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THE USE OF WASTE BANANAS FOR SWINE FEED

Héctor Clavijo*
Jerome H. Maner**

Introduction

The continually rising demand for food needed to feed an ever-increasing human population makes it imperative, if hunger is to be overcome and prevented, to utilize every available food resource in the most efficient manner possible. Within tropical environments there are many feedstuffs that could contribute greatly to increased protein production if properly utilized in agriculture. Reject bananas are exemplary of this unrealized potential.

The banana belongs to the genus Musa, comprising thirty-two or more distinct species and at least one hundred subspecies. The standard varieties of bananas handled in the trade belong to M. sapientum L. (Gros Michel) and M. cavendishii (Cavendish). The plantain (M. paradisiaca L.), a starchy, cooking banana, is used locally but seldom enters into international trade.

Although bananas and plantains are grown largely for export and domestic human consumption, large quantities of this fruit are available for livestock feed. At the packing plants in areas of commercial banana production, the bananas that are too small or too large, slightly bruised, with off color spots, or are not in an optimal stage of maturity for shipping, are rejected for export. The "reject" or waste bananas along with smaller quantities of farm produced bananas and plantains constitute a good source of carbohydrates for livestock.

It is estimated that a world total of more than 28 million metric tons of bananas is

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produced annually. Of this production, more than 65 percent is produced in Latin America, 25 percent in the Far East and 7 percent in Africa. The exact quantity of the total production available for livestock feed is not known. Depending upon season, supply, demand and peculiarities of the market, the total amount available for uses not related to human consumption may represent as much as 50 percent of total production within a country or region. This large percentage of unmarketable fruit probably represents an extreme present only under very poor marketing conditions and a figure of 25 to 30 percent would probably better represent the true quantity. Data from *Costa Rica* (1963) indicate that only 68 percent of all fruit produced is marketed. The remainder could be used for home consumption and for livestock feed. Even if only 20 percent of the world production were available for livestock feed, this would represent more than 5.5 million metric tons of fresh bananas or approximately 1.1 to 1.3 million metric tons of air-dried material.

The fresh whole banana with the peeling contains approximately 80 percent water and 20 percent dry matter; this last figure represents 1.0 percent protein, 1.0 percent fiber, 0.2 percent fat, 1.0 percent ash and 16.8 percent nitrogen-free-extract (Maner, 1970). The crude fiber of whole bananas consists of 60 percent lignin, 25 percent cellulose and 15 percent hemicellulose. The ripe pulp contains 0.50 percent lignin, 0.21 percent cellulose and 0.12 percent hemicellulose (von Loesecke, 1950). Although the more commonly grown commercial varieties of bananas, Gros Michel and Cavendish, conform to this generalized chemical composition, locally grown bananas and plantains vary in their chemical make-up (Bressani et al., 1961).

Fresh Bananas

The banana can be utilized fresh or as a dried meal. The degree of ripeness of fresh bananas greatly affects the results obtained when this fruit serves as the major source of energy in growing-finishing swine rations. Ecuadorian studies (Hernandez and Maner, unpublished data) have clearly demonstrated that the pig will consume daily, large quantities (8.85 kg) of bananas if they are allowed to ripen before they are fed (Table 1); however if they are fed green, in combination with a 30 percent protein supplement, the pig will voluntarily consume only about 50 percent (8.85 vs 4.25 kg per day) as much green bananas as ripe bananas. These animals partially compensate for this reduced banana consumption by increasing their intake of protein supplement.

Table 1. Performance of growing-finishing pigs fed ripe, green or cooked green bananas[a/]

Parameters[b/] \ Treatments	1	2	3	4
	Control	30% Protein Supplement + Bananas		
	Maize + Supplement	Ripe	Green	Cooked-green
Avg daily gain, kg	0.68^{x}	0.56^{y}	0.46^{z}	0.50^{z}
Avg daily feed, kg				
Bananas, kg	-	8.85^{x}	4.25^{z}	6.20^{y}
Supplement, kg[c/]	-	0.71^{x}	1.04^{z}	0.88^{y}
Total dry feed, kg	2.31^{x}	2.48^{x}	1.89^{y}	2.13^{x}
Feed/gain	3.41^{x}	4.44^{y}	4.16^{y}	4.26^{y}

a/ Hernández and Maner (1965). Unpublished data. Eighteen pigs per treatment in two replications of nine pigs per group. Avg initial weight 28.5 kg. Each group removed from experiment when obtained average weight of 92.0 kg.

b/ Means in the same line with different superscripts are significantly different ($P < 0.05$).

c/ 30 percent protein supplement composed of fishmeal, cottonseed meal, maize, vitamins, minerals and antibiotics.

