On-farm Experiments in the Use of Local Resources for Pigs in Vietnam

Nguyen Thi Loc

University of Agriculture and Forestry, Dept. of Animal Nutrition, Thu Duc. Ho Chi Minh City, Vietnam

Abstract

In Vietnam, pig production plays an important role. There were 15 millions pigs in 1995, of which 95% were raised by small scale farmers. They are a very important source of income for the family. Protein is still a very important constraint in the traditional diet for pigs because of the high price. On-farm research has shown that protein intake is very low in traditional diets (94 - 98 g/pig/day).

On-farm feeding trials were conducted in two villages in Central Vietnam, Binh Dien and Xuan (which raise c. 2000 pigs annually).

Fourteen crossbred (Mong Cai x Large White) weaner pigs were fed traditionally and 12 similar pigs on a similar basal diet but given supplements of groundnut cake and fish meal to provide an additional 100 g/day/pig of crude protein. The mean daily live weight gain of pigs under the traditional feeding system was low (202 and 230 g/day in each of the two villages) but was significantly increased to 363 and 366 g/day ($P<0.001$) by giving the protein supplement. The net economic benefit after deducting the cost of the protein supplement was VND 800/day equivalent to VND 135,000 for the 150 day fattening cycle.

Trials were conducted in the two villages to evaluate the effect of processing methods on pH and HCN content of ensiled cassava roots. The HCN content of the ground whole cassava root after ensiling for 60 days was reduced from 109 ppm to 64 ppm, while ensiling the chipped root reduced HCN from 111 to 71 ppm.

Further feeding trials examined the effect of different levels of A molasses replacing cassava root meal or ensiled cassava root on the performance of growing-finishing pigs. The optimum levels of A molasses to replace cassava root (ensiled or dried) in pig diets, with protein supply kept constant at 200 g/day, was from 15 to 20% in terms of live weight gain and economic return. Mean live weight gains were 465 g/pig/day for the cassava root meal diet and 453 g/pig /day for the ensiled cassava root diet replaced by 20% of A molasses. Feed costs/kg gain for the 20% molasses diet with dried and ensiled cassava root were 11% and 27% less than for corresponding diets without molasses.

Sugarcane juice was fed to 40 pigs on 20 farms in the two villages. The results from feeding sugar cane juice with 200 grams CP supplement derived from fish meal and ground cake in farm households in two villages were good.

KEY WORDS: pigs, local feeds, traditional diets, protein supplement, cassava root silage, "A" molasses, sugar cane juice

Introduction

Cassava and sugar cane are the main crops in the upland areas of Central Vietnam. Cereal grains are needed for human consumption and cannot be spared for feeding pigs. Cassava and sugar cane, on the other hand, have several advantages compared with other carbohydrate sources. They give high yields under marginal climatic and soil fertility conditions, which results in a low cost raw material. The most under-utilized feed resource is fresh cassava root which is the cheapest feed in these areas. During the harvest season, the price of fresh cassava roots is only 180-280 VND per kg but it cannot be stored fresh.

The total production of fresh cassava root was 702,000 tonnes and of sugar cane 1.4 million tonnes in Central Vietnam in 1994 (Nguyen Sinh Cuc, 1995). The potential disadvantages of cassava roots are rapid perishability, their low protein content and the presence of cyanide in all root tissues. However, through simple processing, the disadvantage of perishability and cyanide can be overcome. The two most widely used

processing methods are sun-drying and ensiling. In the humid tropics, especially in the wet season, sun drying is difficult and may result in the production of a low quality product with severe Aspergillus and related aflatoxin contamination. Artificial drying significantly increases the cost which makes the use of the root meal non-competitive with cereal by products such as broken rice and bran. Ensiling of the cassava root appears to be a more viable alternative.

Approximately 60% of the sugar cane crop is processed by artisan methods in the villages, giving rise to sugar-rich "A molasses" - the main by-product from artisan sugar manufacture. The total quantity of molasses resulting from the processing of the sugar cane has been estimated at around 35,000 tonnes per year. The prices on a dry matter basis of both fresh cassava root and "A" molasses are usually less than those of rice, maize and cassava root meal (Duong and Ngoan, 1993).

