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Effect of fresh *Stylosanthes guianensis (CIAT 184*), and cassava foliages (*Manihot esculenta* Crantz), fed separately or in a mixture, on feed and nutrient intake and growth performance of pigs

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Abstract

A growth trial was conducted with a total of 16 crossbred (Large White x Mong Cai) castrated male pigs of 23 kg mean initial live weight. After 4 weeks for adaptation and vaccination, they were distributed at random into four treatments to study the effect of feeding *ad libitum* a basal diet (Ctrl) fed alone or together with fresh *Stylosanthes guianensis (CIAT 184*) (Stylo) (ST) and cassava foliages (CT) offered alone or in a mixture (MIX), on intake, growth performance and carcass quality.

Mean total daily DM intakes were 1148, 1383, 1488 and 1602g for treatments Ctrl, CL, ST and MIX, respectively (P<0.001). Average daily gains (ADG) were 363, 425, 561 and 582g for treatments Ctrl, CL, ST and MIX, respectively (P<0.001). Feed conversion ratios (FCR) were 3.16, 3.25, 2.65 and 2.75 kg feed/kg gain for treatments Ctrl, CL, ST and MIX, respectively (P>0.05). There were no consistent effects on carcass quality and organ development. Economical efficiency was improved by offering the foliages, and feed cost/kg live weight gain was 8,582, 8,466, 7,033 and 7,249 Kip for the Ctrl, CL, ST and MIX treatment, respectively.

It was concluded that the mixture of fresh stylosanthes and cassava foliages fed together *ad libitum* improved the quality of the overall diet, which resulted in higher intake, growth rate, better feed conversion ratio and economical efficiency. Including the foliages made use of locally available, low cost resources.

Key words: Growth performance; Crossbred pigs; *Stylosanthes guianensis* CIAT 184; *Manihot esculenta* Crantz; Carcass quality; Economic benefits, Feed intake.

1. Introduction

The livestock sub-sector in Lao PDR plays an important role in generating cash income for smallholder farmers. In particular poultry and pig production can be further developed in rural areas to increase the daily protein intake of the people and to generate cash income for the households (Horne *et al*, 2000). The present production system for monogastrics is commonly subsistence with low inputs. The main constraints for this kind of farming are disease and feed supply, both in terms of quality and quantity. Local breeds are still predominant in the rural production systems and the preference for local breeds is high throughout the country. Feed supply relies mostly on crop residues and wastes from the households, and chickens and pigs are let loose to scavenge in the villages (Bouahom, 1997).

Cassava (*Manihot esculenta,* Crantz) leaves contain cyanogenic glycosides that can affect pig health and performance. However, in terms of nutritive value cassava leaves have a great potential for feeding animals (Phuc, 2000). *Stylosanthes guianensis,* CIAT 184 (Stylo) foliage also can be fed to pigs and is a locally available resource widely cultivated in Laos (Horne, 1997). A mixture of cassava foliages and stylosanthes may be better than the individual plants fed separately, because: (I) Together they may have a better amino acid balance (ii) Total intake of the mixture may be higher. It is known that about 60 to 70% of the total production cost of small monogastric livestock is feed, and therefore technical options to reduce this cost are required.

The objective of this experiment was to maximize the utilisation of locally available low protein feed resources, particularly maize, broken rice, and rice bran as feeds for pigs, and to determine the effect of complementary protein sources, Stylo and cassava leaves, supplied *ad libitum,* either separately or in a mixture, on intake and growth performance and carcass quality of crossbred pigs.

2. Material and Methods

2.1 Location and climate of study area

The experiment was conducted in the Livestock Research Centre, which is located about 40 km from Vientiane, Lao PDR, at an altitude of 150 m above sea level. The climate in this area is divided into two main seasons: dry and wet. The wet season lasts 6 months from May to October. Annual rainfall averages about 1600 mm and the peak rainfall occurs in the period July to August. The dry season lasts from November to April. Only about 1 to 2% of the annual rainfall occurs during the dry season. The experiment was carried out during the months July to September, when the mean daily maximum temperature was around 38^{o}C and total rainfall 2500 mm.