The net result of an overconsumption of protein supplement and a low consumption of green bananas was to depress daily consumption of air-dried feed which reduced the growth rate.

Cooking the green bananas significantly improved both banana consumption and pig performance; however, even this process failed to improve the performance of the pigs to the level obtained when ripe bananas were fed.

Viteri et al. (unpublished data) demonstrated that when groups of growing pigs were fed equal faily quantities of either ripe or green bananas along with a controlled quantity of protein supplement, the growth rate and efficiency of feed conversion obtained were almost identical for both groups (Table 2). Complementary studies (Clavijo and Maner, unpublished data; Viteri and Maner, unpublished data) have shown that the level of consumption of ripe and green bananas is associated basically with differences in the palatability of these two forms of presentation. These data were confirmed by Clavijo and Maner (1973) who showed that the digestion coefficients of green and ripe bananas are not different.

Table 2. Performance of growing pigs fed equal quantities of either green or ripe bananas[a/]

Parameters[b/]	Treatment	
	Ripe bananas	Green bananas
Initial weight, kg	31.9	32.1
Final weight, kg	61.1	60.3
Avg daily gain, kg	.463	.449
Avg daily banana, kg	2.96	2.72
Avg daily concentrate, kg	1.05	1.05
Feed/gain[c/]	3.55	3.55

a/ Viteri, Oliva and Maner (1971), unpublished data.

b/ The parameters are not significantly different ($P > 0.05$).

c/ Feed/gain expressed on 10 percent moisture basis.

The difference in palatability between ripe and green bananas is immediately obvious to the consumer. The green banana is dry and bitter to the taste while the ripe banana is more moist and sweeter. Palatability depends on the chemical composition of the fruit. Many chemical changes occur within the banana during the ripening process and these greatly affect palatability.

One feature of the unripened banana is its strongly astringent taste. This taste is the result, in part, of the presence of tannins in the fruit. It has been suggested that the total amount of tannins in bananas remains practically constant during ripening. The loss or reduction of astringence is associated with a change in the state or chemical form of the tannins (von Loesecke, 1950). They suggest that tannins exist in the banana in two forms: 1) "free" or active tannins which impart a strong bitter taste to the fruit and 2) "bound tannins" or "vegetable tannates" which are insoluble and supposedly inert and which have little or no effect on palatability. During the ripening process, the level of free tannin decreases because the tannins are slowly bound in an insoluble form. The level of free or active tannin is much

higher in the peel than in the pulp but both are significantly reduced by the time the fruit has matured to the "eating-ripe" stage (Table 3) (von Loesecke, 1950). Since that quantity of tannins is greater in the peel, the reduction in active tannin is much greater than in the pulp.

Although the water content of the pulp is increased during the 10 to 11 days required for the banana to ripen to the eating stage, the most conspicuous change in the maturation of the banana is the conversion of starch to sugar (Table 4) (Stratton and von Loesecke, 1930). During ripening there is a decline in starch content and a corresponding increase in sugar content. There is a gradual shift in the carbohydrate fraction from almost all starch to almost all sugar. In the banana, 10 to 11 days are required for this shift. Because of respiration needs there is a small but definite decrease in total carbohydrates in all varieties during ripening.

Table 3. Changes in amount of "active" tannin in the pulp and peel of bananas during the ripening process expressed as units per 100 grams of tissue [a/]

Days	Fruit Condition	Pulp	Peel
0	Green	7.36	40.5
1	Green	8.01	34.0
2	Green	7.57	28.3
3	Green	4.30	25.4
4	Green	5.02	25.9
5	Coloring	4.30	16.5
6	Coloring	3.87	18.1
7	Coloring	1.95	11.2
8	Eating-ripe	2.84	4.6
9	Eating-ripe	1.99	4.7
10	Over-ripe	2.00	4.5
11	Over-ripe	1.32	3.5

a/ von Loesecke, 1950.