Protein is a very big constraint in the traditional diet for pigs because of the high price and lack of experience of using protein supplements.

Experiment 1
Effect of protein supplementation of the traditional diets on the performance of growing-finishing pigs

Materials and Methods
On-farm feeding trials were carried out from May to October 1995.

Animals, diets and management

a) The pigs were Mong Cai x Large White crossbreeds, belonging to the farmers. The farmers also provided their normal management, drugs and vaccines. A total of 14 pigs owned by 5 farmer households (2 or 4 pigs on each farm) with initial live weights of 10.7 to 20.0 kg in the two villages (3 farmers in Binh Dien; 2 in Xuan Loc) were fed on a traditional (control) ration which consisted of 48% rice and rice bran; 45% cassava root meal and 7% vegetables (DM basis). Protein (N*6.25) concentration ranged from 5 to 7% in the DM.The amounts of the individual feed ingredients fed varied between farms and with time, depending on current availability and price. Details of nutrient intake are given in Table 1.

Table 1. Nutrient intakes on diets for Large White x Mong Cai crossbred pigs from 15 to 50 kg in Xuan Loc and Binh Dien villages.

	Standard*	Xuan Loc**	Binh Dien**
DM (kg/pig/day)	1.40	1.29	1.35
ME (MJ/pig/day)	18.1	17.2	17.6
CP (g/pig/day)	213	94	98

* Source: Nguyen Van Thuong, 1992

** Source: PRA survey in the two villages

b) Twelve pigs owned by 6 farmer households (3 in each village), but of similar genetic background and initial live weight from 9.6 to 23 kg, were fed on the traditional diet supplemented with 190 g/day of groundnut cake (39% N*6.25) and 60 g/day of fish meal (42% N*6.25). It was calculated that the supplement would raise the overall protein supply to 200 g/pig/day. The pigs were fed three times per day. The groundnut cake was soaked overnight and then mixed with the boiled basal feed. The fish meal was fed in the morning after being mixed with the rest of the dietary ingredients.

Data collection

The pigs were weighed in the early morning once a month using a 100 kg capacity portable scale with an accuracy of 0.5 kg. Feed intakes were recorded using a 20 kg capacity portable scale. These records were collected every two weeks, and additional random checks were also made. The major feed resources were identified and representative samples were collected and analyzed for dry matter (DM), crude protein (N*6.25), crude fibre (CF), ether extract (EE) and ash (AOAC 1985).

Results

The mean values for initial and final live weights and daily gains of the pigs on the traditional and supplemented diets, in each of the villages, are shown in Table 2.

Table 2. Mean values for initial and final live weight and daily live weight gain for pigs fed on traditional diets with and without a protein (groundnut cake and fish meal) supplement in Binh Dien and Xuan Loc Villages.

	Xuan Loc		Binh Dien		
	Tradi-tional	Supple-mented	Tradi-tional	Supple-mented	SE
Live weight,kg					
Initial	15.3	11.6	15.9	14.7	±2.0
Final	45.6	66.5	50.5	65.1	±4.2
ADG	0.202	0.365	0.230	0.363	±0.02

The results were similar in the two villages indicating little difference in the nutritive value of the basal feed resources. Protein supplementation increased live weight gain (adjusted for differences in initial weight) by 83% from 204 to 375 g/day ($P<0.001$) and final weight from 46 to 68 kg over the 150 days fattening period.

The value of the additional 171 g/day live weight due to supplementation was estimated at VND 1,700 for an additional feed cost of the supplement of VND 800, giving a net benefit of VND 900 per pig per day (VND 135,000 per pig for the total fattening period).

There was some variation in growth rates of pigs between households. This phenomenon is quite common and has been reported previously from Vietnam by Dolberg (1993). The differences are normally ascribed to variations in management practices among households, which may warrant further studies in order to identify them and explain them more precisely. In the analysis of the management factor, Ostergaard (1994) points out that the interactions between farm households are an important aspect to consider, as the decisions about the management of biological or financial subsystems are strongly influenced by the social structure of the farm household and the cultural framework in which it exists. In this case, the trial intervention, which consisted of an equal supplement of protein with variation in energy supply between farmers may therefore be an important factor in explaining the differences.

