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Proceedings of a workshop held at the University of Guelph 18-20 April 1977

Sponsored by the International Development Research Centre and the University of Guelph

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Life-Cycle Swine Feeding Systems with Cassava

Guillermo G. Gómez[1]

Sweet cassava roots are an excellent source of energy for swine feeding if properly supplemented with protein, vitamins, and minerals. Fresh bitter cassava roots because of their high linamarin content are not readily consumed by pigs. Chopped fresh cassava can be fed to pigs throughout their life cycle, separately or mixed with a protein supplement. A tendency to overconsume the protein supplement and therefore to waste the excess protein was observed in all experiments where fresh cassava and supplement were fed ad libitum and separately.

A life-cycle swine feeding program based on the use of high levels of cassava meal (60–70%) was tested at CIAT and compared with a conventional common maize feeding program. Soybean meal was the protein source used for all diets. Gilts in the cassava meal feeding program grew more slowly during pregestation and gestation, as compared with the gilts in the control program. However, gilts fed the cassava diets gained weight during lactation; whereas, the gilts from the maize feeding program lost weight during the same period.

Litter performance at weaning was significantly inferior for the gilts fed the cassava meal diets, and since feed consumption was similar for both experimental groups, the amount of diet required to produce a weaned pig in the cassava feeding program was significantly higher than in the common maize feeding program. Recent experimental information suggests that methionine supplementation is not the factor responsible for the lower reproductive performance obtained in the cassava meal feeding program.

Although most cassava roots are presently used as human food, the prospects for using cassava as an animal feed have been stimulated by the agricultural policy changes of the European Economic Community (EEC), which made the replacement of high-priced cereals in composite feeds by alternative energy feedstuffs, such as cassava, feasible (Coursey and Halliday 1974; Phillips 1974).

As a result of active research on genetic selection and the development of more efficient cultivation methods and production practices, the improvement of cassava yields can be obtained under practical field conditions (CIAT 1975, 1976). Alternative uses of cassava for the industrial starch and animal feed markets thus become economically feasible.

Extensive experimental evidence has been obtained on the use of cassava roots as an animal feed, and least-cost feed rations with varying prices of cassava and other feed ingredients have been estimated for different animal species by several EEC importers of cassava (Phillips 1974). Most of the experimental data on swine feeding have been obtained with growing-finishing pigs, from weaning to marketing weights, but limited information is available on the reproductive periods and life-cycle swine feeding systems. This paper reviews experimental information regarding the use of cassava roots, especially in the form of fresh cassava and cassava meal or flour, throughout the life cycle of the pigs.

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Effect of Cyanogenic Glucosides

Cassava varieties are normally classified as sweet or bitter according to their cyanide content. Most of the hydrocyanic acid (HCN) or cyanide (CN) is found in the form of a cyanogenic glucoside known as linamarin. The concentration of linamarin, as evidenced by the cyanide liberated, is substantially higher in the peel of the roots than in the pulp (de Bruijn 1973; Wood 1965). Linamarin releases HCN on treatment with dilute acids; however, the release of HCN is due to the action of the enzyme linamarase, usually present in the tissues (notably the peel) of the roots. Contact of the enzyme with the substrate linamarin normally occurs when the cellular structure of the plant tissues is destroyed.

Pigs do not readily consume fresh bitter cassava roots, and therefore, their growth is retarded. When a protein supplement was supplied ad libitum along with chopped, fresh bitter cassava roots, the pigs consumed an excess of the supplement to compensate for their limited consumption of bitter cassava roots. On the other hand, fresh sweet cassava roots are readily consumed by growing pigs

Table 1. Comparison of intake and performance of finishing pigs fed either sweet or bitter fresh cassava and a protein supplement (P.S.) free choice or controlled (Gomez et al. 1976).

	Sweet cassava +		Bitter cassava +	
	P.S. Ad. lib.	P.S. controlled	P.S. Ad. lib.	P.S. controlled
Avg. daily gain (kg)	0.66	0.77	0.56	−0.08
Daily intake cassava (kg)	2.99	3.40	0.99	0.93
Daily protein intake (kg)	0.81	0.82	1.21	0.22
Total feed intake (kg)[1]	1.98	2.01	1.60	0.58
Feed/gain	2.99	2.61	2.86	Neg.
Protein in diet (%)	14.1	13.3	23.5	13.3

[1] 10% moisture.

and their growth is acceptable, whether the cassava is separately or thoroughly mixed with a protein supplement (Table 1).