Table 4. Changes in the starch, sugar and total carbohydrate content of banana and plantain pulp during the ripening process expressed as percentage of fresh pulp[a/]

Variety	Number of ripening days							
	0	3	5	7	9	11	14	17
Gros Michel								
Starch	20.65	12.85	6.00	2.93	1.73	1.21	-	-
Total sugars	0.86	7.66	13.76	16.85	16.87	17.91	-	-
Total carbohydrates	21.51	20.49	19.72	19.78	18.60	19.62	-	-
Plantain								
Starch	32.20	31.68	30.90	30.48	28.52	20.17	11.69	6.1
Total sugars	0.82	0.85	1.02	0.92	3.84	9.78	18.89	21.1
Total carbohydrates	33.02	32.53	31.92	31.40	32.36	29.95	30.58	27.2

a/ Stratton, F.C. and von Loesecke, H. W., 1930.

The majority of the sugars present is in the form of sucrose, glucose and fructose; maltose has been identified in trace amounts. The predominant sugar in bananas is sucrose, some of which is hydrolyzed to glucose and fructose (Table 5) (von Loesecke, 1950). Glucose accounts for approximately 58 percent of the total reducing sugars present and fructose for about 42 percent.

The carbohydrate values of the banana peel are much smaller in magnitude than those of the pulp but their changes from starch to sugars follow a pattern similar to that demonstrated for the pulp.

Ripe bananas which are very palatable and readily consumed by the pig are fed whole with the peeling. When offered fresh, ripe, whole bananas, the pig will first consume the banana pulp leaving much of the peel. If the quantity offered is in excess of its daily capacity, it will tend to consume more pulp and less peel. However, if the total daily quantity offered is controlled, it will consume both pulp and peel.

The low protein and high moisture content present in the banana requires that a supplemental source of both protein and energy as well as vitamins and minerals be

Table 5. Average distribution of sugars in the banana at various stages of ripeness of Gros Michel bananas [a/]

Days	Color	Percentage of fresh pulp			Percentage of total sugars		
		Glucose	Fructose	Sucrose	Glucose	Fructose	Sucrose
0	Green	2.24	1.45	7.65	19.24	12.46	68.30
3	Very slightly green	3.09	2.50	10.61	19.07	15.43	65.49
6	Green tip	3.99	2.75	12.00	21.29	14.67	64.03
9	Slightly speckled	4.21	3.24	12.08	21.56	16.59	61.85

a/ Adapted from von Loesecke, 1950.

supplied. Several studies have been conducted to determine the voluntary consumption patterns and performance of growing-finishing pigs and lactating sows fed ripe bananas and protein supplement containing varying levels of crude protein.

One such study (Calles et al.,1970) indicated that the average daily gain of growing-finishing pigs fed whole ripe bananas to stimulate appetite was significantly improved (770 vs 660 g) when a 30 percent protein supplement was supplied instead of a 40 percent protein supplement (Table 6). The improvement in gain was assumed to be the effect of the increased daily consumption of metabolizable energy.

Although the level of protein supplement consumed daily does not vary greatly during the entire period of growing and finishing, as the pig increases in size and weight, there is a marked increase in daily voluntary consumption of ripe bananas. This change in the daily consumption pattern is especially evident during the first two to three weeks of the feeding period and may be associated not only with the need to adapt to changes in taste but also to the need to develop a greater stomach capacity with which to handle the high moisture feed.

When allowed a voluntary choice of the quantity of both ripe bananas and either a 30 or 40 percent protein supplement, the pig will consume a diet during the growing-finishing period that contains 12.4 to 13.0 percent crude protein. From the results of a number of studies it is evident that an average of 8.0 to 8.8 kg per day of ripe bananas is all that the growing-finishing pig will consume. The young pig (25-30 kg)

Table 6. Performance of growing-finishing pigs fed ripe bananas and either a 30 or 40 percent protein supplement free choice[a/]

