Composition and nutritive value of pejibaye (*Bactris gasipaes*) in animal feeds

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Abstract: Nutritive assesment of pejibaye (*Bactris gasipaes*) meals included proximal composition of the lipid and nitrogenous fractions. Caloric values obtained as true metabolizable energy (TME) indicate that the pejibaye has a higher content of energy than corn and that it is not necessary to separate the seeds from the fruits in animal feeds; the level of indispensable aminoacids is considerably low, especially methionine, which is lower than in corn; thin layer chromatography shows that most of the free fatty acids are present in a ratio of 2:1 in unsaturated to saturated acids. The predominant fatty acids in whole pejibaye meal are oleic and palmitic acids with adequate levels of linoleic acid. Saturated fatty acids are predominant in the seed, with a very high content of lauric and myristic acids.

Recently the pejibaye palm (*Bactris gasipaes*) awakened great interest due to its potential value for both industrial and nutritional purposes in some tropical countries. Very little is known of the chemical composition and the nutritional and energetic value of the fruits for animal feeding. Several reports in the literature indicating the proximate, mineral vitamin and aminoacid content of this fruit are conflicting but all coincide that it has a high potential nutritional value despite its rather poor essential aminoacid content. Zapata (1972) found differences in the chemical composition between varieties (red and yellow), although generally the level of crude protein is low, the aminoacid profile is poor and the level of fat and linoleic acid and the content of carbohydrates are high.

Johannessen (1967) reported large variations in different traits in the fruit, mainly in fat, carotene and vitamin C. He specifically analyzed the pulp, which represents about 75% of the whole fruit, and found a low crude protein level (2.13%), which is less compared with 6.3% and 3.14% reported by Zapata (1972) and Munsell (1950), respectively. Unpublished reports from Brazil have shown varietes containing up to 20% crude protein and 50% or more fat. The fat content has been found to range between 5.8% (Zapata, 1971) and 19% for the pulp and from 14 to 25.2% for the seed (Hammond *et al.*, 1982). The fiber content in the pulp is approximately 1.25% but when the seed and skin are included it is much higher. A complete report on the composition of different parts of pejibaye was presented by Murillo *et al.* (1983), who found a possible tripsin inhibitor which is destroyed by heating or cooking the fruit at 100 ^{o}C for 20 minutes.

The present research was conducted primarily to obtain more accurate information on the chemical composition of pejibaye meal for animals, when using the whole fruit and to further observe the effect of eliminating part of the fibrous material in the meal on its nutritive and energetic value. Another objective was to asses pejibaye meal as a possible substitute for corn in poultry diets.

MATERIAL AND METHODS

The pejibaye fruit utilized in all analyses was the yellow variety from the South Pacific Region of Costa Rica. The fruit, including skins and seeds, were chopped, ground and dried in a forced-air oven at 65 ^{o}C to obtain a meal containing approximately 12 % moisture.

The larger particles (mainly seed hulls) were removed from part of the meal with a number 10 mesh sieve, in order to observe the effect on the nutritive and caloric value by reducing the amount of the more fibrous material. Approximately 26.5%of the total material was retained in the sieve.

Three types of meals hence were considered: (1) whole pejibaye meal (WPM); (2) screened pejibaye meal (SPM); and (3) pejibaye residue meal (PRM) composed of the material retained in the sieve, mainly seed particles, parts of the skin, and some of the largest pieces of the pulp from the grinding process. These three meals were ground in a Willey mill to obtain more uniform samples for chemical analysis. Except where indicated, all the analyses were carried out in triplicate samples.

The proximal chemical determination of pejibaye meals, pulp, and seed was performed according to the procedures described by the Association of Official Agricultural Chemists. (A.O.A.C; 1975). Calcium and magnesium were analyzed by atomic absorption spectro-photometry. Phosphorous was analyzed by the procedure of Fiske and Subarrow (1925).

