

Ensilage of cassava products and their use as animal feed

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INTRODUCTION

There is a great deal of information on the potential use of alternate feedstuffs. However, the majority of the materials studied are either produced in limited quantities (i.e. to satisfy only local demand), or are only available during limited periods of the year. Some agricultural products have important agronomical limitations and others may not satisfy the quality standards of the feed industry. For these reasons the major share of alternate feed sources utilization takes place in small, poorly organized units of limited importance to the feed industry. In peasant animal production, the lack of technological knowledge, regarding the economic use of alternative feedstuffs seems to be the main limiting factor that discourages new or continued utilization.

Cassava root is an alternate feed that, based on extensive research, shows considerable potential for use in the Mexican tropics. In this area more than 450,000 ha of land have been identified with the characteristics to support cassava production without displacing other crops. If the maximum level of cassava crop yield, calculated as 80 ton/ha, were achieved, the production of cassava starch, using the land available, would be sufficient to totally satisfy Mexico's animal feed energy demand. However, the actual yield of cassava in Mexico averages only 12 tonnes/ha, and the land dedicated to cassava production is around 40,000 ha per year.

Most cassava is grown on very small peasant farms with well defined harvesting periods, and the major part of the cassava root produced is destined for human consumption or occasionally industrial processing. It is only occasionally used as an animal feed, partly because cassava producers are rarely involved in formal animal production. Further, if it is intended for animal consumption, cassava must be viewed either as a

cash crop or as a part of a production system; neither of these options are currently applied in the field.

Animal feeding requires a constant supply of ingredients; and hence longterm economic considerations must be taken into account including; predictability of price and availability and quality of ingredients. Cassava root meal or pellets can be fully integrated into commercial animal feed production since they can be stored and handled mechanically like other conventional ingredients. In Mexico the main problems relate to the processing of cassava, since it is mostly produced in the humid tropics (50% of the total in Tabasco State, to the south of the Gulf of Mexico) with an average rainfall of more than 2,500 mm and mean temperature of 29°C.

In the humid tropics 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 rootmeal non-competitive with cereal grains (of interest it has been calculated that dry cassava root cannot be economically utilized with a price above 70% of that of cereal grains). Therefore the only viable means by which it can be used as animal feed in these areas is either in the fresh or ensiled form.

Feeding fresh cassava reduces the efficiency of land use, since it results in an extended harvesting period which also diminishes the nutritional quality of the product. It was therefore concluded that ensiling represents the most attractive alternative, but that in both cases, the use of the cassava must take place near the site of cassava production, since the fresh material has a high water content which increases transportation problems and cost. If fresh and ensiled cassava are compared, the main advantage in favour of the latter will be the advantage of storage and extended use, which in turn leads to a programmable and more efficient utilization.

SOME CHARACTERISTICS OF CASSAVA SILAGE

Cassava ensilation is very similar to that of fresh forages. However the high water content of the root and its loss during processing require that

special considerations in silo construction need to be taken into account. Firstly, solid, non-absorbant flooring should be provided in order to prevent excessive liquid losses. Secondly drainage should be provided to avoid excessive water accumulation and alcoholic fermentation and /or putrefaction occurring. As with forages, water content, ensiling time and quality of the initial product are critical in the production of a good quality preserved product. If the fermentation conditions are altered the final product will not be as required, resulting at best in a reduced animal intake.

In the construction of field silos any of the established technologies developed for forages can be used; the only constraining condition is to ensure an anaerobic environment. Careful planning should take place before starting processing, including estimating the amount to be harvested and distance from the field to the silo, as these may affect processing. Consideration should also be given to ways of compacting the harvested mass (to reduce air spaces), the covering to be used to seal the surface, as well as on the number of animals to be fed and the rate of extraction from the silo in order to calculate its size.

The objective of the ensiling process is to preserve the root's nutritional value, by means of a lactic acid fermentation, with a resulting pH of 5 or less. Production of lactic acid occurs initially at the expense of reducing sugars, therefore, if the nitrogen free extract of cassava is below 73%, then addition of a source of soluble carbohydrates (e.g. 3% final cane molasses) should ensure a proper initiation of the fermentation process and prevent alcohol production.

Hydrocyanates (HCN) that are found in the plant limit the use of fresh cassava. Sun drying of roots diminishes the content of HCN and in the case of silage it is reduced by washing and of greater importance, by fermentation. At times this is capable of producing an HCN-free product, which gives added value to this process.

