Cassava root silage for crossbred pigs under village conditions in Central Vietnam

Nguyen Thi Loc, R Brian O'gle[1] and Thomas R Preston[2]
College of Agriculture, Hue University, Vietnam

Abstract

An on-farm trial in Binh dien and Xuan Loc villages in Central Vietnam compared ensiling of cassava roots (ECR) (chipped by hand or ground by machine) with sun-dried cassava root meal (CRM) with supplements of “A” molasses at levels from zero to 20%. 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. The optimum levels of “A” molasses replacing cassava root (ensiled or dried) in pig diets with protein supply kept constant at 200 g/day was in the range of 15 to 20% for live weight gain and economic purposes. 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 each with 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.

A digestibility trial was carried out using 6 pigs of 72 kg average initial live weight. Three pigs were fed the CRM diet and 3 pigs received the ECR diet. The mean values for apparent digestibilities of dietary nutrients were not significantly different (P>0.05) except that crude fibre appeared to be digested to a greater extent (P = 0.03) in the diet with ensiled cassava root compared with the dried meal (63 vs 34 %).

Key words: Pigs, protein supplement, cassava root silage, “A” molasses, growth, digestibility

[1] **Swedish University of Agricultural Sciences, Uppsala, Sweden**
[2] **Finca Ecologica, University of Agriculture and Forestry, Thu Duc, Ho Chi Minh City, Vietnam**

Introduction

There were 15 millions pigs in Vietnam in 1995 of which 95% are raised by small scale farmers. The energy and protein feed resources have a very high potential in Central Vietnam but there is a need to work out different methods to facilitate the management and to improve the knowledge about how to combine these resources in order to improve the nutritive value of the whole diet for pigs.

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. Cassava and sugar cane are the main crops in the upland areas of Central Vietnam. 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). Approximately 60% of the sugar cane crop Cassava root silage for pigs under village conditions is processed by artisan methods in the villages giving rise to sugar-rich “A” molasses[3] - 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 (Nguyen Kim Duong and Le Duc Ngoan 1993).

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.

On- farm feeding trials were conducted in two villages in Central Vietnam to evaluate the effect of processing methods on pH and HCN content of ensiled cassava roots and the effect of different levels of “A” molasses replacing cassava root meal or ensiled cassava root on the performance of growing-finishing pigs.

[3] In the traditional manufacture of crystalline sugar at artisan level the clarified syrup is centrifuged only once to give “A” sugar and “A” molasses. In industrial sugar production, the “A” molasses is recirculated and centrifuged two more times giving respectively “B” and “C” sugar. The residual molasses (from which no more sugar can be crystallized) is known as “final” or “C” molasses. “A” molasses is richer in sugar and has a better feed value than “C” molasses.

Material and methods

Ensiling whole cassava root

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.

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. 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).

“A” molasses replacing cassava root meal or ensiled cassava root

Choice of families

The families were selected in cooperation with the local Women's Union, and the criteria taken into consideration for selection 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, in Binh Dien and Xuan Loc villages. Pigs were purchased by groups of farmers with the assistance of the researcher and the 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. The experimental diets were given for 5 months. Diet composition and amounts of dry matter supplied per pig per day are given in Tables 5 and 6. Feed samples were taken for analysis of dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and ash, using AOAC procedures (AOAC 1985).

The methods of processing the cassava root were described earlier. The “A” molasses was purchased from an artisan sugar 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 weighted 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

Effects of ensiling cassava roots on chemical composition

The ensiled whole cassava root had an acceptable aroma for pigs with no mould growth and kept its white colour. After processing and before ensiling (Table 1) the HCN content was highest in fresh thick peel (238 ppm) 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.

Table 1: Physical composition and HCN content of fresh cassava root, and preparation time for ensiling.

Cassava	% of whole root	DM (%)	HCN (ppm)	Prep. (minutes)
Whole root	100	36	114±5.2	104±15*
Thin peel	3.1±0.49	21.5	212±2.0	133±13**
Thick peel	13.6±0.38	21	238±3.6	350±32***
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*
**** Removing the thick peel takes an additional 350 minutes.*

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. 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.

Table 2: Effect of processing methods and ensiling time of fresh cassava root on chemical composition. (fresh basis)

Days	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 afterharvesting

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). 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 80.6 and 54% of the initial value, respectively. Similar findings were reported by CIAT (1981) and Gomez and Valdivieso (1988). These results show that ensiling ground cassava processing 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 56 ppm. Bolhuis (1954) proposed that the toxicity of cassava cultivars could be rated as follows:

Table 3: Effect of processing methods and ensiling time of fresh cassava root on HCN content

Days	**HCN**			
	mg/kg		**% of initial**	
	Grnd	**Chip**	**Grnd**	**Chip**
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

** In fresh roots*

(*) 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.