Parameters[b/]	Treatments		
	Control	Bananas + Supplement	
	1	2	3
Protein in concentrate, %	16	30	40
Avg daily gain, kg[c/]	0.87^{x}	0.77^{y}	0.66^{z}
Avg daily fresh bananas, kg	-	8.29	8.85
Avg daily bananas, kg, D.M.[d/]	-	1.84	1.97
Avg daily supplement, kg	-	0.82^{x}	0.62^{y}
Total feed, kg[d/]	2.64	2.66	2.59
Feed/gain	3.04^{x}	3.47^{x}	3.92^{y}
Protein in mixture consumed, %	16.0	12.4	13.0

a/ Calles et al., (1970).

b/ Means in the same line with different superscripts are significantly different ($P<0.05$).

c/ Seventy-two pigs, 4 replications of 6 pigs per treatment. Avg initial weight 23.2 kg, avg final weight 90.1 kg.

d/ Bananas and total feed expressed on 10 percent moisture basis.

will consume as little as 5 to 6 kg of ripe bananas per day, and it appears that the finishing pig approaching market weight will not consume more than 10 to 11 kg daily. Because of this inadequate level of banana consumption, when a 40 percent protein supplement is fed energy becomes limiting. The increased consumption (820 vs 620 g) of a 30 percent protein supplement which supplies more carbohydrate and less protein calories partially corrects the energy deficiency.

Later studies made at the same station (Clavijo, 1972) also showed that no further improvement in pig performance or efficiency of feed utilization was obtained by using

a 20 percent protein supplement to replace the 30 percent supplement when ripe bananas were fed (Table 7).

Although pig performance was similar when either the 20 or 30 percent protein supplement was fed with bananas, the level of supplement consumption was increased and the daily consumption of bananas was reduced when the 20 percent supplement was used.

Under practical feeding conditions the recommended level of protein in the supplement will depend upon price relationships of bananas, proteins and grains or grain substitutes. Locally available energy sources such as maize, sorghum, rice bran, sugar and molasses can be efficiently used as energy sources for supplement preparation and dilution.

Fresh bananas can be used efficiently for sows during gestation. During this period the daily feed is controlled to meet the needs of the sow and maximum feed consumption is not required; therefore, either green or ripe bananas can be utilized. Clavijo et al.(1971) fed gestating sows, maintained on pasture, a ration of ripe bananas and protein supplement and compared the performance of these sows to similar sows fed

Table 7. Comparison of 20 and 30 percent protein supplements for growing-finishing pigs fed supplement and ripe bananas free-choice[a/]

Parameters[b/]	Treatments		
	Bananas + Supplements		
	16% protein	20% protein	30% protein
Avg daily gain, kg	.70^{x}	.61^{y}	.64^{y}
Avg daily consumption of fresh bananas, kg	-	5.97^{y}	7.37^{x}
Avg daily consumption of supplement, kg	2.46^{x}	1.91^{y}	1.15^{z}
Feed/gain[c/]	3.52^{x}	4.42^{y}	4.27^{y}

a/ Clavijo, 1972.

b/ Means in the same row without a common superscript are significantly different from each other ($P < 0.05$).

c/ Feed/gain expressed on 10 percent moisture basis.

a basal 16 percent protein diet based on maize, wheat, wheat bran, alfalfa meal and fishmeal. The control sows were fed 1.5 kg of feed per day from the day of breeding until the 76th day of gestation. During the remainder of the gestation period and until the sows were moved to farrowing crates (76th to 110th day) daily feed was increased to 2.0 kg per day.

The sows receiving bananas were fed 4.5 kg of ripe bananas and 600 g of a 40 percent protein supplement per day from the day of breeding until the 76th day of gestation. The ration was then altered to supply 6.0 kg of bananas and 800 g of supplement from day 76 until the 110th day of gestation. The supplement employed was composed of 55.44 percent fishmeal, 20 percent maize, 12.34 percent alfalfa meal, 2.82 percent bone meal and 9.4 percent vitamins, minerals and salt premix.

The reproductive performance of both groups of sows was not different. The number, weight and vigor of the pigs were similar for both treatment groups (Table 8). Sows from both treatment groups entered the farrowing crates in good condition. The banana fed sows gained an average of 11 kg more weight during gestation than the sows fed the control diet. After farrowing no differences in pig livability or performance were observed.

