UTILIZATION OF YUCA IN SWINE FEEDING

—*by*—

Jerome N. Maner, Julian Buitrago, and Ivan Jimenez.
Instituto Colombiano Agropecuario and the Rockefeller Foundation

The ever expanding world population demands a continued interest in increasing the quantity and quality of food produced to feed these new generations and to reduce the widespread pains of malnutrition that exist among much of the present population. The development and expansion of an animal industry must take this fact into consideration, and every attempt must be made by animal nutritionists to reduce competition between the human and animal population for available protein and energy sources.

Swine require large quantities of energy and moderate quantities of protein for their growth and development. In the leading pork producing countries of the world there exist large supplies of grains that are available for animal feeding. In other countries the annual production of all classes of grains is not great enough to satisfy the needs of existing human population ; however, many of these countries have the potential or are already producing large quantities of other food sources that are available for livestock feeding if they can be incorporated into efficient and economical rations.

A good example of an energy source that has great potential in many countries is *Manihot* or in more common terms yuca or cassava, whichever is preferred. Large quantities of this crop are now being produced and future potential feeding and especially in swine rations is limited. Experimental results reported by Oyenuga and Opeke, (1957) and Modebe, (1963) of West Africa indicate that up to 50 to 55% of the diet of growing-finishing pigs can be supplied by either wet or dried yuca. Noland, *et al,* (1957) from very limited data suggest that pigs will grow well when fresh yuca is included in the diet but must be fed a controlled quantity protein supplement in order to prevent over-consumption.

The utilization of yuca, basically a carbohydrate source with very little protein, in swine feeding requires that special attention be given to protein, vitamin and mineral supplementation, to toxicity caused by the presence of hydrocyanic acid, and to feeding management. Therefore experiments were conducted to study these factors of protein, vitamins, minerals and feeding management as they are related to yuca utilization by the pigs.

PROCEDURE AND RESULTS

The yuca utilized in the studies was a mixture of several varieties commonly used for human consumption and was produced at the Palmira Experiment Station of the Colombian Agricultural Institute (ICA). The fresh yuca utilized was harvested two or three times weekly to prevent spoilage. After harvest the yuca was washed to remove the adhering soil and chopped daily as it was needed. Yuca for the first studies was chopped by hand using a large knife (machete) ; a soil shredder was later utilized for chopping. The yuca meal utilized was produced by drying the chopped yuca at 180°F in a forced-air oven for 24 to 36 hours.

The yuca and protein supplements of all studies utilizing fresh, chopped yuca were fed in automatic metal feeders and all yuca not consumed within 24 hours after feeding was collected, weighed and discarded.

Experiment 1.

Fifteen weanling Duroc pigs weighting an average of 18.1 kgs. were used in an experiment with a completely randomized design. The pigs were maintained on pasture which was equipped with a shade over a concrete slab. Automatic feeders and waters were used. The rations fed were (1) a basal diet of corn, soybean meal, cottonseed meal, bone meal and vitamin-trace mineral premix; (2) raw, chopped yuca *ad libitum* and a protein supplement also offered *ad libitum,* and (3) raw, chopped yuca *ad libitum* and a protein supplement fed in quantities sufficient to supply the pigs minimal daily requirement. The composition of the basal diet and the protein supplement are presented in Table 1. Upon analysis the basal diet contained 19.81% protein and the protein supplement contained 42.88% protein (Table 2). The yuca contained 63.76% moisture and only 1.04% protein.

The performance of the pigs in all lots was very satisfactory and very similar (Table 3). The pigs fed the control diet gained an average of 0.765 kgs. daily during the 112-day experimental period as compared to 0.774 kg. daily gain by the group consuming both yuca and the 42.88% protein supplement free choice. Group 3 which received a controlled amount of protein supplement (average daily intake 0.69 kgs.) gained 0.730 kgs per day. Average daily intakes of fresh yuca was 3.66 and 3.84 kgs. respectively for groups 2 and 3. For convenience of comparison the feed intakes were also calculated on a dry basis . The basal group consumed more dry feed daily and required 11.8% more feed to produce a unit of gain when compared to those receiving yuca and protein supplement.