FEEDING AND NUTRITIONAL CONSIDERATIONS

Similar considerations must be taken into account when using ensiled cassava, as part of an animal's diet, as when feeding fresh roots. In

particular the high water content of the material may prevent animals consuming sufficient feed to satisfy their daily energy needs. Protein consumption may also be inadequate, and in particular in nonruminants, since the protein content is extremely low and of low quality (the protein is almost lacking in sulfur amino acids, which is worsened by the use of these amino acids in the metabolic detoxification of HCN) and as much as 60% could be non protein nitrogen. These two constraints are responsible for the following recommendations concerning the feeding of ensiled cassava.

Recommendations for the feeding of ensiled cassava

Although this material is palatable and animals consume it without problem the feeder should ensure that the animals consume sufficient dry matter to meet their requirements. Due to its low nutrient density, animals, and in particular young animals may not be able to consume sufficient to meet their needs. Also, unlike many other materials, such as cane molasses etc. the rate of passage of the ingesta is not proportionally increased with intake when this material is fed. As the age of swine and ruminants increase, and in particular as they approach puberty, their ingestion potential increases and even progressive gut hypertrophia occurs, and the animals are better able to satisfy their maintenance and production energy needs. Lactating animals are probably the exception to this effect, due to their high nutrient demand during this phase. The application of this material therefore seems particularly suited to use by gestating and finishing animals.

Ad libitum systems are probably the most appropriate means of feeding ensiled cassava, but average daily dry matter intake should be closely monitored and wastage prevented by appropriate feeder design and regular feeding. If the observed animal's intake exceed the desired amounts, restricted feeding is recommended to prevent excessive fatness.

Dietary supplementation is an important aspect of cassava utilization; protein, vitamins and minerals must be added either in the form of supplements and (or) additives in the silage. With regard to the latter, De Uriarte *et al.* (1971) (Table 1) observed no improvement in silage quality

TABLE 1.
Productive response off finishing pigs fed with cassava silage

	AVG. DAILY WT. GAIN (g)	INTAKE SILAGE	(KG) SUPPLEMENT
CASSAVA	622	3.8	0.8
CASSAVA + CORN	546	3.6	0.9
CASSAVA + SOY BEAN MEAL	42	1.6	1.0
CASSAVA + CORN + SOYA BEAN MEAL	33	1.6	0.4

Source: De Uriarte et al., 1971

from silage enrichment with maize or soya bean meal, except that dry matter content showed a concomitant increase. When these materials were fed the greatest daily intake was obtained from the silage made without any of these "additives"; and in fact soyabean meal reduced the quality and performance of animals fed that silage. It was concluded therefore that dry feedstuffs are better utilized in the formulation of supplements for the animals fed the silage.

Due to the low protein content of cassava, several concentrates have been evaluated as supplements, the final decision on their use relates to the complementary composition of the sources available and their respective prices. In certain circumstances the cost of protein supplements may override the benefits of cassava feeding. Rodriguez (1989) studied the now common practice of supplementing growing pigs, fed ensiled cassava, with commercially supplied protein supplements (36% crude protein), which were originally intended for mixing with cereal grains. Protein supplementation followed the general recommendations made with regard to body weight (mostly based on calculations of daily protein requirements, similar to those given by NRC). The animal evaluation was carried out on communal commercial farms (Ejido Tierra Nueva and Colonia Jose Maria Pino Suarez, Tabasco State), using pigs (256 heads) fed from approximately 15 to 95 Kg. In the study ensiled cassava was fed *ad libitum* with a restrict fed protein concentrate, to pigs in a trial in

which their individual weights and the costs of production were recorded. Mean ensiled cassava consumption was of 3.75 kg/day (1.50 Kg of dry matter) and intake of the protein concentrate an average of 0.830 Kg/day (i.e. a mean of 14% crude protein was provided). Mean daily gain during the observed period was 0.610 Kg/day which resulted in a feed efficiency (gain/feed) of 0.26; and an economic return (from feed and feeding related expenditures, others fixed) of 16.58%.

Data from Lopez *et al.* (1988) in Table 2 show the response to feeding locally produced meat and bone meal as the main ingredient in a protein concentrate (35% crude protein) used to complement ensiled cassava in sow feeds. From mating to day 70 of gestation 3.0 Kg. of cassava ensilage were offered each day with 400 g/day supplement to provide an average daily intake of about 1.4 kg dry matter and 140 g protein. From 70 days the same amount of ensilage was offered, but the protein concentrate was fed at 600 g/day to provide a daily dry matter intake of 1.6 Kg. and 210 g of crude protein). During lactation, cassava root meal based diets were formulated (as it was previously shown that lactating sows were unable to satisfy their energy needs using silage) to provide feeds with 13.6, 15.8 and 18% crude protein. The response to this feeding regimen was good during gestation, but during lactation good results were only obtained at the higher protein levels, suggesting that the supply of amino acids from the meat and bone meal was limiting.