Because of the physical contact of linamarase and linamarin when cassava roots are chopped to be dried, most of the HCN is released; thus meal prepared from bitter cassava roots has a relatively low HCN content (100–150 ppm on a dry matter basis). A composite diet including high levels (approx. 73%) of bitter cassava meal (150–200 mg HCN/kg fresh cassava) was consumed slightly less (1.35 kg/day) by growing pigs than a diet based on similar levels of sweet cassava meal (1.77 kg/day) (Gómez et al. 1976), but the difference in consumption was not as great as that observed with the fresh roots. These data suggest that drying the roots greatly reduces the problem of limited consumption of fresh bitter roots by the growing pigs.

Limited information is available on the effect of cyanogenic glucosides present in bitter cassava varieties when fed during the reproductive periods. Fresh sweet cassava plus a 40% protein supplement containing 0, 250, and 500 ppm of added cyanide (as potassium cyanide) throughout the gestation period had no deleterious effect on the reproductive performance of gestating gilts at farrowing; nor was any carry-over effect observed in the subsequent lactation performance (Tewe 1975). During lactation all gilts were fed a control diet based on common maize and soybean meal. An enlargement of the thyroid glands was observed in fetuses at the end of gestation of gilts fed diets containing high cyanide levels (Tewe 1975); however, those gilts that received high levels of cyanide during the gestation period performed similarly at weaning time. Apparently the placental barrier plays a significant role in protecting the growing fetuses from toxic effects. Experimental information (Ekpechi 1967, 1973; Ermans et al. 1969; van der Velden et al. 1973) has been published in which a goitrogenic character is attributed to cassava, especially in areas where dietary iodine is limited. A working hypothesis has been proposed (Ermans et al. 1973) to explain the goitrogenic characteristic of cassava, as a consequence of the increased thiocyanate concentration in the blood. Fortunately, most of the cassava cultivars grown in Latin America are sweet, therefore no major problems are encountered in feeding fresh, ensiled, or dried cassava.

Sweet Cassava Roots for Swine Feeding

Fresh roots and meal are the forms in which cassava is most commonly used for swine feeding. Ensiled roots are also acceptable to pigs, and could be a form of preservation in highly humid environments such as the lowland tropics. Information on the use of fresh cassava in the different periods of the life cycle of the pig has been obtained through collaborative research between the Centro Internacional de Agricultura Tropical (CIAT) and the Instituto Colombiano Agropecuario (ICA) in Colombia.

Fresh cassava was fed ad libitum, either separately from the protein supplement or thoroughly mixed with it, and fed in quantities calculated to supply the minimal daily requirements of the growing pigs. The control diet was fed in automatic feeders, and all experimental animals were kept in confinement on cement-floored corrals. Body weight gain was similar for the animals fed the control diet (0.84 kg/day) and those fed fresh cassava

Table 2. Performance of growing-finishing pigs[1] fed fresh sweet cassava and a 20, 30, or 40% protein supplement (P.S.) free choice (Job 1975).

	Control diet	Cassava +		
		20% P.S.	30% P.S.	40% P.S.
Daily gain (kg)	0.63	0.70	0.67	0.65
Daily feed intake (kg)				
Fresh cassava	—	1.78	2.74	3.32
Protein supplement	—	1.39	1.00	0.75
Total feed intake[2]	2.08	2.08	2.07	2.04
Feed/gain	3.30	2.97	3.09	3.14
Protein in diet (%)	14.3	14.6	16.6	17.3

[1]Mean of five individually fed pigs per treatment: avg. initial weight 21.1 kg; avg. final weight 86.1 kg; 98-day trial.
[2]Approximately 10% moisture content.

roots and the protein supplement ad libitum (0.83 kg/day). The animals fed fresh cassava mixed with controlled quantities of the protein supplement, consumed less cassava and protein supplement; consequently, the average daily gain was lower (0.79 kg/day) than that of the other two experimental groups. On the other hand, the effect of restricting both cassava and the protein supplement according to the appetite and needs of the animals resulted in a better feed efficiency for the cassava plus protein mixture (2.90 kg feed/kg body wt compared with 3.43 for the control diet and 3.36 for the cassava plus the protein supplement).