Lipids were extracted from the pejibaye meal and also from coconut and corn for comparison, using a chloroform-methanol mixture and homogenizing them in a high speed Sorvall Omni mixer following the procedure of Folch *et. al.* (1957). The methyl esters of the fatty acids were extracted by refluxing the samples in a 5% sulfuric acid solution for 2 1/2 hours at 60 °C, followed by extraction with petroleum ether. The extract was injected in a Hewlet-Packard model 5840 A gas liquid chromatographer with a copper column packed with 20% diethylene glycol succinate and chromosorb W-Aw, 80/100 mesh operated isothermally and furnished with a hydrogen flame detector. Identification of the esters was accomplished by comparison of retention times with those of known standards.

The level of each fatty acid was expressed as percentage of total lipids, computed directly by the apparatus. Chain length was confirmed by hydrogenation of the esters of unsaturated fatty acids (UFA) injecting them once again in the chromatograph (Brown and Brown, 1962).

Whole pejibaye meal (WPM) samples were analyzed for aminoacid (AA) composition by heating the material in 6N HCl at 110 °C for 24 hours, obtaining a hydrolysate of AA's which were separated by ion-exchange chromatograohy in an AA analyzer.

Determination of true metabolizable energy (TME) was performed according to the modified procedure of Sibbald (1976), by drying the samples in a forced-air oven at 65 °C instead of freeze-drying.

For the TME determination, thirty-four adult Single Comb White Leghorn roosters were utilized. After a fasting period of 24 hours, the birds were force-fed 30 grams of either whole pejibaye or screened pejibaye meal using ten birds for each trial. The other fourteen birds, used as controls, were fasted for a total period of 72 hours. Total fecal collection was carried out for the three groups of birds 48 hours after they were force-fed.

In a second trial, the same procedure was followed but instead the birds were force-fed 25 g of WPM, a combination of WPM and ground yellow corn (50:50), or ground yellow corn alone. In this trial the fecal collection time was 24 hours after force-feeding. Feed and excreta samples were analyzed for gross energy (GE) using a Parr adiabatic bomb calorimeter. Gross nitrogen (GN) and dry matter (DM) determinations were made according to A.O. A.C. (1975).

RESULTS

The proximal chemical composition of the different pejibaye meals as well as values for calcium, phosphorus and magnesium are shown in Table 1. The main difference is observed in the crude fiber content, much higher in the pejibaye residue meal (PRM). The other components did not differ among the different pejibaye meals. In the pulp analysis the skin was not included.

Analysis of the lipid fraction of the experimental samples as well as the results of Hammond *et al.* (1982) corresponding to pejibaye pulp and seed are included in Table 2.

Pejibaye seeds contain higher amounts of lipids and saturated fatty acids (SFA) than pejibaye pulp. The ratio of unsaturated fatty acids (UFA) to SFA in the seed is 1:3, while in the pulp this ratio is 2:1. Consequently, lipids from screened pejibaye meal (SPM) contain more UFA than SFA due to its higher proportion of pulp. On the other hand, pejibaye residue meal (PRM) has a higher content of SFA than screened pejibaye meal due to its greater content of seed particles. Also, whole

TABLE 1

Proximal and mineral composition of three different types of pejibaye meals

Constituent	WPM	SPM	PRM	Pulp	Seed
Dry matter %	88.6	88.1	88.2	88.0	88.3
Crude protein %	5.1	4.8	5.6	6.4	7.1
Crude fiber %	6.3	5.0	10.4	1.3	20.1
Ether extract %	9.3	9.7	9.3	17.9	14.3
Ash %	2.0	1.9	2.1	2.8	2.4
Calcium %	0.5	0.45	0.6	ND	ND
Phosphorous %	0.05	0.04	0.07	0.05	0.06
Magnesium %	0.045	0.042	0.054	ND	ND

WPM = Whole pejibaye meal; SPM = Screened pejibaye meal; PRM = Pejibaye residue meal; ND = Values were not determined.

