi, D. D., Y. H. Kuo and F. Lambein. 2003. Cassava cyanogens and free amino acids in raw and cooked leaves. Food Chem. Toxicol. 41:1193-1197.

Nguyen, L. Q., H. Everts, H. T. Hue and A. C. Beynen. 2004. Feeding of spinach or sweet potato leaves and growth performance of growing pig kept on smallholder farms in Central Vietnam. Trop. Anim. Health Prod. 36:815- 822.

Ngoan, L. D., O. Brian and J. E. Lindberg. 2000. Effect of replacing fish meal with ensiled shrimp by-products on the performance and carcass characteristics of growing pigs. Asian-Aust. J. Anim. Sci. 14:82-87.

Nguyen, T. H. L., M. W. A.Verstegen and W. H. Hendriks. 2009.

Ensiling techniques for preserving cassava leaves. Anim. Feed Sci. Tech. (submitted).

Padmaja, G. 1989. Evaluation of techniques to reduce assayable tannin and cyanide in cassava leaves. J. Agric. Food Chem. 37:712-716.

Pham, K. T., N. D. Hoang, L. D. Ngoan, W. H. Hendriks and W. W. A. Verstegen. 2009. Nutritional constraints and possibilities for pig production on smallholders farms in Central Vietnam. Asian-Aust. J. Anim. Sci. (in press).

Peters, D., N. T. Tinh, M. T. Hoan, N. T. Yen., P. N. Thach and F. Keith. 2005. Rural income generation through improving crop-based pig production systems in Vietnam: Diagnostics, interventions, and dissemination. Agric. Human Values 22:73-85.

Phuc, B. H. N. 2000. Tropical forages for growing pigs. Ph.D Thesis, Swedish University of Agricultural Sciences Uppsala, Sweden.

Phuc, B. H. N. and J. E. Lindberg. 2001. Ileal digestibility of amino acids in growing pigs given cassava root meal diets with inclusion of cassava leaves, leucaena leaves and groundnut foliage. Anim. Sci. 72:511-517.

Phuc, B. H. N., B. Ogle and J. E. Lindberg. 2000. Effect of replacing soybean protein with cassava leaf protein in cassava root meal based diets for growing pigs on digestibility and N retention. Anim. Feed Sci. Technol. 83:223-235.

Ravindran, V. 1993. Cassava leaves as animal feed: Potential and limitations. J. Sci. Food Agric. 41:45-53.

Scipioni, R. and G. Martelli. 2001. Consequences of the use of ensiled sugar beet-pulp in the diet of heavy pigs on performance, carcass characteristics and nitrogen balance: a review. Anim. Feed Sci. Technol. 90:81-91.

Spackman, D. H., W. H. Stein and S. Moore. 1958. Automatic recording apparatus for use in chromatography of amino acids. Anal. Chem. 30:1190-1206.

Van An, L., T. T. T. Hong, B. Oble and J. E. Lindberg. 2005. Utilization of ensiled sweet potato (*Ipomoea batatas* (L.) Lam) leaves as a protein supplement in diets for growing pigs. Trop. Anim. Health Prod. 37:77-88.

Van Soest, P. J., J. B. Robertson and B. A. Lewis. 1991. Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3583-3597.

Woolfe, J. A. 1992. Sweet potato: an untapped food resource. Cambridge University Press, Cambridge, p. 643.