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

Days	**HAc**	**Lactic**	**Butyric**
30	0.81	4.55	0.23
60	0.79	5.62	0.14
90	0.74	5.70	0.06

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) apparently caused no ill effect in the pigs 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 the fresh cassava root is shown in Table 4. 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.

Table 5: Average values for dry matter intakes of the mixture of cassava/molasses, protein supplement and sweet potato leaves

	Live weight, kg			
	10–30	30–50	50–70	70–90
	Intake (kg DM/day)			
Cass./mol.	0.57	1.01	1.45	1.85
Prot. Supp.	0.42	0.42	0.42	0.42
SPL	0.06	0.06	0.12	0.12

** 200 g/d of crude protein supplement obtained from 384 g of a 39 % protein groundnut cake and 120 g of a 42 % protein fish meal fortified with salt.*

Ensiled or dried cassava root with molasses on pig performanceM
Chemical composition of the feeds

The composition and chemical analysis of the feeds are shown in Tables 5 and 6. 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).

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

	CRM	ECR	Mol	FM	GC	SPL
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;
Mol. "A" molasses;
FM fish meal;
GC groundnut cake;
SPL sweet potato leaf.

Growth performance
Overall treatment effects are shown in Table 7. 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). The relationship between molasses levels and live weight gains in pigs fed ensiled or dried cassava root meal is shown in Figure 1. 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%.

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 (kg DM/kg LWG)		Feed costs VND/kg gain
Villages			
Xuan Loc	433	4.12	8520
Binh Dien	436	4.09	8440
SE	±3.50	±0.04	70
Probability	0.62	0.58	0.450
Processing			
Ensiling	429	4.16	7550
Drying	440	4.05	9420
SE	±3.50	±0.03	±64
Probability	0.027	0.022	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	±6.30	±0.60	±110
Probability	0.001	0.001	0.001

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 (436 g/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 (by 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%.

Conclusions

- Ensiling ground cassava roots appeared to be as effective as sun-drying in reducing cyanide levels to non-toxic proportions. Ensiling increased 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 than for sun-dried cassava root meal).

Acknowledgments

The authors gratefully acknowledge the help of the People's Committee and the Women's Union of Binh Dien and Xuan Loc villages, and the Womens' Union of Thua thien Hue Province in developing the activities with the farmers at the research sites. Thanks are due to the Swedish International Development Agency (SIDA) for providing the financial support that made possible the study.

References

AOAC 1985 Official methods of analysis. Association of Official Analytical Chemists 12th edition. Washington DC

Balagopalan C, Padmaja G, Nanda S K and Moorthy S N 1988 Cassava in food, feed and industry. CRC Press, Florida USA pp205

Bolhuis G G 1954 The toxicity of cassava root. Netherlands Journal of Agricultural Science 2: 176–185.

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

CIAT 1981 Informe anual; programa de Yuca. Centro Internacional de Agricultura Tropical, Cali, Colombia.

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

Gomez G and Valdivieso M 1988 The effects of ensiling cassava whole-root chips on cyanide elimination. Nutrition Reports International 37: 1161–1166.

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

Ikediobi C O, Onyila GOC and Eluwah C E 1980 A rapid and inexpensive enzymatic assay for total cyanide in cassava and cassava products, Agricultural Biology and Chemistry 44 (12): 2803–2809.

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

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. 95 pp.

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

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 Development. Volume 7, Number 2: 30–39.

Serres H and Tillon J P 1972 Lensilage des racines de manioc. Rev. Elev. Med. Vet. Pays Trop. 25 (3): 455–456.

Tewe O O and Iyayi E Cyanogenic glycosides. In: Toxicants of plant origin. Volume II Glycosides (Editor: P R Cheeke) CRS Press pp43–60

Vinas R C and Cisneros J C 1990 Feeding growing pigs with sugarcane molasses to replace maize as an energy source. Revista Argentina de Production Animal. 10:3, 193–199

22.0 SILAGE MAKING FROM LOCAL CROP RESIDUES AND BY-PRODUCTS.

22.1 Why make silage?

The problems usually encountered with agro-industrial by-products is seasonality of supply which is often accented by their high moisture content. Hence, they easily spoil creating a nuisance and are often wasted. Ensuing by-products is the most suitable method for their conservation for a long period. The main advantages are:

- Silage can be used strategically for efficient use for off-season feeding.

- It is a means of increasing feed resource availability and a form of insurance for good feeding

management, especially for freshly calved dairy cows.

- It can be efficiently used as a supplement for cattle grazing under coconut plantation.

- It can be stored in a well chosen area close to the farm and provide an excellent and cheap I feed to dairy cows and calves.