Experiment 2
Evaluation of Processing Methods of Whole Fresh Cassava Root.

Material and Methods

Ensiled cassava root (ECR) was produced by washing and grinding (or chipping) the fresh roots and adding salt (0.5% of the fresh weight of the root). The material was ensiled immediately after processing, either in pits dug out of the ground, in a cement container or in plastic bags. These were filled with ground or chipped cassava root as quickly as possible and compacted properly to eliminate air, so as to minimise the loss of nutrients by oxidation. Usually a polyethylene sheet was used to cover the ensiled material, to create anaerobic conditions for fermentation. The time taken for preparation of the cassava roots and the ensiling process was recorded.

Chemical analysis

Samples of the freshly processed root were taken on the day of ensiling and after 30, 60, 90, 120, 150 and 180 days for analysis of DM, hydrocyanic acid (HCN), organic acids and pH in laboratories of the Animal Nutrition Department of Hue Agricultural University and the Biochemistry Department of Medical University. HCN was analysed by the method of Easley *et al.*, (1970). Organic acids (acetic, lactic and butyric acids) were determined according to the method of Lepper *et al.*, (1982).

Results and Discussion

The ensiled whole cassava root had an acceptable aroma for pigs with no mould growth and kept its white colour.

HCN in the root component after processing and before ensiling is shown in Table 1.

Table 1. Physical composition and HCN content of fresh cassava root,and preparation time for ensiling. Cassava Fresh weight DM HCN Preparation time

	(% of fresh whole root)	DM (%)	HCN (ppm)	Prep Time (minutes)
Fresh whole root	100	36	114 ±5.2	104 ±15(*)
Fresh thin peel	3.1 ±0.49	21.5	212 ±2.0	133±13 (**)
Fresh thick peel	13.6 ±0.38	21	238 ±3.6	350 ±32 (***)
Fresh pulp	83.3 ±0.80	38	91 ±2.6	

(*) The time taken to pull up, cut , wash and grind 100 kg of whole fresh cassava root and mix with salt. (**) if the thin peel is removed the process takes 133 minutes more , (***) while removing the thick peel takes an additional 350 minutes

The HCN content was highest in fresh thick peel (238ppm) and lowest in fresh pulp (91 ppm). Tewe and Lyayi (1989) analyzed Nigerian cassava and found that the HCN contents of fresh thick and thin peel were much higher (364-815 ppm), while HCN in fresh pulp was only 34-301 ppm (air dry basis). They considered that these differences of HCN were probably due mainly to the variety and the time of harvest of the cassava. They further showed that the concentration of HCN in the cassava root, when the thin peel was removed, was reduced by only 5 % and there was a 3% reduction in content of energy and farmers spent 256 % more time on peeling compared with no peeling.

Effect of processing methods and time of ensiling on DM, HCN content and pH

The data (Table 2) indicate that the effect of both processing methods (grinding or chipping) was to increase the dry matter content, with increased length of the ensiling period from 0 to 30 days and 60 days, although this difference disappeared at 180 days.

Table 2. Effect of processing methods and ensiling time of fresh cassava root on DM content and pH.

Whole cassava root

Days ensiled	Ground		Chipped	
	DM,%	pH	DM,%	pH
0*	36.2	6.2	34.7	6.3
30	40.8	4.0	37.0	4.0
60	41.8	3.9	38.3	3.8
90	43.0	3.7	41.3	3.7
120	43.0	3.7	42.0	3.7
150	41.8	3.7	41.7	3.7
180	41.0	3.7	41.0	3.7

*Samples were taken 2 hours after harvesting

The increase of DM content in ground ensiled cassava root was higher than in chipped ensiled cassava root from 0 day to 30 days. Almost certainly the grinding (by machine) exposed a greater surface area to the air which facilitated loss of moisture. Chipping was by hand and thus the particles were larger and less likely to lose moisture. The ensiled material had some 10% more dry matter (after 150-180 days of ensiling) than the freshly processed root. A similar effect was reported by workers at CIAT (1978), who found that the dry matter content increased from 35 to 39% during the space of 25 weeks of ensiling.

The pH was reduced to about the same level (pH=4.0) for both processing methods after 30 days, and then decreased slightly to 3.7 at 90 days and remained at this value.

