Nutritional Evaluation of the *Jessenia bataua* Palm: Source of High Quality Protein and Oil from Tropical America[1]

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Current agricultural realities dictate that crops be developed which can be grown with fewer petroleum inputs and on marginal croplands. A palm tree native to the Amazon Valley, Jessenia bataua, *found in both swamplands and upland forests has been studied. The fruits of this tree have long been exploited by indigenous peoples as a source of oil and a milk-like drink. Chemical analyses of the oil show it to be similar to olive oil. Chemical and biological assays of the mesocarp pulp protein reveal its quality to be comparable to that of good animal protein and considerably better than most grain and legume proteins. Rats fed diets containing* Jessenia bataua *mesocarp oil and pulp showed normal weight gains when compared to those fed diets with similar quanities of corn oil and casein.* Jessenia bataua *is an example of a little-known wild plant that could provide a new source of food protein and oil for combating world hunger.*

Most scientists and national policy makers foresee increasing difficulty in feeding the everexpanding world population, particularly in tropical countries (Mayer, 1976). Various recommendations have been advanced; in the agricultural sector the majority are based on improving yields of conventional crops through an increased dependence on petroleum-derived fuels, fertilizers, pesticides and other agricultural chemicals (Barrons, 1975). Current realities regarding diminished energy sources appear to require somewhat more unconventional approaches towards food production specifically aimed at low input technologies. One such is the identification and cultivation on a mass scale of plant foods presently possessing only regional importance, but having high nutritional or economic value in these areas (National Academy of Sciences, 1975). Minor crops of local origin, when studied and introduced into neighboring or distant areas could provide several substantial benefits. They can be grown in rural centers with significant and direct impact upon local diets, requiring only simple cultivation, harvest and processing technology. Many will flourish on lands otherwise of marginal value for conventional agriculture: e.g., swamps, hillsides and belts of impoverished soils. An increase in the number of crops utilized broadens the base upon which food production systems are built, lessening the chance for agricultural calamity in a particular area if supplies of energy inputs become reduced through inflation or scarcity. The major grain and legume crops traditionally introduced through development programs frequently require complex technology, significant capital outlay, fertile soils and a constant flow of petroleum-based products for greatest success. All too often peasant farmers subsisting at the periphery of the national economy are unable to reap resultant benefits of such programs.

[1] Received 12 November; accepted 30 December 1980.

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Economic Botany, 35(3), 1981, pp. 261–271

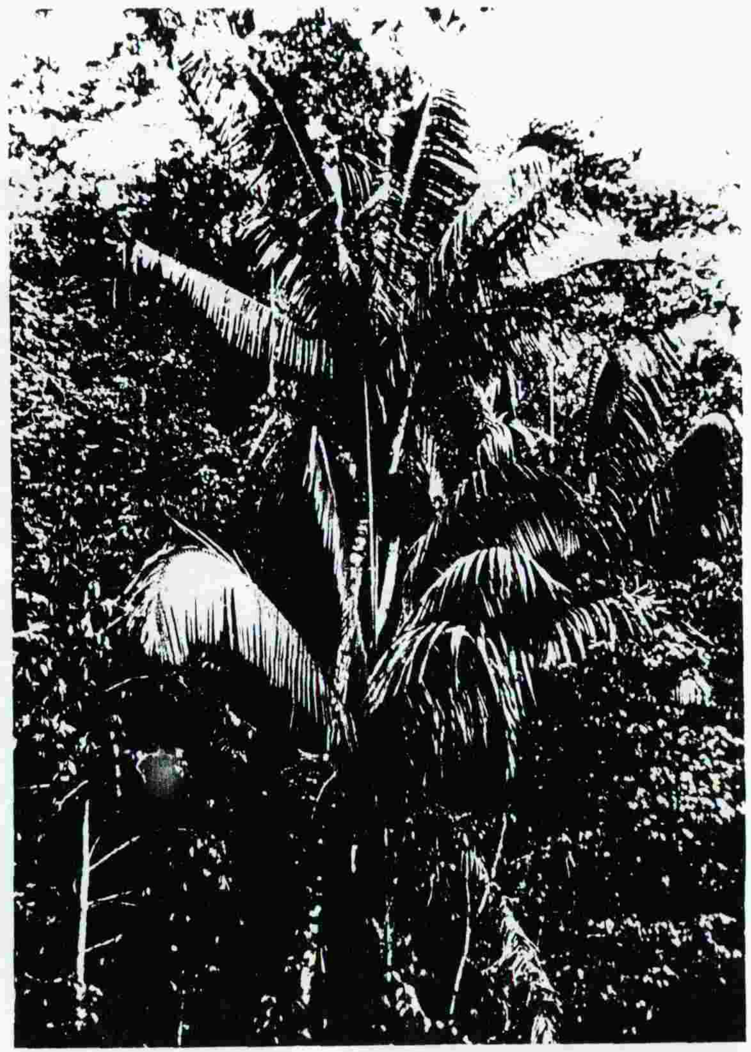

Fig. 1. *Jessenia bataua* growing in the northwest Amazon Valley of Colombia (photo by J. L. Zarucchi).

Indians living in the Amazon Valley of South America have always relied upon the local flora to provide a major portion of their daily nutritional uptake. Generations of experience in gathering foods from the forest qualifies them as "botanical experts" able to search out the best kinds of edible plants growing in the jungle environment. Through ethnobotanical studies by Schultes (1963), Prance

Fig. 2. A ripe fruit of *Jessenia bataua* with the epicarp peeled away to reveal the oil-rich mesocarp.

(1972), Pinkley (1975) and others, we have some indication of the vast quantity and variety of plant foods that sustain these people.