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2.2 Experimental design, treatments and management

A growth performance trial was carried out with 16 individually housed crossbred (Large White x Mong Cai) castrated male pigs of average initial live weight 20 kg. The pigs were allocated at random to four dietary treatments, with four replications, according to a completely randomized design (CRD). The dietary treatments were as follows:

- Ctrl -Basal diet (*ad-libitum*)
- CL - Basal diet (*ad- libitum*) + cassava foliages (*ab-libitum*)
- ST- Basal diet (*ad-libitum*) + fresh stylosanthes (*ad-libitum*)
- MIX- Basal diet (*ad-libitum*) + a mixture of 50% cassava foliages + 50% fresh stylosanthes, on DM basis (*ad-libitum*)

The fresh stylosanthes (*Stylosanthes guianensis*, CIAT 184) and cassava foliages (*Manihot esculenta*, Crantz, Rayong 72) were offered separately from the basal diet. The pigs were vaccinated against swine fever and were treated with Ivomectin against external and internal parasites. All pigs were weighed at the beginning of the experiment and allocated at random to the four dietary treatments, and were randomly distributed and housed individually in 1.5 m x 1.8 m /pens following the experimental design. Before commencement of the experiment all pigs were allowed to adapt the conditions of the experiment for 15 days, especially to the experimental feeds.

2.3. Experimental feeds

The cassava foliages were harvested from 4 month-old plants grown in plots at the Livestock Research Centre. The leaves were not separated from the petioles and stems, chopped to about 2 to 3 cm lengths, and were then spread out in the shade with cross ventilation and wilted for three days before being offered to the pigs. Each morning fresh Stylo 184, at the age of 2 to 3 months, was cut and carried from fields near the pig house, then chopped into 4 to 5 cm lengths and fed immediately. The diets were a basal diet fed alone or together with fresh Stylo 184 or cassava foliages or a mixture of cassava foliages and fresh stylo 184 (50:50 on a DM basis). The foliages and basal diet were offered *ad-libitum*. Feeds were given two times per day, in the morning at 08:00h and afternoon at 16:00h, and refusals were collected and weighed the following morning.

2.4. Data collection

Feeds offered and refused were weighed daily, and once per week samples of feeds offered and refused were taken for analysis. The pigs were weighed every 14 days over the experimental period until reaching 70 kg live weight. At the end of the finishing period the animals were slaughtered to measure the percentage of carcass, back fat thickness, and fat colour by simple observation. Samples of feed offered and refused were collected daily and sub-samples stored at – 20 ^{0}C before being analyzed for DM, CP, CF, Ash, Ca and P, by standard methods (AOAC, 1990). Amino acid analysis (Spackman, *et al.*, 1958) of stylosanthes, cassava leaves and the basal diet (3 samples) was carried out at the National Institute of Animal Husbandry (NIAH), Hanoi, Vietnam. Also an economic analysis was carried out based on the cost of diet ingredients and performance

2.5 Carcass measurements

For the evaluation of carcass traits, eight representative pigs, two castrated males from each treatment, were slaughtered at a final body weight of around 70 kg. The pigs were starved for 24 hours, weighed and then slaughtered at the slaughterhouse in Vientiane City. Carcass weights were measured according to Kauffman and Epley (2000). Hot carcass weights were measured immediately after slaughter. The carcass ratio was calculated as the ratio between carcass mass and live body weight after the pigs had been starved for 24 hours. Carcass weights without blood, hair and internal organs were recorded and the weight of hot carcass without head. Average back fat thickness and loin area were determined at the tenth rib. Carcass length was measured from the first rib to the pubis bone. Chest depth was measured from the middle of the sixth and seventh ribs. A line quadrate was drawn from the back at the middle of the sixth and seventh ribs. Ham width was measured from the back with a line quadrate across the lower abdomen, which borders to the pubis bone.

2.6. Statistical analysis

The data were analyzed by ANOVA using the General Linear Model procedure in MINITAB 13.31 program (2000). Tukey pairwise comparisons were used to determine the differences between treatments with confidence level 95.0%.