Observations like these are common in the literature, indicating that the amino acid availability and balance in the protein source should be quite different to those normally used for diets based on cereal grains, since cassava provides almost no protein and therefore most of the protein must be provided from the supplement. Further research is needed, including careful evaluation of amino acid supply to optimize animal response and to identify appropriate, locally available, protein supplements.

In ruminants the task seems to be simpler, as non-protein nitrogen and lower quality protein can be used. Ensiling cassava with the low grade protein gives the added advantage of improved utilization of these sources of nitrogen, as during fermentation crude protein quality may be increased from nitrogen incorporation into bacterial protein.

TABLE 2.
Performance of pregnant and lactating sows fed with cassava silage

	GESTATION		
	FED 3Kg Cassava Silage + Conc.		
Mena Daily Liveweight Gain (Kg)	47.6		
Live Piglets Born	10.2		
Mean Piglet Weight (Kg)	1.4		
	LACTATION		
	FED Cassava Root Meal Feed with 3 different levels of protein		
Protein in Feed%	13.6	15.9	18.0
Weight Change (Kg) (During lactation)	-21.6	-21.14	-15.9
Feed Intake (Kg/day)	3.8	4.1	4.0
Weaning-Oestrus Period (days)	6.8	5.7	5.5
No. Pigs Weaned	9.1	8.4	9.0
Piglet Weaning Wt. (kg)	5.3	6.3	5.7

Source: Lopez et al., 1988

Recently Cruz and Cruz (1990) ensiled fresh cassava root with Taiwan grass (*Pennisetum purpureum* x *P. typhoides*) and 10% poultry litter. Cassava was included to replace grass at four levels, resulting in 4 silages containing 0, 20, 40 and 60 % of cassava and the corresponding 90, 70, 50 and 30 % of Taiwan grass. In total 6 tonnes of each were ensiled. After 56 days the silos were open, samples were taken for laboratory analysis and the silages fed to Pelibuey rams (18 Kg initial weight). Dry and organic matter content linearly increased as cassava inclusion increased, while pH lowered quadratically, reaching a plateau (pH 4.4) at a break point estimated at about 45% cassava inclusion. Also of interest was that ammonia diminished linearly as the cassava inclusion increased in the following way:

$$Y \text{ (g/100 g of N)} = 49.90 - (0.63 \pm 0.042)(X), r = 0.93$$

In this study the sheeps performace (daily gain and feed efficiency) (Figure 1) improved quadratically, as the level of cassava in the diet increased, with daily gain reaching its maximum at about 43% cassava inclusion, whilst feed efficiency peaked at 29% inclusion.

The source of nitrogen ensiled with cassava is an important consideration and needs further investigation: indications are that urea gives results similar to those described above, but swine faeces are apparently better utilized than poultry litter, i.e., the nitrogen digestibility is lower, but absorbable nitrogen, as true protein is of better quality (Cruz *et al.*, 1990).

The carbohydrate content of cassava can also be utilized to preserve other feed sources by means of lactic acid produced during fermentation. This was used to preserve waste by-catch fish from shrimp fishing, where the fermentable carbohydrate was fresh cassava root and cane molasses (Loeza *et al.*, 1980). Several mixtures of the ingredients were tested and the conclusion was that the best proportions of each, on a dry matter basis, were 45% fish (finely chopped), 40% cassava root, 10% molasses and 5% of a culture of acidifying bacteria in a cabbage solution (Tables 3, 4 and 5.). The resulting silage had stabilized pH of 4.31 (Figure 2) and a protein content of 33% of dry matter, which was of similar quality to fish meal, as measured by chemically available lysine determination.

Other organic materials could be added to ensiling cassava, to either preserve them or to improve the nutritional value of the resulting silage, eg., cassava fodder, fruits and other food byproducts, etc.