Table 1. Composition of Basal Diet and Protein Supplement utilized in Experiments Nos. 1 and 2

Ingredients	Basal Diet (%)	Protein Supplement (%)
Soybean Meal	10.59	61.50
Cottonseed Meal	3.53	20.53
Corn	81.33	—
Bone Meal	2.00	7.90
Vitamins-Trace Mineral Premix[a]	2.55	10.07
Total	100.00	100.00

[a] Contributed 2500 I.U. vitamin A ; 250 I.U. vitamin D ; 2.5 mg. riboflavin ; 12.5 mg. niacin ; 7.5 mg. pantothenic acid ; 125 mg. chlorine choloride ; 16.5 mg. vitamin B 50 mg. chloratetracycline ; 51.5 mg. Mn ; 2 mg. Co ; 4. 4. mg. Cu ; and 45.5 mg. Zn per kg. of finished feed in the control diet ; approximately 4 times this amount was added to the protein supplement.

Table 2. Proximate Analysis of Basal Diet, Protein Supplement and Yuca utilized in Experiments Nos. 1 and 2

Analysis	Basal Diet (%)	Protein Supplement (%)	Yuca (%)
Moisture	10.84	8.60	63.76
Protein	19.81	42.88	1.04
Fiber	3.86	4.40	1.06
Ether Extract	4.64	1.67	0.26
Ash	6.57	14.85	0.86
Nitrogen-Free Extract	51.11	20.74	32.02

Table 3. Performance of Pigs Fed basal Diet or Raw-yuca and protein supplement – Experiment No. 1

	(1)	(2) Raw-yuca + Supplement ad lib	(3) Raw-yuca Supplement Controlled
		kilograms	
Av. daily gain[a]	0.765	0.774	0.730
Av. daily intake, wet yuca	–	3.66	3.84
Av. daily intake, dry yuca	–	1.33	1.38
Av. daily intake, supplement	–	0.84	0.69
Av. daily intake, supplement[b]	2.40	2.17	2.07
Feed/unit gain	3.13	2.80	2.83

[a] Five pigs per treatment; 112-day experiment; Av. initial wt., 18.1 kg.

[b] Total intake expressed on a dry matter basis.

Experiment 2.

This experiment was a replication of Experiment 1 except that the pigs were housed in confinement. Fifteen weanling Duroc pigs were randomly allotted to the three treatments previously described in Experiment 1. The performance of the pigs (Table 4) was similar to those of Experiment 1. The growth rates of the basal group and the yuca group offered protein supplement free choice were very similar, 0.843 and 0.834 kg. daily gain, respectively. The efficiency of feed utilization was not different for the two groups. The group receiving yuca plus a controlled amount of protein supplement (Lot 3) consumed slightly less wet yuca daily and only 0.67 kg. of supplement daily as compared to 1.06 kg. consumed by the free choice group. As a result this group had 4.7% less daily gain but required 20.5% less total feed to produce a kilo of gain.

Table 4. Performance of Pigs Fed Basal Diet or Raw-yuca and Protein Supplement – Experiment No. 2

Item	Basal	Raw-yuca + Supplement Ad-Lib	Raw-yuca † Supplement Controlled
	.....	kilograms	.....
Av. daily gain[a]	0.843	0.834	0.794
Av. daily intake, wet yuca	–	4.05	3.89
Av. daily intake, dry yuca	–	1.47	1.40
Av. daily intake, supplement	–	1.06	0.67
Av. daily intake, total[b]	2.58	2.53	2.07
Feed/unit gain	3.05	3.03	2.61

a
Five pigs per treatment ; 98-day experiment ; Av. initial wt. 17.8 kg.
b
Total expressed on a dry matter basis.

Experiment 3.

Ninety-six Duroc and Duroc-Landrace crossbreed pigs weighting an average of 23.0 kgs. were divided according to weight, sex, litter and condition to 12 outcome groups of 8 pigs each. These outcome groups were then allotted to six treatments, each with two replications. Each group was fed fresh, chopped yuca daily to allow voluntary consumption, and the excess was removed, weighed and discarded each morning before offering additional yuca. It was of interest to compare two basic protein supplements with two levels of vitamin-trace mineral supplementation (Table 5). A combination of cottonseed meal and soybean meal was compared with only soybean meal, both with a normal level of vitamin-trace mineral supplementation and with two times this normal level. Supplements 2 and 4 were offered *ad libitum* and in daily rations calculated to exceed the pigs' daily protein requirements by 10%. (National Research Council, 1964)