3. Results and Discussion

3.1 Chemical composition of the ingredients and experimental diets

The chemical composition of the ingredients is shown in Table 1. DM contents of maize, rice bran, and broken rice and cassava foliages are similar as those feed components were dried in the sun before storing. The CP and CF contents of stylo 184 and cassava foliages were higher than maize, rice bran and broken rice. CP content of cassava foliages indicates that the protein level was about 191 g/kg DM (Table 1), which is similar to the literature values of around 200 g/kg DM crude protein (Eggum 1970; Bui Vanh Chinh *et al*, 1994), and lowers than the 264 g/kg DM, reported by Phuc (2000). The CP content of the stylo leaves was 149 g/kg DM (Table 1), which is lower than the 190 and 220 g/kg DM, reported by Chanphone and Mikled (2003) and Bounhong *et al.* (2002), respectively.

The chemical composition of the experimental diets is shown in Table 3. Crude protein (CP), neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents of Ctrl, CL, ST and MIX treatments were 93.5, 99.3, 97.0 and 98.1 g / kg DM; 219, 315, 405 and 312 g / kg DM and 54, 22, 29, and 19 g / kg DM, respectively. The content of CP in the basal diet (Ctrl) (93.5 g / kg DM) was lower than the range of 145 to 150 g / kg DM recommended for growing pigs according to NIAH (1995) and NRC (1988), although the pigs in our experiment were crosses with an indigenous breed, and would have had a lower requirement for protein compared to the NRC recommendation, which is for improved pigs. The CP content in the basal diet was similar to typical diets for Lao indigenous pigs of 99 g / kg DM (Chanphone and Mikled, 2003).

The amino-acid (AA) content in the cassava foliages and stylo, and compared with the basal diet and the Ideal Protein, are shown in Table 4. The foliages used in the present study were found to be relatively high in CP and AA, and the AA composition is in approximate agreement with values earlier reported on cassava leaves (Eggum, 1970; Ravindran, 1993). Also, the content of most of the essential amino-acids (EAA) in the foliages was similar to that of soybean meal, which is in agreement with earlier reports (Garcia *et al*., 1996; West *et al*., 1988). In contrast, the basal diet had a lower content of lysine, methionine, threonine, histidine, valine and total EAA than those in the Ideal Protein and the foliages.

Table 1 Chemical composition of the dietary ingredients (g/kg on dry basis)

Ingredient	DM	CP	CF	NDF	ADF	Ash	Ca	P
Maize	900	110	23.6	ND	ND	12.6	6.8	3.8
Rice bran	858	86	119	ND	ND	131	7.8	7.8
Broken rice	848	83	12.5	ND	ND	11.4	3.3	5.8
Stylo CIAT-184	230	191	186	404	288	59.4	12.8	2.5
Cassava foliages	808	149	188	315	218	72.0	50.6	40.6

ND: not determined

Table 2 The ingredient and chemical composition of the basal diets

Basal diet*	Proportion as fed, %	DM	CP	CF	g/kg DM
Ingredients					
Maize meal	40	90	44	9.4	413
Rice bran	20	85	17.2	23.8	195
Broken rice	39	85	32.3	4.9	382
Vitamin mineral premix	0.5				5
Salt	0.5				5
Total	100		93.5	38.1	1000
N			15		
Chemical composition **					
DM					872
CP					93.5
CF					38.1
NDF					219
ADF					54.0
Ash					35.6
Ca					5.5
P					7.5

* Control (Ctrl)

**Calculated value (See Table 1)

Table 3 Chemical composition of the experimental diets (g/kg DM) **

Item	**Ctrl**	**CL**	**ST**	**MIX**
DM	872	867	833	850
CP	93.5	99.3	97	98.1
CF	38.1	47.1	47	47
NDF	219	225	230	227
ADF	54	64	68	66
Ash	35.6	37.8	37.0	37.4
Ca	5.5	8.4	6.3	7.3
P	7.5	9.5	7.2	8.3

Ctrl: Basal diet; CL: Basal diet *ad libitum* and cassava foliage *ad libitum*; ST: Basal diet ad libitum and fresh stylo *ad libitum*; MIX: Basal diet *ad libitum* and (50:50) cassava foliages, fresh stylo ad libitum