Effects of processing methods on cyanide content are shown in table 3. The HCN content was affected by the processing method and was lower at all stages of ensiling in the ground root than in the chipped root ($P<0.001$).

Table 3. Effect of processing methods and ensiling time of fresh cassava root on HCN composition.

Ensiling time, days	Total HCN (mg/kg)		HCN,% of initial concentration	
	Ground	Chipped	Ground	Chipped
0	109	111	100	100
30	76	88	70	80
60	64	71	59	64
90	61	68	56	61
120	59	66	54	59
150	58	61	53	55
180	56	60	51	54

HCN levels for both processing methods decreased very quickly up to 30 days and then continued to decrease more slowly up to 180 days. Ensiling ground cassava reduced HCN content to 70, 59 and 51 % of the initial value after ensiling periods of 30, 60 and 180 days respectively,while ensiling cassava chips reduced the HCN content to 80, 64 and 54% of the initial value, respectively. Similar findings were reported by CIAT (1981) and Gomez and Valdivieso (1988). These results shown that ensiling ground cassava procesing was slightly better in reducing HCN.

The reported levels of reduction of cyanide content are sufficient to make the ensiled cassava safe as a feed for pigs according to Gomez and Valdivieso (1988) who fed roots ensiled for 60 days with a residual cyanide content of 56ppm. Bolhuis (1954) proposed that the toxicity of cassava cultivars could be rated as follows:

(*) Innocuous: less than 50 ppm HCN in fresh peeled tuber.

(**) Moderately toxic: 50-100 ppm HCN in fresh peeled tuber

(***) Dangerously toxic: more than 100 ppm HCN in fresh peeled tuber.

However, Ikediobi *et al.*,. (1980) have reported that cassava containing 144 to 164 ppm HCN after processing can be used for livestock in Nigeria.

The HCN level of ground ensiled cassava root after 60 days ensiling (64 ppm HCN) apparantly caused no ill effect in the pig used in the experiments on farm and on station.

Organic acid content in whole ensiled cassava root
The effect of the ensiling time on organic acid levels in cassava root is shown in Table 4.

Table 4. Effect of ensiling time on organic acid content of whole cassava roots (% of DM)

Ensiling time, days	Acetic acid%	Lactic acid%	Butyric acid%
30	0.81	4.55	0.23
60	0.79	5.62	0.14
90	0.74	5.70	0.06

The content of acetic and butyric acids decreased with increased ensiling time, while that of lactic acid increased. The results are fairly similar to those reported by Serres and Tillon (1972) who recorded levels of acetic and butyric acids in ensiled cassava after three months of 0.3% and 0.09%, respectively.

Experiment 3.
Effect of Different Levels of A Molasses Replacing Cassava Root Meal Or Ensiled Cassava Root on the Performance of Growing-finishing Pigs

Hypotheses
An on-farm survey (Nguyen Thi Loc *et al.*, 1997) in two villages in the hilly areas in Central Vietnam indicated that the cheapest feed resources with potential for pig feeding were fresh cassava roots and A molasses. The hypotheses to be tested in the following experiment were: 1. Ensiling would be a convenient way of processing cassava root and that the

feeding value for pigs would be similar to that of cassava root processed by sun-drying. 2. There would be advantages from incorporating low levels of A molasses in the basal diets of dried and ensiled cassava root

Materials and Methods

Choice of families

The families were selected in cooperation with the local Womens Union, and the criteria taken into consideration for selecting the families for the on farm trials were

- Farmers willingness to participate in research trials
- Importance of pig production as a source of income in the household
- Experience with pig rearing
- Availability of a closed pig pen with cement floor of adequate size
- Cassava and vegetables were planted on the farm
- Number of family members supported by farm

Experimental design

The experiment was carried out from May to November, 1995. Pigs were purchased by groups of farmers with the assistance of the researcher and Women's Union of the villages.