Contrary to the limited daily feed intake required for good performance by the gestating sow, the lactating sow must consume 5 to 6 kg of good quality air-dried feed if she is to meet the nutrient demands for maintenance and milk secretion. If an equivalent quantity of dry matter were supplied by fresh bananas and supplement, a sow would be required to consume at least 20 kg of bananas and 2.0 kg of a 40 percent supplement per day. This quantity appears to be greater than the sow's physical capacity.

Clavijo and Maner (1971) fed ripe bananas and a 40 percent protein supplement to lactating sows in the tropical banana zone of Ecuador and reported smaller and lighter litters when the sow's rations were based on ripe bananas (Table 9). The control sows voluntarily consumed an average of 3.66 kg per day of a 16 percent grain-supplement diet. The test sows were fed a mixture of bananas and supplement. In order to provide a 16 percent diet, the proportion of supplement to ripe bananas was 1.0 kg of supplement to 11 kg of bananas. The sows were allowed voluntary consumption of the mixture and consumed an average of 1.02 kg of supplement and 11.22 kg of bananas per day. Because of the inability of the sow to consume adequate fresh

Table 8. Performance of gestating sows fed a diet based on ripe banana and a 40 percent protein supplement [a/]

Parameters [b/]	Treatments	
	Control 16%	Bananas + Supplement
Avg daily concentrate, kg	1.66	0.67
Avg daily fresh bananas, kg	-	5.00
Avg daily feed, kg [c/]	1.66	1.67
Avg daily crude protein, kg	.266[y]	.318[x]
Avg No. of pigs per litter	8.9	8.4
Avg pig weight at birth, kg	1.22	1.26
Avg daily sow gain 1-100 day, kg	26.08[y]	37.04[x]

a/ Clavijo et al. (1971).

b/ Means in the same line with different superscripts are significantly different ($P < 0.05$).

c/ Calculated on basis of approximately 10 percent moisture.

bananas to meet her energy needs and also because of the extremely laxative effect observed when the sow consumes a ration containing 14 to 15 kg of ripe bananas, fresh bananas are not generally recommended as the major energy source for the lactating sow.

Fresh plantains are similar to bananas in appearance, but their chemical composition is somewhat different. They have a higher dry matter content which is principally represented by a 10 to 12 percent increase in the level of carbohydrates in the plantain. On the basis of their chemical analysis, similar or better results than those obtained with bananas might be expected; however, results from studies in Ecuador (Clavijo, 1972), where plantains were compared to bananas (Table 10), seem to indicate that the performance of growing-finishing pigs fed plantains was inferior to that of similar groups of pigs fed bananas.

The reason for the slower rate of growth, lower level of plantain consumption and depressed feed efficiency is not readily apparent, but may have been associated

Table 9. Performance of lactating sows fed either a complete concentrate or ripe bananas plus a protein supplement[a/]

Parameters[b/]	Treatments	
	Control	Banana + Supplement
Avg pigs per litter, No.	8.5	8.7
Avg weight at birth, kg	1.31	1.24
Avg pigs weaned, No.	6.3^{x}	5.9^{y}
Mortality, %	26.4	30.3
Avg daily concentrate, kg	3.66	1.02
Avg daily cons. fresh banana, kg	-	11.22
Avg daily protein consumption, kg	.586	.520
Weight loss of sows, kg	9.5^{x}	11.3^{y}

a/ Clavijo and Maner (1971).

b/ Means in same line with different superscript are significantly different ($P < 0.05$).

with the chemical stage of ripeness. As is shown in Table 4, six to eight days longer are required for the plantain as compared with bananas to reach an ideal stage of ripeness. After 10 to 12 ripening days, only about one-third of the plantain starch has been converted to sugars whereas almost 90 percent of the banana carbohydrate at that time is in the form of sugar. If a similar pattern exists for the contents of tannins, then the low performance as well as reduced voluntary consumption of plantains might be explained.