The amount of fresh cassava required per animal to reach marketing weight (95–100 kg) was approximately 390–400 kg of fresh chopped roots. The basic difference in feed intake was the amount of protein supplement saved when it was mixed with chopped fresh cassava; however, the extra labour required for mixing could reduce the advantages of this method. The consumption of fresh cassava by growing-finishing pigs varies according to the protein content of the supplement. The daily intake of cassava was greater when the protein supplement (fed free choice) supplied higher protein levels and the intake of the supplement decreased. An overall tendency to overconsume protein throughout the growing-finishing periods was observed as the protein content of the supplement increased (Table 2).

Fresh sweet cassava is readily consumed by gestating gilts or sows when an adequate supplement provides a good source of protein, minerals, and vitamins. The results of an experiment to evaluate the use of fresh cassava by gestating gilts are shown in Table 3. All gilts were fed a control diet (maize-soybean meal) throughout the lactation period. Gestating gilts fed fresh cassava and kept in confinement gained more body weight during gestation than both those fed fresh cassava but kept on pasture lots, and those gilts fed the control diet. The number of baby pigs farrowed and weaned by the gilts fed cassava in confinement was, however, less than that of the other two experimental groups.

Lactating sows fed a diet based on fresh chopped cassava mixed with a 40% protein supplement consumed on the average 6.5 kg of fresh cassava and 1.2 kg of protein supplement per day. The litter performance for the cassava-fed sows was inferior with respect to the number of weaned pigs (7.6/litter) to the control-fed sows (9.0/litter); the average weight of weaned pigs was higher (7.63 vs. 6.03 kg) for the cassava-fed sows, but total litter weight was similar for both experimental groups (54.3 kg for the control vs. 58.0 kg for the cassava-fed group).

Results obtained during the different periods of the swine life cycle suggest that fresh cassava roots are an excellent source of energy for growing-finishing pigs when properly supplemented with protein, minerals, and vitamins. Handling of feeding programs based on fresh cassava is an important aspect to be considered. Self-feeding systems, based on the separated ad libitum consumption of fresh chopped cassava roots and protein supplement, lead to an excess intake of the supplement and result in a daily protein uptake significantly higher than the recommended level. A controlled supply of chopped cassava mixed with a protein supplement restricts excess protein consumption to normal levels, but the additional labour must be taken into account.

Table 3. Performance of gestating sows fed diet based on fresh cassava and a protein supplement (P.S.) (40%).

	Control diet[1]	Fresh cassava + P.S.	
		Pasture[2]	Confinement[3]
No. bred	10	10	10
No. farrowed	9	7	7
Weight (kg)			
Breeding	165.8	163.6	152.8
Farrowing	185.7	188.5	190.5
Gestation wt. gain	19.9	24.9	37.7
Lactation wt. gain	13.2	7.7	8.4
Progeny at farrowing			
No. pigs/litter	10.4	10.0	7.7
Litter wt. (kg)	13.3	11.2	9.1
Individual wt. (kg)	1.28	1.12	1.18
Progeny at weaning (35 days)			
No. pigs/litter	8.3	7.3	6.9
Individual wt. (kg)	6.94	6.05	6.49

[1]1 kg/sow/day.
[2]1.7 kg fresh cassava + 0.4 kg P.S./sow/day.
[3]3.1 kg fresh cassava + 0.62 kg P.S./sow/day.

During the reproductive periods of gestation and lactation, a controlled individual feeding system is the most advisable under all circumstances. Unfortunately there is no information available on the use of fresh cassava during the consecutive gestation and lactation periods. It is assumed that no major differences would be encountered if a feeding system was based on the continuous use of fresh cassava; however, more experimental information is needed, especially with regard to the lactation period.

Life-Cycle Feeding Using Sweet Cassava Meal

Because of the handling difficulties normally encountered when fresh cassava roots are used for swine feeding, the most convenient and practical way to handle cassava is to dry the chopped fresh roots and grind them into a meal or flour, which can be easily incorporated and mixed into composite diets. Cassava meal is an excellent energy source of good nutritive value due to its highly digestible carbohydrates (70–75%), mainly starch, but its protein content is extremely low, therefore it requires supplementary protein to balance the diet. In all experimental work at CIAT, cassava meal has been obtained from sweet cassava cultivars, mostly of the variety Llanera. The roots are chopped, sun dried on cement floors, and then ground into a meal.