- The method improves palatability, significantly reduces toxic substances present in some fresh vegetables and destroy harmful micro-organisms possibly present in poultry litter or fish wastes.

- Silage can also provide a major diet source, and be used as basal ration as well as a feed supplements for grazing animals.

22.2 How to succeed in silage - making?

The ensiled feed supplements should be stored in airtight conditions, preventing contact with air. This will allow foodstuffs preservation and minimise losses in nutrient content. The factors that contribute efficiently to the successful silage are the following:

- Moisture content: ensiled material should contain between 25 and 50 % of moisture. Water can be added to drier feeds to obtain such moisture,

- Length of chop: The finer the chop, the better the silage. Chopping into small pieces can be done by hand or in a stationary forage chopper.

- Presence of enough easily fermentable energy (naturally present or added). For this reason, protein-rich feeds with low content of energy are very difficult to successfully ensile and should be mixed with easily fermentable energy-rich products, such as molasses, rejected bananas and root crops.

22.3 How to make silage?

Leaves and root crops are finely chopped and sliced (see **Photo 26**). They are mixed with fine ingredients, such as spent grain and poultry litter (see **Photo 27**) then properly blended with molasses. when the mix is too dry, molasses is therefore diluted in order to reduce total dry matter content.. The moisture content in the mix can be assessed manually by squeezing strongly a handful of mix. The moisture content is considered satisfactory when liquid trickles, slowly flowing between fingers.

The silage can be stored in stacked layers, packed in succession on the soil which has been beforehand covered with a plastic sheet and banana leaves. This heap, once finished, is then tightly covered with banana leaves and plastic sheets, pressed down by some heavy objects which are placed on its **top (see Photos 28, 29). Packed** silage in plastic bag that is tightly closed is also an effective storage method. This storage method is easy to handle and has the potential to produce high quality silage with less waste in a well-sealed bag (see Photo 30). It is ideal for spent grain storage. However, it is not recommended for coarse materials, such as banana trunk and cassava leaves, which can puncture the bag and render the contents useless.

After approximately 6 weeks, the farmer can open the silo and start to feed silage to animals. Silage can be suitably preserved for as long as air is kept away from the ensiled material, it is therefore possible to store airtight silage for 6 months. Once the silo is open, care must be taken to cover the ensiled material after each opening that is made to feed the animals.

22.4 Practical examples of successful silage combinations.

In order to succeed silage making, one should keep in mind that there are different crop residues and by-products and each one has its own specific composition and physical structure:

> **-** Carbohydrate or energy-rich feeds: such as crop roots; spent grain, rejected bananas, and fruit wastes can be successfully ensiled alone.
>
> **-** Agro-industrial by-products, such as spent grain, which is rich both in energy as well as in protein may be successfully ensiled alone.
>
> **-** Fibre-rich feeds with low energy and protein contents, such as banana pseudostems should not be ensiled alone..
>
> **-** Protein-rich feeds with low energy-content , such as cassava leaves, fish wastes and poultry litter should not be ensiled alone. However, in order to ensure adequate preservation, this type of feeds can be successfully ensiled when mixed with one or various energy-rich products such as crop roots, rejected bananas, spent grain and molasses. This silage making is highly recommended because it would provide a balanced diet.
>
> **-** Incorporation of molasses to silage is optional, nevertheless this is an excellent additive to ensure a good conservation and enhance high silage quality of any ensiled feed resource.

Incorporation rate of the different ingredients to be ensiled are function of (i) available amount of by-products and (ii) animal categories to be fed. For example a high-quality silage, containing increased proportions of energy-rich ingredients such as spent grain and crop roots, should be prepared for high producing dairy cows. whereas high proportions of cassava leaves and banana pseudostems can be used when there is seasonal feed shortage and therefore when silage would compose the bulk diet, as for instance during off-season feeding. The following associations have been successfully ensiled during on-farm demonstrations carried out in

Samoa:

Table 14. High quality silage making

Ingredients (for 100 kg dry matter basis)	Kg	Equal to Kg fresh matter basis (or Kg fresh ingredients per mix)
Cassava leaves	15	100
Chopped crop roots (Cassava roots)	25	100
Chopped banana pseudostems	10	70
Spent grain	30	150
Poultry litter	10	15
Molasses	10	15
Total	100	450

Table 15. Medium quality silage

Ingredients (for 100 kg dry matter basis)	Kg	Equal to Kg fresh matter basis (or Kg fresh ingredients per mix)
Cassava leaves	25	150
Chopped crop roots (Cassava roots)	15	60
Chopped banana pseudostems	20	150
Spent grain	15	75
Poultry litter	20	25
Molasses	5	7

Total	100	467