Table 5. Composition of Protein Supplements fed with Raw-yuca to growing – finishing pigs – Experiment No. 3

Ingredients/Treatments	(1) %	(2) %	(3) %	(4) %	(5) %	(6) %
Soybean Meal (SOM)	65.00	64.00	90.00	88.00	64.00	88.00
Cottonseed Meal (CSM)	25.00	24.00	—	—	24.00	—
Bone Meal	8.00	8.00	8.00	8.00	8.00	8.00
Vitamin-Trace Mineral Premix[a]	2.00	4.00	2.00	4.00	4.00	4.00
Total	100.00	100.00	100.00	100.00	100.00	100.00

a
Contributed 3 mg. riboflavin ; 11 mg. pantothenic acid ; 25 mg. niacin ; 125 mg. chlorine chloride ; 16.5 mg. vitamin B 250 I.U. vitamin D, 2500 I.U. vitamin A ; 51.5 mg. of Mn ; 4.4 mg. Cn ; 2 mg. Co ; 45.5 mg. Zn ; and 5 mg. chlorate-ra-ycline per kg. of finished feed.

The pigs were grown in concrete lots 2.5 x 8 meters and body weights and protein supplements consumption were recorded at weekly intervals. Yuca consumption was recorded daily.

The performance data for this trial is presented in Table 6. The average daily gains were very similar for all groups fed either of the basic protein supplements free choice. There was no consistent advantage of adding higher than recommended levels of vitamins and trace-minerals. The average gains obtained from the groups fed controlled daily rations of protein supplement were not different between treatments, but were inferior to those produced by pigs receiving *ad libitum* quantities of either supplement.

Average daily intakes of wet yuca were very similar varying an average of only 480 gms. between the highest and lowest daily consumption (3.89 to 3.41 kg.). Higher daily intakes of protein supplement were observed among the groups fed *ad libitum* the combination of cottonseed meal-soybean meal (CSM and SOM) when compared to the groups offered voluntary consumption of the supplement containing only soybean meal (SOM). As a result of this higher daily consumption the CSM and SOM groups required more total feed (yuca and supplement) to produce a unit of gain. Feed required to produce a unit of gain was not different among the S O M groups nor between the groups receiving controlled quantities of either supplement.

Table 6. Influence of protein source and vitamin-trace mineral level of growing –finishing pigs fed raw-yuca ad-lib – Experiment No. 3

Protein	SOM + CSM			SOM		
Vitamin-Trace – mineral Supplement	Normal Ad-Lib	2 x Normal Ad-Lib	2 x Normal Control	Normal Ad-Lib	2 x Normal Ad-Lib	2 x Normal Control
	kilograms					
Av. daily gain[a]	0.687	0.657	0.614	0.627	0.661	0.618
Av. daily intake, wet yuca	3.89	3.65	3.50	3.41	3.67	3.60
Av. daily intake, dry yuca[b]	1.38	1.30	1.25	1.21	1.31	1.28
Av. daily intake, supplement	0.83	0.93	0.67	0.70	0.73	0.61
Av. daily intake, total	2.21	2.23	1.92	1.91	2.04	1.89
Feed/unit gain	3.22	3.38	3.10	3.03	3.07	3.06

[a] Sixteen pigs per treatment ; 84-day experiment ; Av. initial wt., 23.0 Kg.

[b] Yuca calculated on 10% moisture basis.

It was observed that pig does an acceptable job of balancing his own diet when offered fresh, chopped yuca and protein supplement *ad libitum*. It was, however, observed that the pig tends to slightly overeat protein when calculated over the entire experiment. This is basically due to excessive consumption during the early stages of the feeding trial. In general, the daily voluntary consumption of wet yuca increases progressively from weaning to market weight, and the daily voluntary con-

sumption of protein remains almost constant over the entire period.

Experiment 4.

It was of interest to measure the performance of growing-finishing pigs fed complete-balanced diets with varying levels of dried yuca. Yuca, chopped in a soil shredder and dried in a forced-air oven at 180°F to a final moisture content of approximately 10%, was substituted for 33.66 or 100% of the corn in the basal, 16% protein, corn-cottonseed meal-soybean meal diet (Table 7), and the protein level equalized in these diets by increasing the level of soybean meal. The level of cottonseed meal was held constant at 7% in all diets to avoid problems of gossypol toxicity. These four treatments were repeated adding 10% cane molasses to increase palatability by reducing the dustiness of diets caused by the powdery nature of the dried yuca.