A life-cycle swine feeding program was outlined, in which the level of crude protein in the experimental diets followed the recommendations of the National Research Council (1973) (i.e. growing (20–50 kg) 16%; finishing (50–90 kg) 13%; pregestation (90–120 kg) 13%; gestation 16%; lactation 16%; and baby pigs (starter feed, 10–56 days) 18%). The feeding program was based on çassava meal and was simultaneously compared with a control feeding program based on common maize. For both programs, soybean meal was used as the protein source to balance the experimental diets (Gómez et al. 1977). The experimental work studied the long-term effects of feeding high levels of cassava meal on the reproductive performance of gilts.

Experimental animals were grouped according to their initial body weight and litter history into two groups of 16 weaned female pigs each. Selected gilts initiated the feeding program, either on cassava meal or common maize, when they weighed approximately 20 kg. They were fed the experimental diets throughout their growing (20–50 kg), finishing (50–90 kg), pregestation (90–120 kg), gestation, and lactation periods. Methionine was not added to any of the experimental diets (composition of the diets is given by Gómez et al. 1977). Boars used to breed the experimental

Table 4. Experimental results of the gestation and lactation periods in life-cycle swine feeding program based on cassava meal or common maize.

	Common maize	Cassava meal
No. gilts farrowed	10	14
Changes in gilt weight (kg)		
Weight at breeding	127.6	118.5
Weight at 110 days gestation	175.6	156.0
Total gestation gain	48.3	37.5
Postfarrowing wt.	160.6	146.1
Net gestation gain	33.1	27.6
Weaning wt.	153.9	159.6
Change during lactation	−6.7	+13.5
Change during gestation-lactation	+26.3	+41.1
Data at farrowing		
No. live-born pigs	10.0	8.4
Avg. weight/pig (kg)	1.09	0.97
Data at weaning (56 days)		
No. weaned pigs	9.4	6.6
Avg. weight/pig (kg)	15.87	15.70
Total litter wt. (kg)	145.4	103.6

gilts were fed a standard common maize-soybean meal diet. Experimental diets were supplied in automatic feeders during the growing, finishing, and lactation periods. Individual, daily controlled feeding was undertaken during the pregestation (2.0 kg/diet/gilt) and gestation (1.8 kg/diet/gilt) periods. In all phases or periods of the experiment, water was available to the animals at all times.

Results obtained during the growing-finishing periods were: average daily gain (kg) 0.77 and 0.71; average daily feed intake (kg) 2.38 and 2.30; and feed/gain 3.09 and 3.24, for the maize and cassava meal diets, respectively. The average daily gain obtained by the growing gilts fed the cassava meal-based diet was significantly lower ($p < 0.05$) than that of the gilts fed the control diet but similar to gains previously reported when fresh cassava or cassava meal-based diets were fed to groups of females and castrated males (Maner 1972). Reproductive performance of the two experimental groups is summarized in Table 4. In general, gilts in the cassava meal feeding program gained less body weight (37.5 vs. 48.3 kg) during gestation than gilts in the common maize feeding program; however, gilts on cassava meal diets continued gaining body weight (+13.5 kg) throughout their lactation period; whereas, the gilts on common maize diets lost weight (−6.7 kg) during the same period. Consequently the overall change in body weight of the gilts in the cassava meal feeding program was significantly higher ($p < 0.05$) than that of the gilts in the common maize feeding program (41.1 vs. 26.3 kg, respectively). The number and weight of the live-born baby pigs were similar ($p > 0.05$) for both experimental groups, although a trend of fewer and lighter baby pigs per litter was observed for the gilts in the cassava meal feeding program. At 21 days of age and thereafter, the number of suckling pigs per litter was significantly inferior ($p < 0.05$), by approximately three pigs per litter, for the lactating gilts in the cassava feeding program. The average body growth of the suckling pigs in both experimental groups was similar, as evidenced by practically the same average weight at weaning time (15.87 vs. 15.70 kg). However, because of the larger number of weaned pigs per litter, the common maize feeding program produced heavier litters than the cassava meal feeding program (145.4 vs. 103.6 kg). A similar trend of raising fewer suckling pigs throughout the lactation period was previously reported in feeding fresh cassava or cassava meal during either the gestation or lactation periods (Maner 1972).

The reasons or factors involved in the lower reproductive performance of the gilts in the cassava meal feeding program are not clear. The slightly lower body weight, although within the normal range, of the gilts fed the cassava meal-based diet at breeding could have had an adverse effect on the number of embryos, which would subsequently affect the number of live-born pigs. From the production point of view, however, the most striking difference was the significantly lower number of weaned pigs in the cassava feeding program. Whether these results are a consequence of a carry-over effect from the gestation period or are due to the gain in body weight during lactation (or to both) needs further experimental evidence.