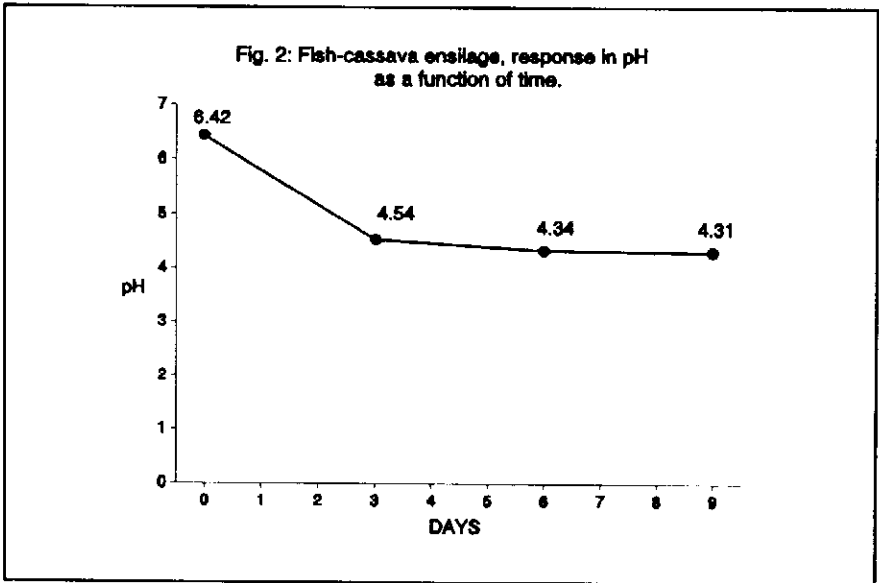
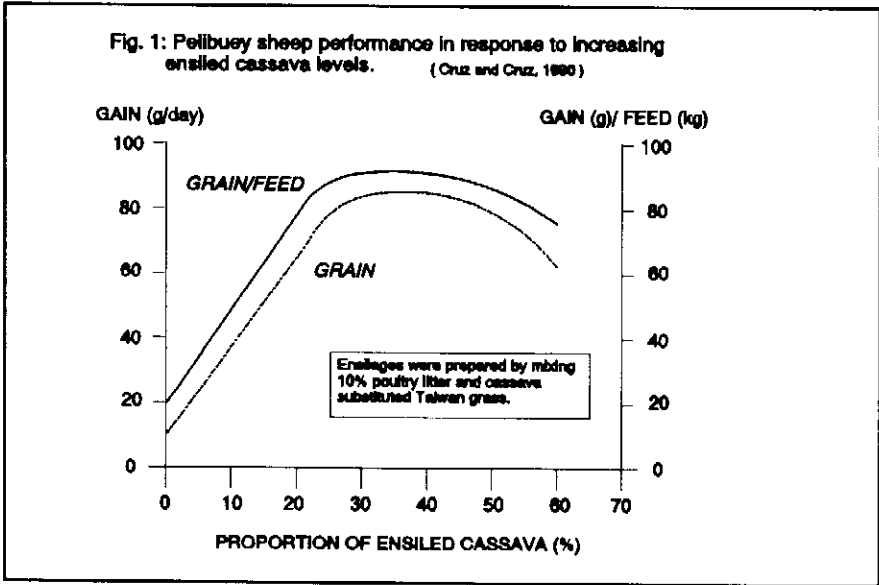


TABLE 3.
Proximate composition of waste fish from shrimp by catch (WF)

	%
Crude Protein (N x 6.25)	66.4 ± 0.78
Ether Extract	5.3 ± 0.08
Ash	4.2 ± 0.02
Nitrogen free extract	< 25%
Dry matter	41.0 ± 0.42

Source: Loeza et al., 1980

TABLE 4. Ingredient content of fish silage

	Dry Matter (%)
Waste fish	45
Cassava	40
Cane molasses	10
<i>Lactobacillus</i>	5

Source: Loeza et al., 1980

TABLE 5. Fish silage composition (after 30 days)

Crude protein (N x 6.25)	33.0 ± 0.8
pH	4.5 ± 0.23
NH ₃ ppm	31 ± 2.24
<i>Lactobacillus</i> spp. x 10 ³	3.7 ± 1.8
<i>Salmonella</i> spp. x 10 ³	-

Source: Loeza et al., 1980

CONCLUSION

Cassava silage is an alternative means of preserving the nutritive value of cassava root, as well as a means of increasing land use. It can also be used as a means of preserving other feed materials or food byproducts, by mixing them with fermenting cassava in silos. This may result in improving their nutritional quality, though it may be more effective to use the other ingredients as supplements rather than additives.

Cassava ensilage is a technology that could be used as a means to assist the development of animal production, but also as an alternative means of encouraging the utilization of this crop, by offering market options in tropical environments, where processing for export is limited, or other markets are non-existent.

However, further research is needed on the amino acid profile required for optimal supplementation of cassava silage, taking into consideration environmental constraints. Although cassava silage can be shown to have the potential to be a major ingredient, practical commercial feeding systems must be developed to take advantage of its potential. In order to achieve this a better knowledge of other available feed resources and their nutritional complementation value must be established. Further research is also needed on means of improving the nutritional value of cassava silage by the use of appropriate microbial enrichment.

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