Dried Bananas

It is difficult to dry ripe bananas and plantains; however, the green fruit of both dries readily in the sun or in drying ovens. Once dried, the banana slices are ground to form green banana meal. Banana meal prepared from whole, unpeeled green bananas should contain approximately 12 percent moisture, 4.3 percent protein, 2.8

Table 10. Comparison of ripe bananas and plantains as the principle source of energy in diets for growing-finishing pigs[a/]

Treatments	1	2	3
	Control	30% Protein Supplement	
Criteria[b/, c/]	diet	banana	plantain
Avg daily gain, kg	.48^{x}	.46^{x}	.43^{y}
Avg banana cons. per day, kg	-	3.8^{x}	2.4^{y}
Avg cons. concentrate per day, kg	1.89^{x}	1.26^{y}	1.25^{y}
Feed/gain[d/]	3.63^{x}	4.39^{y}	4.69^{z}

a/ Clavijo, 1972.

b/ Ten pigs per treatment in two replications of five pigs per group. Average initial weight 11.0 kg.

c/ Means in the same line with different superscript are significantly different ($P < 0.05$).

d/ Feed/gain expressed on 10 percent moisture basis.

percent fat, 2.0 fiber, 4.3 percent ash and 74.1 percent nitrogen-free-extract. Plantain meal from whole, unpeeled green plantains should contain approximately 10.0 percent moisture, 4.3 percent protein, 1.0 percent fat, 6.2 percent fiber, 4.5 percent ash and 74.0 percent nitrogen-free-extract.

Celleri et al.(1971) used dried green banana meal as a substitute for grain to supply 0, 25, 50 or 75 percent of the total diet for growing-finishing pigs. The protein of the 16 percent protein diets was supplied by a combination of fishmeal and cottonseed meal. As shown in Table 11, each increase in level of dried banana meal in the diet caused a small but significant linear reduction in average daily gain, and a linear increase in daily feed intake and in feed required per unit of gain.

Similar studies (Oliva, 1970 and Oliva et al., 1971) employed 0, 12, 24, 36 and 48 percent banana meal and confirmed the previous findings. Although daily feed

intake was increased, a linear depression in both growth and efficiency of feed conversion was observed.

The reason for this linear depression in pig performance, when increasing levels of banana meal replaced grain, was elucidated in studies by Clavijo and Maner (1973). The results of these studies (Table 12) clearly demonstrated that although the fresh ripe and green bananas were equal in both digestible and metabolizable energy as was green banana meal, the level of metabolizable energy of all these types of presentation is inferior to that of maize (3200 vs 3800 kcal/kg of dry matter).

These studies further showed that ripe bananas will not dry at 60°C but because of the sugar content must be dried at a higher temperature. When treated in this

Table 11. Performance of growing-finishing pigs fed diets containing varying levels of green banana meal

Treatments	1	2	3	4	5
Celleri et al., 1971 [a]					
Level of green banana meal, %	0	25	50	75	-
Avg days to slaughter, No. [c]	119	121	124	128	-
Avg daily gain, kg [c]	.67	.65	.63	.61	-
Avg daily feed, kg	2.45	2.54	2.54	2.55	-
Feed/gain [c]	3.66	3.88	4.04	4.19	-
Oliva et al., 1971 [b]					
Level of banana meal, %	0	12	24	36	48
Days on trial, No. [c]	126	126	128	131	143
Avg daily gain, kg [c]	.62	.60	.61	.59	.54
Avg daily feed, kg	2.62	2.59	2.78	2.78	2.82
Feed/gain [c]	4.24	4.35	4.36	4.48	5.23

a/ Adapted from Celleri, Oliva and Maner (1971) who utilized a dehydrated, commercial banana meal pellets.

b/ Adapted from Oliva, Viteri, Calles and Maner (1971) who utilized sun dried, green bananas slices for preparing meal.

c/ Significant linear response ($P < 0.05$).

manner, dry matter, nutrient and energy digestibility is severely reduced.

Two experiments with gestating sows (Oliva et al., unpublished data) provide evidence to show that banana meal can supply at least 40 percent of the total diet without affecting reproductive performance of the sow (Table 13). Sow weight gains, post-partum weight losses, and pig numbers and weight were not different when fed either the 16 percent protein control diet based on grain or a similar test in which 40 percent green banana meal substituted for an equal quantity of grain.