Seventy two crossbred (Mong Cai x Large White) pigs of 18 kg initial weight were randomly assigned to 12 treatments with 3 replicates per treatment and 18 farms (10 in Xuan Loc and 8 in Binh Dien). Each farm had 4 pigs fed the same A molasses level, but 2 pigs per pen (1 castrate and 1 gilt) were fed cassava root meal and 2 pigs were fed ensiled cassava root. The design comprised 2 factors :

- Level of molasses (0, 5, 10, 15, 20, 25% of diet DM)
- Ensiled whole cassava root (ECR) versus cassava root meal (CRM)

Diets and feeding

An adaptation period of 25 days was used to change to the experimental feed. Experimental diets were given for 5 months.

Diet composition and amounts of dry matter supplied per pig per day are given in Table 5 and 6. Feed samples were taken for analysis of dry

matter (DM), crude protein (CP), ether extract (EE), ,crude fibre (CF) and ash at the laboratory of the Animal Nutrition Department of the Hue Agricultural and Forestry University using AOAC procedures (AOAC 1985).

Table 5. Dry matter (DM) intakes of the dietary ingredients, kg/day

Live weight,kg	10-30	30-50	50-70	70-90
Intake (kgDM/day)				
Cassava+-A Molasses	0.35-0.82	0.82-1.21	1.2-1.71	1.71-2.04
Fishmeal+Groundnut	0.42	0.42	0.42	0.42
Sweetpotato leaves	0.06	0.06	0.12	0.12
Total diet	0.83-1.30	1.30-1.75	1.75-2.25	2.25-2.58

*Two hundred g crude protein (CP) supplement obtained from 384 g of a 39 % CP of groundnut cake (GC)and 120 g of a 42 % protein fish meal fortified with salt per day per pig, this being kept constant throughout the experiment

Table 6. Chemical composition of the experimental diets (% fresh basis)

	*CRM	ECR	AM	FM	GC	SL
DM	87	42	75	87	83	12
N*6.25	2.9	0.95	1.75	42	39	2.4
EE	2.2	0.42	-	9	10.2	0.6
CF	3.84	1.05	-	-	4.3	2.6
Ash	2.52	0.85	4.5	30	4.6	1.4
ME MJ/kg	12.5	4.7	6.9	11.6	14.1	1.3

*CRM, cassava root meal ECR,ensiled cassava root AM, Amolasses FM, fish meal GC, groundnut cake SL, sweet potato leaf.

Details of the methods of processing the cassava root are given in Experiment 2. The A molasses was purchased from an artisan factory in Binh Dien village. On the basis of the results of Ospina *et al.*, (1995), the ad libitum feeding of the cassava root was complemented by 200 g protein/day derived from a mixture of 75% groundnut cake and 25% fish meal. The required weekly amounts of molasses (according to treatment) and cassava root were weighed and put into plastic bags to facilitate the work of the farmers. The farmers mixed these two ingredients immediately prior to feeding three times per day, estimating the quantities needed at each feed according to indicated guidelines provided by the researchers which were revised weekly. The protein supplement was also weighed in weekly amounts and given in two feeds per day. The daily amount remained constant (384 g groundnut cake: 120 g fish meal) throughout the experiment.

Measurements and statistical analysis

The pigs were weighed in the early morning every 30 days using a 100 kg capacity portable scale with an accuracy of 0.5 kg. Records of feed consumption were kept by the farmers and checked twice weekly during visits to the farms.

All data collected were analysed by analysis of variance using the General Linear Model (GLM) procedure of Minitab statistical software.

Results and Discussion

The pigs on all dietary treatments readily consumed the diets with no palatibility problems or digestive upsets, except for a few cases of diarrhoea. Cassava diets have often been found to be of low palatability due to the powdery nature of the root flour (Balagopalan *et al.*, 1988).

Growth performance

Overall treatment effects are shown in Table 7.

Table 7. Effect of location, cassava processing and A molasses levels on live weight gain of pigs , feed conversion ratio and feed costs

	Live weight gain (g/day)	FCR kgDM/kgLW	Feed costs VND/kg gain
Villages			
Xuan Loc	433	4.12	8520
Binh Dien	436	4.09	8440
SE/P	3.50/0.621	0.04/0.578	70/0.450
Processing			
Ensiling	429	4.16	7550
Drying	440	4.05	9420
SE/P	3.50/0.027	0.03/0.022	64/0.001
A molasses levels			
0	417	4.27	8910
5	423	4.22	8720
10	435	4.09	8520
15	442	4.03	8330
20	458	3.90	8000
25	432	4.13	8400
SE/P	6.30/0.001	0.60/0.001	110/0.001

The major parameters of biological performance in finishing pigs (rate of gain and feed conversion) were significantly better for dried cassava root meal than for the ensiled root, although the absolute differences were relatively small (2.5 and 2.6%, respectively, for gain and feed conversion).