TABLE 2

Fatty acid content of corn, coconut, pejibaye pulp and seed and three different pejibaye meal expressed as percentage of total lipids

	Pejibaye						
Fatty Acid	Pulp	Seed	WPM	SPM	PRM	Corn	Coconut
Caprilic	–	0.5	–	–	–	–	4.7
Capric	–	0.6	–	–	–	–	5.2
Lauric	–	33.3	7.6	4.4	14.5	–	46.6
Myristic	–	28.4	4.9	3.0	9.2	–	19.4
Palmitic	29.6	10.4	20.0	21.8	14.9	11.0	10.7
Estearic	Traces	3.1	1.4	1.3	1.5	1.7	4.1
Arachidic	–	–	–	–	–	0.6	–
Total SFA	29.6	76.3	33.9	30.5	40.1	13.3	90.7
Palmitoleic	5.3	–	4.7	5.3	3.9	0.2	–
Oleic	50.3	18.2	44.0	45.6	40.3	23.5	7.9
Linoleic	12.5	5.1	14.3	15.3	12.8	61.7	0.8
Linolenic	1.8	–	2.7	3.0	2.6	1.3	–
Total UFA	69.9	23.3	65.7	69.2	59.6	86.7	8.7
Total lipids %	19.0	25.2	9.6	9.0	9.6	3.9	6.7

WPM = Whole Pejibaye meal; SPM = Screened Pejibaye meal; PRM = Pejibaye Residue meal; SFA = Saturated fatty acids; UFA = Unsaturated fatty acids.

pejibaye meal (WPM) contains more UFA because the meal is prepared with the whole fruit whose seed content represents approximately 20%of the total weight.

As a comparison, coconut and corn oils were analyzed to observe their fatty acid pattern. Coconut oil showed much more SFA than UFA (90.7% vs 8.3%) while in corn oil UFA was predominant (86.8%). Those results are presented in Table 2.

Thin layer chromatography (TLC) G-plates showed that the main component of pejibaye lipids are free fatty acids with rather small amounts of triglycerides and phospholipids. When the procedure was repeated and the lipids were extracted with petroleum ether, the results were similar to chloroform:methanol extraction. Conversely, TLC of corn oil showed the largest proportion of triglycerides with a small amount of free fatty acids.

Aminoacid composition of pejibaye meal is presented in Table 3. The values for cystine and tryptophan had to be omitted due to their destruction during the acid hydrolysis of the proteins. The aminoacid composition of yellow corn is included for comparison. According to the results, it seems that corn compared to pejibaye has slightly higher levels of most indispensable aminoacids such as arginine, glycine, histidine, methionine and others for poultry (Table 3).

True metabolizable energy values (TME) were very similar for all the pejibaye meals analyzed (Table 4).

Corn samples tested for energy content showed lower TME values than pejibaye meals. This was corroborated in a mixture of equal parts of yellow corn and pejibaye. The mixture gave a higher caloric value than corn alone and lower than both WPM and SPM (3.48 kcal/g for corn vs 3.52 and 3.61 kcal/g for WPM and SPM, respectively).

TABLE 3

*Indispensable aminoacid content of whole pejibaye meal compared to that of yellow corn**

Aminoacid	Pejibaye	Yellow corn
Arginine	0.29	0.50
Glycine	0.27	0.40
Histidine	0.09	0.20
Isoleucine	0.16	0.40
Leucine	0.28	1.10
Lysine	0.21	0.20
Methionine	0.08	0.18
Phenilalanine	0.14	0.50
Threonine	0.18	0.40
Tyrosine	0.14	0.41
Valine	0.19	0.40
Protein %	5.10	8.60

* Expressed as percentage of total ingredient.

TABLE 4

True metabolizable energy (TME) content of pejibaye meals and corn, expressed as kilocaries per gram (Kcal/g)

Ingredient	TME_N	TME as percentage of gross energy
Whole pejibaye meal	3.52	86.0
Screened pejibaye meal	3.61	84.8
WPM: Yellow corn (1:1)	3.45	86.8
Corn	3.34	85.0

TME_N = True Metabolizable Energy corrected for endogenous nitrogen.

DISCUSSION

According to the results, a pejibaye meal of the whole fruit appears to be a very important energetic source for animals. This palm fruit presents excellent values for fat, essential fatty acids and carbohydrates and provides a good source of metabolizable energy comparable to that found in corn. This suggests that pejibaye meal can be introduced at high levels in animal diets in substitution of corn if an adequate supplement of limiting aminoacids is provided either by synthetic aminoacid or animal proteins such as fish meal, meat meal or poultry by-product meal. Commercial feeds for monogastric animals are commonly supplemented with aminoacids when corn-soybean diets are prepared. Therefore, similar diets in which corn is substituted by pejibaye meal will only need adjustmentsin the levels of aminoacids.