Table 7. Composition of Experimental Diets – Experiment No. 4

Diet	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	%	%	%	%	%	%	%	%
Dried ground yuca[a]	—	25.72	48.65	69.25	—	21.70	41.04	58.26
Ground yellow corn	81.31	51.43	24.33	—	69.00	43.38	20.52	—
Soybean Meal	7.69	11.85	16.02	19.75	10.00	13.92	17.45	20.74
Cottonseed Meal	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Cane Molasses	—	—	—	—	10.00	10.00	10.00	10.00
Bone Meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Vitamin-Trace – Mineral Premix[b]	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

[a] Dried in forced-air oven at 180° F.

[b] Contributed the same concentration of vitamins and trace minerals as in premix of Table 5.

The summary of performance data is presented in Table 8. Each increase in level of dried yuca caused a corresponding decrease in average daily gain with or without 10% molasses. These decreases in gains were not caused by decreased feed intake as the average daily voluntary consumption among treatments without added molasses was not different. Adding 10% molasses increased daily feed consumption by 13.7% and supported a 9.8% increase in average daily gains when treatments with and without molasses were compared. As contrasted to the treatments without molasses, increasing the yuca level in the presence of molasses caused a decrease in average daily consumption. Feed conversion was not greatly different among treatments.

Table 8. Influence of level of dried-yuca on growing-finishing pigs' performance Experiment No. 4

Treatments/Results[a]	Av. daily gain,	Daily feed intake	Feed/unit gain,
	..... kilograms		
1 Basal	0.773	2.68	3.47
2 25.72% yuca	0.744	2.66	3.57
3 48.65% yuca	0.743	2.79	3.76
4 69.25% yuca	0.708	2.48	3.49
5 Basal + 10% molasses	0.888	3.38	3.84
6 21.70% yuca + 10% molasses	0.827	2.95	3.56
7 41.04% yuca + 10% molasses	0.777	3.00	3.85
8 58.26% yuca + 10% molasses	0.767	2.73	3.54

[a] Six pigs per treatment; 111-day experiment; Av. initial wt. 18.5 Kg.

Experiment 5.

In view of the results obtained in the previous experiment, reduced gains as the level of dried yuca was increased, an experiment was conducted to evaluate the influence that additions of animal protein (fishmeal) and double vitamin-trace mineral fortification might have on growing-finishing pig performance when dried yuca was used to completely replace corn in the diets (Table 9.) Forty weanling Duroc and Duroc x Landrace pigs weighting an average of 19.3 kg. were alloted to the 2 x 2 x 2 factoral experiment using a randomized design. The variables of the experiment were two levels of fishmeal, two levels of vitamin-trace mineral fortification and two levels of molasses. Feed was supplied *ad libitum* in automatic metal feeders. The pigs were housed in 4 x 5 mt. concrete lots of all which were sheltered.

Table 9. Composition of Experimental Diets — Experiments 5 & 6

Diet	(1) %	(2) %	(3) %	(4) %	(5) %	(6) %	(7) %	(8) %
Dried ground yuca[a]	69.25	69.03	66.25	66.03	58.26	58.04	55.26	55.04
Fishmeal	—	—	3.00	3.00	—	—	3.00	3.00
Soybean Meal	19.75	19.75	19.75	19.75	20.74	20.74	20.74	20.74
Cottonseed Meal	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Cane Molasses	—	—	—	—	10.00	10.00	10.00	10.00
Bone Meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Vitamin-trace Mineral Premix[b]	2.00[c]	2.22[d]	2.00	2.22	2.00	2.22	2.00	2.22

[a] Dried in forced-air oven at 180°F

[b] Supplies the same level of vitamins and trace minerals as premix in Table 7

[c] Normal vitamin-trace mineral fortification

[d] Double vitamin-trace mineral fortification

The second day after the initiation of the 28-day experiment, diarrhoea developed in all lots and by the third day all pigs in all lots had developed the same symptoms. All drugs and antibiotics used were ineffective in controlling the diarrhoea. As would be expected all pigs grew very poorly as can be seen in Table 10. The experiment was terminated after 28 days, and the pigs changed to another diet. The diarrhoea stopped almost immediately and the pigs began to make acceptable gains. Yuca toxicity was suspected. A close check of the yuca source, revealed that two rows of yuca variety (H-34) known to be very high in hydrocyanic acid had been accidently included in the dried yuca. Heating this yuca for 24 to 36 hours at 180°F did not eliminate the hydrocyanic acid toxicity and this small quantity included in the mixture was sufficient to cause the severe diarrhoea.