**Calculated value (See Table 2)

Table 4 Comparison of essential amino acid contents in basal diet with cassava foliages, stylo 184 and the ideal protein (g/kg protein)

Amino acid	Ideal protein[a]	Basal diet[b]	Cassava foliage[c]	Stylo 184[d]
Lysine	70	28	89	87
Methionine + Cystine	35	ND	ND	ND
Methionine	ND	8	22	16
Threonine	42	27	84	75
Trytophan	10	ND	ND	ND
Isoleucine	38	31	92	86
Leucine	70	81	171	145
Histidine	23	13	31	32
Valine	49	31	91	83
Phenylalanine	ND	21	92	94
Tyrosine	ND	20	57	49
Phenylalanine + Tyrosine	67	ND	ND	ND

[a] Agricultural Research Council, 1987
[b, c, d] Analyzed values, National Institute of Animal Husbandry, 2005
ND: not determined

3.2. Feed and nutrient intakes

The results of the effects of supplementing fresh stylo 184 and cassava foliages on feed and nutrient intakes are presented in Table 5 and 6. Intakes of the basal diet were 1,148, 1,297, 1,400 and 1,511g/day (P<0.001) for the Ctrl, CL, ST and MIX treatments, respectively. This indicates that providing the foliages stimulated intake of the basal diet, although the reason for this is difficult to explain. Overall, intakes of foliage DM on the CL, ST and MIX treatments were only around 6% of total diet DM intake, which was low, but in agreement with Paper I and the study of Chanphone and Mikled (2003). Intakes of total DM were 1,148, 1,383, 1,488 and 1,602g/day for the Ctrl, CL, ST and MIX treatments, respectively (P<0.001). The differences in DM intake in the MIX treatment compared with other treatments were highly significant (P<0.001), while there was no significant difference between the CL and ST treatments (Table 6) (P>0.05). The trends in DM intake in this study were different from values found by Giang (2003), who reported that the DM intake was higher in a basal diet, but decreased in other treatments that included foliage (sweet potato leaves) in the diets, which thus had a negative effect on the DM intake of growing pigs. This could have been due to differences in the composition of the basal diet and to the bulkiness and high fibre content of sweet potato leaves, and/or its lower palatability (Giang, 2003: Metz, 1985 cited by Dominguez and Ly 1997; Kyriazakis and Emmans, 1995). Also the low CP content of the basal diet in our study, which was below recommendations (NRC, 1995), could have encouraged the pigs to consume more cassava foliages and stylo 184, as they are relatively high in CP, in order to meet their requirement for protein and amino acids. In an earlier study carried out in Laos supplying stylo 184 as a supplement to a poor quality basal diet was also shown to increase total feed intake (Horne and Sture, 2000), and Bounhong *et al.* (2002) also found that the total DM intake was higher when the diets were supplemented with stylo 184 and cassava foliages. The overall CP intake was lowest for Ctrl (Table 6), and was significantly higher (P<0.001) for CL and ST, although there was no difference between CL and ST (P>0.05). CP intake was highest for MIX (P<0.001), mainly as a result of the higher total DM intake and fairly high CP content of the cassava foliages and stylo. However, the CP of the overall diet was still only 9.8% of DM (Table 6), well below the requirement for growing pigs of 150 g/kg DM (NIAH, 1995).

Table 5 Daily intakes of cassava foliages (DCL) and fresh stylo (FST), fed either separately or in a mixture, and a basal diet and total DM, g.