The high level of lipids in the different pejibaye meals suggests that they may have a higher net energy value than most common energetic feedstuffs used in the animal industry, such as corn and sorghum. Forbes and Swift (1944) found that fats have a lower heat increment than carbohydrates and protein in rats, once their metabolizable energy is used. This was called the "associative dynamic effect" of fats. Jensen *et al.* (1970) called an "extra caloric effect" of fats when fat was used in substitution for carbohydrates in turkey diets. Increasing the fat content of the diets improved feed efficiency and this improvement was greater than that expected from the calculated metabolizable energy values. For this reason, it would be very beneficial if strains of pejibaye with a higher fat content, as has been reported in Brazil, are developed.

Renner and Hill (1961a) showed that stearic and palmitic acids were little utilized by chicks when fed as free fatty acids, while unsaturated fatty acids such as oleic, linoleic, and linolenic acids were well utilized. When these saturated fatty acids were fed at high levels but as intact triglycerides, absorbability was greatly improved. The thin layer chromatography studies of pejibaye oil conducted in the present research showed that it mostly contains free fatty acids. Thus, if we consider that pejibaye lipids contain 22% stearic and palmitic acids and also high levels of other saturated fatty acids, then it seems that pejibaye lipids will have a poor utilization by the chick. More studies are required regarding the type of lipids present in pejibaye fruits because it is difficult to find free fatty acids under natural conditions but rather they are present as triglycerides, glycolipids, phospholipids or other forms (Lehninger, 1975; Fuller, 1973).

Saturated fatty acids can be better utilized when relatively high amounts of unsaturated fatty acids such as oleic and linoleic acids are present in the diet or in the fat. Pejibaye lipids, despite their high saturated fatty acid content (Table 2) also show high unsaturated fatty acid levels, with a ratio of 2 (UFA) to 1 (SFA). In the seed, that ratio is 1:3 and in the pulp it is 2.5:1. Generally, a 1:1 ratio has been found to greatly improve the absorbability of palmitic and stearic acids in chicks (Young, 1964).

Renner and Hill (1961b) also reported a detrimental effect on chick growth when the diet contained high levels of lauric and myristic acids. When the level of lauric acid exceeded 20% in the diet, laying hens refused all the feed. In the case of pejibaye, despite the high content of lauric acid in the seeds, it is almost absent in the pulp. Therefore, when whole pejibaye meal (WPM) is prepared there will be a lower level of lauric acid and of the overall content of saturated fatty acids. This will probably ameliorate a possible problem in using high levels of pejibaye meal in animal diets.

The patterns of fatty acid content in pejibaye lipids are very typical of all palm fruits. Hildith (1956) made a survey of world palms and found that generally the major fatty acid components of palm seed lipids were lauric and myristic acids, followed by palmitic and oleic acids.

Further research will have to be conducted on the effect of pejibaye meal fed to animals on body, egg and milk fat composition. It has widely been demonstrated that the type of fat in the diet affects the composition of fatty acids in these animal products (Feigenbaum and Fisher, 1950). According to Edwards *et al.* (1973), feeding tallow with high palmitic (21%), stearic (20%) and oleic acids (37.9%) will produce a broiler chicken with increased stearic and oleic acid levels at the expense of linoleic acid, affecting the meat in such a way that it feels much firmer to the touch.

According to the results obtained on TME determination, it does not seem necessary to separate the seeds from the pulp through screening because this procedure apparently did not improve the caloric value of the meal. Removing the seeds will reduce the fiber content of the meal but the fat level will also be lowered, as the seed concentrates both components at higher levels than the pulp. Further, on and from a practical point of view it is not recommended to separate the seeds because it will raise the cost of labor at the processing plants.

A detailed analysis on the mineral and vitamin content of pejibaye is needed in future