Table 10. Influence of vitamin-trace mineral level, molasses and fishmeal on dried yuca utilization by growing-finishing pigs — Experiment No. 5

Treatments/Results[a]	Av. daily gain, (Kg.)	Daily feed intake, (Kg.)	Feed/unit gain, (Kg.)
	..... (0% molasses)		
1 Basal	0.246	1.30	5.28
2 Basal + 2 x Vit. Tr. Min.	0.225	1.19	5.29
3 Basal + 3% Fishmeal	0.335	1.37	4.09
4 Basal + 2 x Vit. Tr. Min. + 3% Fishmeal,	0.375	1.58 (10% Molasses)	4.21
5 Basal	0.201	1.02	5.07
6 Basal + 2 x Vit. Tr. Min.	0.104	0.89	8.56
7 Basal + 3% Fishmeal	0.257	1.13	4.40
8 Basal + 2 x Vit. Tr. Min. + 3% Fishmeal,	0.227	1.07	4.71

[a] Five pigs per treatment ; 28-day experiment ; Av. initial wt. 19.3 Kg.

Experiment 6.

The same experiment was then repeated using a new batch of dried yuca. The performance data of the pigs are presented in Table 11. As can be seen from the data the pigs performed very satisfactorily. Doubling the vitamin-trace mineral supplementation in the diet tended to increase gains and feed efficiency. Contrary to the results obtained in Experiment 4, molasses had no effect on either rate of gain or feed efficiency. The addition of 3% fishmeal was not of value in improving gains or feed conversion; however, in the presence of 10% molasses and a double vitamin-trace mineral fortification, 3% fishmeal did support faster gains.

Table 11. Influence of vitamin-trace mineral level, molasses and fishmeal on dried yuca utilization by growing-finishing pigs — Experiment No. 6

Treatments/Results[a]	Av. daily gain, Kg.	Daily feed intake, Kg.	Feed/unit gain Kg.
	..... (0% molasses)		
1 Basal	0.714	2.03	2.84
2 Basal + 2 x Vit-Tr. Min.	0.748	2.27	2.99
3 Basal + 3% Fish Meal	0.672	2.19	3.26
4 Basal + 2 x Vit-Tr. Min. + 3% Fish Meal,	0.710	2.17	3.06
	..... (10% molasses)		
5 Basal	0.708	2.16	3.05
6 Basal + 2 x Vit-Tr. Min.	0.716	2.03	2.84
7 Basal + 3% Fish Meal	0.714	2.63	3.68
8 Basal + 2 x Vit-Tr. Min. + 3% Fish Meal,	0.780	2.25	2.88

[a] Five pigs per treatment ; 57-day experiment ; Av. initial wt. 22.3 Kg.

DISCUSSION

The satisfactory daily feed consumption, gains and feed efficiency of pigs fed fresh, chopped yuca in combination with a well fortified protein supplement, demonstrate that yuca can be used as the only energy source in growing-finishing pig rations. It is essential that yuca be fresh and free from spoilage and that varieties with low hydrocyanic acid (HCN) content be utilized as even small quantities of HCN have severe effects on the growth and condition of pigs.

Although young pigs tend to overeat protein supplement probably to satisfy drymatter and energy needs until their stomachs are large enough to allow for consumption of large quantities of fresh yuca, older pigs are able to consume sufficient yuca to satisfy their daily energy needs and consume only enough supplement to meet their daily requirements for protein and vitamins.

The dusty-powdery nature of dry ground yuca could possibly cause a problem in ration palatability although it was not shown to be a problem in the present studies. In addition to its very low protein and vitamin content which requires that special care be given to proper supplementation, yuca is almost void of other extract. It is possible that additions of small quantities of fat or oil would be useful in improving pig performance.

These studies only represent the first phases in research that needs to be conducted to study how to better utilize yuca in complete life-cycle feeding of swine.

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