	Dietary treatment							
	CL		**ST**		**MIX**		SE	P-value
	g/d	%	g/d	%	g/d	%		
Period 1, days	28		28		28			
Basal diet, g/d	1147	94	1187	94	1183	93	22.86	0.451
DCL intake, g/d	70[b]	6						
FST intake, g/d			72[b]	6				
DCL+FST intake					90[a]	7	0.16	0.001
Total DMI, g/d	1217	100	1259	100	1273	100		
Period 2, days	28		28		28			
Basal diet, g/d	1293[b]	93	1471[b]	94	1571[a]	94	35.35	0.017
DCL intake, g/d	95[b]	7						
FST intake, g/d			96[a]	6				
SCL+FST intake					94[b]	6	0.14	0.001
Total DMI, g/d	1388	100	1567	100	1665	100		
Period 3, days	14		14		14			
Basal diet, g/d	1451[c]	94	1543[b]	94	1779[a]	95	20.82	0.001
DCL intake, g/d	94[a]	6						
FST intake, g/d			96[a]	6				
DCL+FST intake					89[b]	5	0.35	0.001
Total DMI, g/d	1545	100	1639	100	1868	100		
Overall, days	70		70		70			
Basal diet, g/ d	1297[c]	94	1400[b]	94	1511[a]	94	26.01	0.001
DCL intake, g/ d	86	6						
FST intake, g/d			88	6				
DCL+FST intake					91	6		
Total foliage intake	86[b]	6	88[b]	6	91[a]	6	0.35	0.001
Total DMI, g/ d	1383[c]	100	1488[b]	100	1602[a]	100	23.26	0.001

[a, b, c] Mean values within rows with different superscript letters are significantly different (P<0.05).
DCL: cassava foliage; FST: fresh stylo; MIX: mixture of cassava foliages with fresh stylo (50:50 on DM basis).

The percentage of foliage of total DM intake might be expected to increase with age, but did in fact remain fairly constant, and even decreased slightly in Period 3 on the MIX treatment. This is difficult to explain, as pigs can normally consume more of fibrous feeds as they get older and adapt to the diets, although in our study they were allowed 15 days to adapt to the foliages before the start of the experiment. Payne *et al.*, (1999) stated that adult pigs can be given up to 4.5 kg per day of fresh forage unless they are fed rations containing a grass or legume meal. A meal made from dried leaves of legumes is often included in feed mixtures but the inclusion rate should not exceed 5% of the total ration (Payne and Wilson, 1999), In our experiment pigs fed with fresh stylo 184 and cassava foliages consumed an amount approximately equal to 6% of total diet dry matter, which was slightly higher than the recommendation of 5%.

Table 6 Daily intakes of dry matter (DM), crude protein (CP), and crude fibre (CF) in pigs fed cassava foliage (CL) and fresh stylo (ST), either separately or in a mixture (MIX), and a basal diet (Ctrl)

	Dietary treatment					
	Ctrl	**CL**	**ST**	**MIX**	SE	P-value
Period 1, days	28	28	28	28		
DMI, g/ day	1088^{b}	1217^{a}	1259^{a}	1273^{a}	22.74	0.001
CPI, g/ day	102^{b}	121^{a}	122^{a}	125^{a}	2.78	0.001
CFI, g/ day	41^{b}	57^{a}	59^{a}	60^{a}	3.17	0.001
Period 2, days	28	28	28	28		
DMI, g/ day	1135^{c}	1388^{b}	1567^{b}	1665^{a}	34.61	0.002
CPI, g/ day	106^{c}	138^{b}	152^{b}	163^{a}	3.18	0.001
CFI, g/ day	43^{c}	65^{a}	74^{a}	78^{a}	2.88	0.001
Period 3, days	14	14	14	14		
DMI, g/ day	1221^{c}	1545^{ab}	1639^{ab}	1868^{a}	98.58	0.003
CPI, g/day	114^{b}	153^{b}	159^{a}	183^{a}	8.70	0.001
CFI, g/ day	46^{b}	73^{b}	77^{a}	88^{b}	7.36	0.001
Overall, days	70	70	70	70		
DMI, g/ day	1148^{a}	1383^{b}	1488^{b}	1602^{a}	1.02	0.001
CPI, g/ day	107.3^{c}	137.3^{b}	144.3^{b}	157.1^{a}	0.08	0.001
CFI, g/ day	43.	65.1^{b}	69.9^{b}	75.2^{a}	0.61	0.001
CP, % of diet DM	9.3^{b}	9.9^{a}	9.7^{a}	9.8^{a}	0.03	0.001

[a, b, c] Mean within rows with different superscripts differ significantly (P<0.05)