Live weight gains of pigs fed ensiled cassava roots were lower than of pigs fed cassava root meal for A molasses levels from 0 to 15%.

Live weight gains of pigs fed ensiled cassava roots were similar to those of pigs fed cassava root meal for A molasses levels from 15 to 25%.

The response to A molasses appeared to be curvilinear with optimum performance in terms of growth and feed conversion being observed for

levels of between 15 and 20% of A molasses for both methods of processing the cassava root.

These results agree with those of Vinas and Cisneros (1990) who found that mean daily gains of pigs were significantly greater for a group given 15-20 % molasses than for the controls.

In addition, the taste and consistency of the ration can be maintained by the addition of molasses (Gomez, 1979). The average growth rates of the experimental pigs were quite satisfactory considering the genotype (exotic*local) and the restricted protein level (200 g/day).

Average daily gains of pigs in Binh Dien village (436g/day) did not differ (P=0.62) from those on farms in Xuan Loc (433 g/day) and there were no interactions between village and the dietary treatments (P>0.70).

This is evidence for the reliability of data from on-farm experiments of the kind described in this study.

Economic Comparisons of the Dietary Treatments

In contrast to the results for growth and conversion, feed costs per unit liveweight gain were much lower (20%) for ensiled cassava root than for the sun-dried meal (Table 7) and followed a similar pattern as growth performance for the effect of molasses level, with the lowest feed costs corresponding to molasses levels of 15 to 20%.

Experiment 4.

Sugar Cane Juice for Pigs

A trial with cane juice was conducted in Binh Dien village, Huong tra district, Hue province involving 40 pigs (crossbred between Mong cai and Cornwall) and 20 farmers. The pig ration (DM base) consist of sugarcane juice 68%, fish meal 16%, vegetable 16% and salt. Data was collected from pigs raised by 7 families.

In the morning the pigs were fed the full ration of protein supplements (fish meal and groundnut cake) and half the sugar cane juice ration and some sweet potato leaves

The second feed at 17.00h, the pigs were fed the remainder of SCJ and some sweet potato leaves .Water was available ad-libitum.

The results are showed in Table 8.

Table 8. Daily gain of pigs fed sugar cane juice

Groups	No of pigs	Initial LW	Final LW	Gain,g/day
I (low init. LW)	8	18.3+-1.97	56.5+-3.7	318.5+-19
II (high init. LW)	8	43.5+-3.44	104.1+-5.96	505.3+-45.7

The results were satisfactory (a mean daily live weigh gain of 318 g/d and 503 g/d) so it is feasible to use sugar cane juice to replace cereals and their by-products in the diet of pigs.

The data show that the weight gain of pig fed sugar cane juice was good. It is possible to replace entirely concentrates with sugarcane juice in pig rations. The ADG was affected by farmer management.

Conclusions

- The typical diet fed to fattening pigs is based on the following ingredients in order of importance: cooked rice, rice bran, cassava meal, fresh cassava root and sweet potato leaves. Calculation of the probable nutrient supply showed that protein was the main limiting nutrient with the amount supplied being less than 100 g per pig per day in most cases.
- Limited supplementation of the traditional diet with the equivalent of 100 g protein/pig/day increased live weight gain by 83% and improved economic benefits to the farmers.
- Ensiling ground cassava roots appeared to be as effective as sun-drying in reducing cyanide levels to non-toxic proportions. Ensiling increases the palatability of the roots for pigs. The technique is simple, cheap and suited to the conditions of farmers in Central Vietnam.
- Inclusion of low levels of "A" molasses appears to improve slightly the utilization of cassava root meal and ensiled cassava root. Feeding cassava meal or ensiled cassava root with 15 or 20% replaced by "A" molasses and maintaining the protein allowance at a level of 200 g/pig/day throughout the growing-finishing period gave reasonably high growth rates and good economic returns (20% lower feed costs

per unit gain).