Dried green banana meal can also be used to supply at least 50 percent of the diet of lactating sows. Studies by Ecuadorian workers (Viteri et al., unpublished data, and Celleri et al., unpublished data) indicate that the performance of both sows and their offspring is not different whether they are fed a control 16 percent protein, lactation diet based on maize, wheat and fishmeal or a test diet in which 50 percent of the maize was replaced by a similar level of banana meal (Table 14). Both groups of sows consumed a similar level of total diet. In doing so, the banana meal fed sows consumed less digestible energy and, as a consequence, lost an aver-

Table 12. Coefficients of digestibility and digestible and metabolizable energy values of fresh and dried ripe and green bananas[a/]

Digestibility	Fresh		Meal	
	ripe	green	ripe	green
Dry matter, %	84.25	76.93	50.52	83.63
Protein, %	-42.65	-102.00	-126.61	3.38
Crude fiber, %	78.01	56.98	-39.40	78.35
Ether extract, %	32.40	-24.87	24.50	22.09
Nitrogen-free extract, %	92.43	92.74	68.60	92.51
Total digestible nutrients, %	81.51	83.13	57.39	80.94
Digestible energy, kcal/kg D.M.	3114	3199	1703	3207
Metabolizable energy, kcal/kg D.M.	2967	3141	1520	3173

a/ Clavijo and Maner, 1973.

Table 13. Reproductive performance of gestating sows fed diets containing green banana meal with peeling [a/]

Criteria [b/] \ Diets	1 Control	2 40% Banana Meal
Sow weight gain (1-110 days), kg	41.3	40.0
Post-partum weight loss, kg	26.3	27.6
Avg pigs born per litter, No.	8.9	9.0
Avg pig weight at birth, kg	1.4	1.4

a/ Clavijo, 1972.

b/ Means not different ($P>0.05$).

age of 7.6 kg body weight each during the 56-day lactation while the control sows gained an average of 2.1 kg.

These studies provide information to indicate that fresh bananas can adequately provide the major source of energy for pigs during the growing-finishing and gestation periods of the life-cycle if properly supplemented. However, because of the high moisture content which prevents adequate energy consumption, it is not recommended as the sole source of energy for lactating sows.

The poor palatability of fresh green bananas, which significantly limits daily consumption, prevents the efficient use of green fruit in swine rations. Banana meal is prepared from the green fruit. However, because of its lower content of metabolizable energy as compared to grains for which it is substituted, it supports a lower level of pig performance.

Summary

Reject or waste bananas (Musa sapientum L.) which contain an average of 20 percent dry matter, 1.0 percent crude protein, 1.0 percent fiber, 0.17 percent fat, 0.08 percent calcium and 0.28 percent phosphorus, have been used to provide the

Table 14. Performance of lactating sows fed diets containing green banana meal with peelings[a/]

Treatments Criteria[b/]	1 Control diet	2 50-53% Banana Meal
Number of sows	24	24
Avg number of pigs per litter, No.	9.2	9.5
Avg birth weight, kg	1.1	1.1
Avg number of pigs weaned, No.	7.1	7.3
Avg weight at weaning, kg	11.5	11.4
Avg sow gain, kg	2.1^{x}	-7.6^{y}
Avg daily feed intake, kg	5.8	5.8

a/ Clavijo, 1972.

b/ Means in the same line with different superscripts are significantly different ($P < 0.05$).

major source of dietary energy for swine during the entire life-cycle. Properly supplemented with protein, vitamins and minerals, fresh ripe bananas can be used during all phases of the life-cycle of the pig except during lactation at which time the sow, because of limited gastrointestinal capacity, will not consume adequate quantities of fresh bananas to meet her energy needs. Because of bitter taste and poor palatability,which significantly limit daily intake, fresh green bananas should not be fed if maximum voluntary consumption is required. Since ripe bananas have poor drying characteristics, banana meal was prepared from green bananas. Meal prepared in this manner can be used to supply up to 75 percent of the pigs' diet. During the growing-finishing period each increase in banana meal substitution for maize is associated with a small linear depression in growth rate and feed conversion efficiency. This depression in performance results from the reduced daily consumption of metabolizable energy which is only 3200 kcal/kg dry matter for bananas as compared to 3800 kcal/kg for maize. Performance equal to that obtained with control diets based on cereal grains has been obtained during gestation and lactation when banana meal replaces up to 50 percent of the diet.

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