3.3. Pig performance

The results for initial and final weights, daily weight gain (ADG) and feed conversion ratio (FCR) for each period and overall are shown in Table 7. Pigs on the Ctrl treatment had lower ADG compared with other treatments, in all three periods and overall, the difference being significant (P<0.01). The lower gain for the Ctrl diet was partly due to the lower feed intake and nutrient content, and especially the CP content was lower than the requirement for crossbred growing pigs (NIAH, 1995). Overall ADG was highest in the MIX diet (582g/day), which was similar to the ST treatment (561g/day) (P>0.05), and significantly higher (P<0.001) than for the CL (425g/day) and Ctrl diets (363g/day), The superior performance on the MIX and ST treatments was probably mainly due their higher total DM intakes and also a better balance of amino acids. Lysine, methionine and threonine contents were more than twice as high in the cassava foliages and stylo as in the control diet. Although a vitamin-mineral premix was supplied to all treatments, vitamin A in particular tends in deteriorate rapidly in hot humid conditions, and it is possible that the additional supply of vitamin A precursors by the foliages help correct a deficiency in the basal diet. Because the higher ADG on the foliage diets was mainly due to higher DM intakes there was no difference in FCR in among treatments (P<0.05), although they tended to be lower on the ST and MIX treatments.

Table7. Effect of cassava foliage and fresh stylo, fed either separately or in a mixture, and a basal diet, on growth performance and feed conversion ratio of growing pigs

	Dietary treatment					
	Ctrl	**CL**	**ST**	**MIX**	SE	P-value
Period 1, days	28	28	28	28		
Initial LW, kg	25.8^{c}	30.0^{b}	29.5^{ab}	32.5^{a}	0.89	0.002
Final LW, kg	35.8^{c}	40.0^{b}	43.3^{bc}	48.8^{a}	1.41	0.001
ADG, g/ day	357^{c}	357^{bc}	493^{bc}	582^{a}	29.18	0.001
FCR, kg DM/ kg LWG	3.04	3.40	2.55	2.18	0.26	0.301
Period 2, days	28	28	28	28		
Final LW, kg	46.3^{c}	54.8^{b}	61.5^{ab}	66.5^{a}	2.15	0.001
ADG, g/ day	375^{b}	357^{b}	650^{a}	632^{a}	63.98	0.038
FCR, kg DM/ kg LWG	3.02	4.32	2.41	2.63	0.26	0.312
Period 3, days	14	14	14	14		
Final LW, kg	51.3^{c}	59.8^{ab}	68.8^{ab}	73.2^{a}	2.77	0.001
ADG, g/ day	357^{c}	528^{b}	512^{b}	478^{a}	34.96	0.011
FCR, kg DM/ kg LWG	3.41	2.62	3.14	3.90	0.26	0.301
Overall, days	70	70	70	70		
Feed intake, kg/d	1.15^{c}	1.38^{b}	1.49^{b}	1.60^{a}	1.02	0.001
Final LW, kg	51.3^{c}	59.8^{c}	68.8^{ab}	73.2^{a}	2.44	0.001
ADG, g/ day	363^{b}	425^{b}	561^{a}	582^{a}	24.01	0.001
FCR, kg DM/ kg LWG	3.16	3.25	2.65	2.75	0.23	0.301

[a, b, c] Mean values within rows with different superscript letters are significantly different (P<0.05)

Table 8 Effect of diets containing cassava foliages (CL) and fresh stylo (ST), fed either separately or in a mixture (MIX), and a basal diet (Ctrl) on carcass characteristics of growing pigs slaughtered at 70 kg live weigh.

	Dietary treatment*					
Parameter	Ctrl	CL	ST	MIX	SE	P-value
Days in experiment	96	83	72	70		
LW, at slaughter, kg	70.3	71.2	70.0	73.2	0.55	0.610
Carcass length, cm	77.7^{a}	71.3^{b}	70.2^{b}	80.5^{a}	0.98	0.001
Large intestine, g	1300^{c}	1440^{b}	1600^{ab}	1700^{a}	52.24	0.001
Dressing percentage	63.3^{b}	65.3^{b}	64.6^{b}	68.6^{a}	0.28	0.001
Loin area, cm^2	64.4	66.8	64.4	64.8	0.91	0.352
Heart wt, g	200^{b}	200^{b}	240^{a}	200^{b}	6.12	0.001
Lung wt, g	800^{b}	810^{a}	840^{a}	820^{a}	5.44	0.001
Pancreas wt, g	440^{a}	400^{a}	350^{b}	400^{a}	11.7	0.001
Small intestine, g	850^{a}	780^{b}	940^{a}	900^{a}	44.6	0.021
Stomach wt, g	600^{c}	600^{c}	660^{b}	700^{a}	10.8	0.001
Liver wt, g	1200	1100	1000	1200	57.7	0.089
Hot carcass, kg	44.9^{c}	45.5^{ab}	45.5^{ab}	47.2^{a}	0.44	0.006
Back fat, cm	4.2^{a}	4.0^{a}	3.4^{b}	4.0^{a}	0.75	0.008