- The technical of feeding sugar cane juice with 200 grams CP supplement derived from fish meal and ground cake in farm households in two villages were good.

References

Association of Official Analytical Chemists (AOAC), 1985. Official methods of analysis. 12th ed. Washington, DC.

Balagopalan, C., Padmaja, G., Nanda, S.K. and Moorthy, S.N. 1988. Cassava in food, feed and industry. CRC Press, Florida, USA. 205pp.

CIAT (Centro Internacional de Agricultura Tropical), 1978. Informe anual, programa de Yuca. 1978. Cali, Colombia.

CIAT, 1981., Informe anual, programa de Yuca. 1981. Cali, Colombia.

Dolberg F., 1993 Transfer of sustainable technologies in Vietnam. Development of sustainable livestock technologies for ecologically fragile zones in the tropics. Swedish International Development Agency (SIDA) Stockholm Sweden. Internal Report

Easley.J.F, J.T. McCall, G.K. Davis and R.L. Shirley., 1970. Nutrition laboratory of department of Animal Science University of Florida,1970

Gomez, G., 1977. Lifecycle swine feeding systems with cassava. In: Nestel, B.; Graham, M. (Eds.) World Animal Review .

Gomez, G., Valdivieso, M., De la Cuesta, D. And Salcedo, T.S. 1984. Effect of variety and plant age on the cyanide content of whole root cassava chips and its reduction by sundrying.Animal feed Science and technology 11: 57-65

Gomez, G., 1979. Cassava as swine feed. World Animal Review 29: 13-20.

Ikediobi, C.O.; Onyila, G.O.C.; Eluwah, C.E., 1980. A rapid and in expensive enzymatic assay for total cyanide in cassava and cassava products, Agric. Biol. Chem. 44 (12): 2803-2809.

Lepper *et al.*, 1982. Methods how to determine volatile fatty acids in silage. Handbook for feed analyses. Moscow Kolos. Ministery of Agriculture, Soviet Union-Cooporation Chemistry Agriculture.

Nguyen Van Thuong, 1992. The hand book of nutrient composition of animal feed in Vietnam. Agricultural Publishing House, Hanoi, 1992. 237-238 pp

Nguyen sinh Cuc, 1995. Agriculture of Vietnam 1945-1995.Stat. Publishing House, Hanoi, 1995. 225-231 pp.

Nguyen Kim Duong and Le Duc Ngoan, 1993. A molasses in diets for pigs, broilers and ducks. Proceeding of the Regional Workshop: Increasing Livestock Production by Making Better Use of local Feed Resources. Hanoi/Ho Chi Minh City. Vietnam. Nov. 25-29, 1991. FAO-SAREC. FAO Regional Office for Asia and the Pacific (RAPA) publications. Bangkok, Thailand. 80 pp.

Nguyen Thi Loc, Ogle, R.B. and Preston, T.R. 1997. Village pig production in central Vietnam: results of a participatory rural appraisal survey and on-farm feeding trials with protein supplementation of traditional diets. Livestock Research for Rural Develoment. In Press.

Ospina Liliana, Preston, T.R and Ogle, R. B., 1995. Effect of protein supply in cassava root meal based diets on the performance of growing - finishing pigs. Livestock Research for Rural Develoment. Volume 7, number 2, October 1995, pp 30-39. Serres. H.y

Ostergarrd V., 1994. Livestock systems research-appropriate methods of the future. Integrated livestock / crop production systems in the small scale and communal farming sector. Symposia at the Department of Animal Science, University of Zimbabwe, January 26- 28, 1994

Serres. H.y Tillon.J.P., 1972. L ensilage des racines de manioc. Rev. Elev. Med. Vet. Pays Trop. 25 (3): 455-456.

Tewe, O.O. and Iyayi, E.A. 1989. Cyanogenic glucosides. In Toxicants of plant origin, Vol II. Glycosides. Ed. Cheeke, P.R. CRS Press. pp. 43-60.

Vinas, RC; Cisneros, JC., 1990. Feeding growing pigs with sugarcane molasses to replace maize as an energy source. Revista-Argentina-de-Production-Animal.1990, 10:3, 193- 199