The absence of methionine supplementation does not appear to be responsible for the lower reproductive performance of gilts in the cassava meal feeding program. The results of recent experimental work in which cassava meal-soybean meal based diets were fed throughout the gestation and lactation periods, with and without methionine, showed that gilts fed the cassava meal diets performed simi-

Table 5. Effect of methionine supplementation in cassava meal-based diets for gestating-lactating gilts.

	Common maize	Cassava meal + soybean meal	
		0.0% methionine	0.3% methionine
No. gilts farrowed	14	10	10
Body weight of gilts (kg)			
At breeding	117.0	121.2	120.1
Total gain, gestation	56.9	49.1	47.6
Weight loss, lactation	17.3	13.8	15.3
Total gain, gestation-lactation	39.6	35.3	32.3
Data at farrowing			
No. pigs/litter	8.5	9.1	9.4
Avg. pig wt. (kg)	1.09	1.06	1.07
Data at weaning (56 days)			
No. pigs/litter	7.1	8.2	8.0
Avg. pig wt. (kg)	16.74	16.15	16.54
Total litter wt. (kg)	117.02	128.50	131.95

Table 6. Intake (kg) of experimental diets and basic ingredients in life-cycle swine feeding programs based on cassava meal or common maize.

	Common maize diets			Cassava meal diets		
	Total	Maize	Soybean meal	Total	Cassava meal	Soybean meal
Growing	77.9	59.5	14.7	91.9	63.6	23.9
Finishing	137.9	121.2	10.1	124.0	94.1	23.9
Pregestation	230.6	202.7	16.8	217.2	164.9	41.9
Gestation	209.9	160.4	39.5	211.0	146.0	54.9
Lactation	265.5	202.8	49.9	292.5	196.0	82.8
Baby pig/starter	79.6	49.8	18.1	51.1	25.9	17.7

larly, irrespective of the methionine supplementation, at least for the first gestation and lactation periods (Table 5). The experimental period was initiated at breeding when gilts exhibited similar body weights, and individual controlled feeding (1.8 kg diet/gilt/day) was followed throughout the gestation period. On average, all animals of the experimental groups lost weight during lactation, as compared to the weight gain exhibited during lactation in the previous experiments (Gómez et al. 1977).

The use of methionine supplementation is recommended when high levels of cassava are mixed in composite diets with plant protein sources, such as soybean meal. Apparently, methionine supplementation serves the double purpose of improving the protein quality of the diets and of supplying a readily available source of labile sulfur for cyanide detoxication (Maner and Gómez 1973). In the case of experimental information obtained with rats, methionine supplementation in cassava meal diets normally produces significant improvement because the protein source used is casein, which is known to be deficient in this amino acid. In addition, for this type of biological evaluation with laboratory animals, suboptimal levels of dietary protein are commonly employed, making a response to methionine supplementation feasible. The effect of methionine supplementation would depend basically on the protein quality of the feedstuff used as the protein source.

Data on intake of the experimental diets and the basic ingredients recorded from the life-cycle swine feeding program based on cassava meal are presented in Table 6. Overall total intake of experimental diets and for individual periods were similar for both groups. The most important difference was the amount of soybean meal required for the cassava meal feeding program as compared with the maize-based feeding program. Considering only the growing and finishing periods, the total relative amounts of cassava meal and soybean meal required per animal to reach marketing weight are 87 and 193%, respectively, of the amounts of common maize and soybean meal required to obtain similar performance with pigs in the common maize feeding program. Almost twice as much soybean meal is required for the growing-finishing periods of feeding programs based on cassava.

Feed intake during the reproductive periods (pregestation, gestation, and lactation, as well as the baby pig starter feeding) was also similar for both feeding programs. The cassava meal-based feeding program required 87 and 159% of cassava meal and soybean meal, respectively, as compared with the amounts of common maize and soybean meal required in the feeding program based on common maize. However, because of the lower experimental results obtained at weaning time with the cassava meal-based feeding program, the amount of diet required to produce a weaned pig was 45% higher (119.0 vs. 82.1 kg diet/weaned pig) for this feeding system as compared with the common maize feeding system. These data support the theoretical concept that the economic feasibility of using cassava as a substitute for other energy sources would depend on the relative price of cassava, as well as the price of the protein supplement needed to balance a cassava-based diet (Phillips 1974).