[a, b, c] Mean values within rows with different superscript letters are significantly different (P<0.05)

* See Table 1

Performance of the pigs on the control diet was similar to results from other experiments with similar diets that have been carried out in SE Asia (Borin *et al.*, 1996: Borin *et al.*, 2000), with ADG in the range of 320 to 470 g/day for crossbred pigs. However, ADG on the MIX and ST treatments were much higher than those reported by Chanphone and Mikled (2003) in an experiment carried out at the same location and feeding similar diets. The experimental diets in Chanphone and Mikled's study, however, did not include a vitamin and mineral premix, which could have depressed performance, particularly on the basal diet. The more likely explanation though is that they used small (initial weight only around 12 kg compared to 25-30 kg in our study) indigenous Lao pigs, which have a low genetic potential for growth.

3.4. Carcass characteristics

There were treatment effects (P<0.01) on carcass length and stomach weight, which were highest in the pigs fed the mixture of foliages (Table.8), although this would have been partly a result of a higher slaughter weight. Dressing percentage was higher (P<0.01) in the MIX diet, which was unexpected as weight of the gastro-intestinal tract and its contents (Kyriazakis and Emmans, 1995) tends to be higher on fibrous diets, and large intestine weight was higher (P<0.001) in the MIX treatment.

3.5. Economical analysis

Feed ingredient costs and an economic analysis of the experimental treatments are shown in Table 9 and 10, respectively. Feed cost/kg DM was lower for CL, although differences between diets were small. However, because feed conversion ratios were lowest for the ST and MIX treatments (2.65 and 2.75 kg feed DM/kg gain, respectively), feed costs/kg weight gain of the ST and MIX treatments were lowest (7,033 and 7,249 kip/kg live weight gain, respectively) and were highest for the control diet (8,582 kip/kg gain).

Table 9 Feed ingredient costs

Feedstuff	Kip/ kg as fed	Kip/ kg DM
Cassava foliages	500	618
Stylosanthes	200	360
Rice bran	1,200	1,500
Broken rice	2,000	2,360
Maize meal	1,800	2,000
Salt	1,000	1,000
Premix	25,000	25,000

Kip: Lao currency, exchange rate: 10,500 Kip = 1 USD

Table 10 Economic analysis of experimental treatments.

Parameter	Diets				SE	P-value
	Ctrl	CL	ST	MIX		
Number of pigs	4	4	4	4		
Days in experiment	70	70	70	70		
LW gain, kg	25.5[c]	29.7[ab]	39.2[ab]	40.7[a]	0.58	0.001
DMI kg/day	1.14[c]	1.38[ab]	1.49[ab]	1.58[a]	0.07	0.001
FCR kg DM/kg	3.16	3.25	2.65	2.75	0.23	0.310
Feed cost/kg	2,716	2,605	2,654	2,636		
Feed cost/kg LWG	8,582	8,466	7,033	7,249		

Kip (Lao currency) exchange rate: 10,500 = 1 USD

5. Conclusions

- Offering a combination of Stylo 184 and cassava foliages improved the quality of the diets, which resulted in higher intakes and growth rates as well as lower feed conversion ratios compared to the typical, poor-quality control diet.
- The inclusion of foliages in low protein diets appears to be a feeding strategy with the potential to improve the CP and amino acid supply to pigs, when other protein-rich feeds are not available.
- Utilisation of inexpensive, locally available feed resources, such as cassava foliages, stylosanthes, have the potential to improve the economical efficiency of smallholder pig production in Laos.

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