Palms in particular play an important role in the indigenous diets of this area. Examples include *Bactris gasipaes* (Seibert, 1950), *Manicaria saccifera* (Wilbert, 1976) and *Astrocaryum tucuma* (Wallace, 1853).

Fig. 3. Large fruiting panicles of *Jessenia bataua* in various stages of maturity.

Perhaps among the most utilized but least known groups of palms are the genera *Oenocarpus* and *Jessenia*, providing not only food but also fiber, construction materials, medicines, toys, weapons and other items of daily importance. These 2 genera are known variously as *pataua*, *seje*, *milpesos* or *ungurahuay* in the Amazon Valley. *Jessenia* consists of a single species, *J. bataua*

(Mart.) Burret distributed in forests over much of the northern half of South America, including Panama and Trinidad (Fig. 1). Occurring in inundated locations in monospecific stands or scattered through upland areas, its size (to 25 m tall) makes *J. bataua* a striking and easily recognized component of the neotropical forest. *Oenocarpus* is a far more diverse genus, consisting of 8 variable species. These range from several meters in height (*O. minor*) to 20 m or more (*O. bacaba*), include solitary and tufted habits, and carry spirally or distichously (2-ranked) arranged leaves. As with *Jessenia*, *Oenocarpus* is found in both swampy and upland locations.

The ripe fruits of *Oenocarpus* and *Jessenia* are purplish black with a firm epicarp under which there is a soft pulp (mesocarp) (Fig. 2). This pulp is rich in oil with some species containing up to 50% (National Academy of Sciences, 1975). Fruits are borne on panicles, which in *J. bataua* may be quite large and contain 1,000 or more fruits, each weighing 10–15 g (Fig. 3). Indians have long exploited these, deriving a beverage from the pulp, extracting and purifying the oil, consuming the fruits directly or feeding them to domestic animals.

During field work in the Amazon Valley, it was observed that the daily consumption of *Oenocarpus* and *Jessenia* fruits during their season of abundance had a profound effect on the local inhabitants. They gained weight, appeared healthier with more endurance and reported fewer respiratory infections. Such effects seemed to be directly related to the consumption of the fruit and its products, a conclusion which was supported in discussions with other workers (personal communication R. E. Schultes, H. García-Barriga and D. L. Dufour).

The present study was designed to measure some of the nutritional qualities of these palm fruits. As their domestication for commercial exploitation is being considered in a number of tropical regions, such nutritional information is crucial.

MATERIALS AND METHODS

Samples for analysis were collected during expeditions to the Amazon Valley in 1976, 1977, and 1978 (see for example, *Balick and Hoyos 76-22*, ECON). These collections included fresh fruit, oil and dried outer pulp (mesocarp + epicarp). From the fresh fruit, we prepared a beverage identical to the one made by Indians in the Amazon Valley. The methodology for preparation of this drink from *Jessenia bataua* fruits in the laboratory was as follows: heat 250 ml water to 70°C. Add 25 fruits (ca. 11–15 g each) to the water, bringing volume up to ca. 540 ml. Heat continually at 70°C for 20 min. Macerate to separate pulp from seeds. Allow to settle for 10 min. Strain out seeds, pulp pieces and fibers; beverage ready for analysis or consumption.

In this laboratory, fatty acid content of 3 oil samples was determined by gas chromatography, and the nitrogen content of several pulp samples by micro-Kjeldahl analysis. Subsequently all samples, including the initial ones, were sent to R. Kleiman (Research Leader, Instrumental Analysis Research, Horticultural and Special Crops Laboratory, U.S.D.A., Northern Regional Research Center, Peoria, IL) who performed the following analyses: fatty acids (gas chromatography), amino acids (amino acid analyser), oil content (Butt extraction with petroleum ether) and nitrogen content (micro-Kjeldahl). Proximate analyses (Ral-

TABLE 1. DIETS USED IN RAT STUDIES ON PRODUCTS FROM *Jessenia bataua*.[a]

% Component	A Experimental	B Basal	C Control	D Control + palm oil
Casein	5.0	5.0	7.8	7.8
Cellulose	—	15.3	15.3	15.3
Dried pulp[b]	50.0	—	—	—
Salts IV[c]	4.0	4.6	4.6	4.6
Choline	0.3	0.3	0.3	0.3
Corn oil	5.0	10.6	10.6	5.0
Jessenia oil	—	—	—	5.6
Sucrose	35.7	64.2	61.4	61.4

[a] Vitamins were added so that each 100 g of diet contained 0.4 mg thiamin hydrochloride, 0.8 mg riboflavin, 0.4 mg pyridoxine hydrochloride, 4 mg niacin, 0.02 mg biotin, 2 mg calcium pantothenate, 0.1 mg folic acid, 0.005 mg vitamin B12, 0.1 mg menadione, 10 mg α-tocopherol, 180 IU vitamin D and 1,800 IU vitamin A.

[b] The palm pulp used was a mixture of pulp obtained from 3 different samples. By analysis its composition on a dry weight basis (in %) was: protein 5.6, oil 11.1, carbohydrate 51.5, fiber 30.6 and ash 1.2.

[c] Chu and Hegsted, 1976.

tech Scientific Services, Inc., Madison, Wisconsin) and tryptophan determinations of pulps were also carried out (Matheson, 1974).

On the basis of these data, rat feeding studies were undertaken. Four groups of 8 male weanling, Charles River CD rats in group cages were fed the diets in Table 1, ad libitum, for 5 wk. Each diet contained identical quantities of fiber (15.3%), ash (4.6%) and oil (10.6%). Diets A, C, and D had 61.4% carbohydrate. Diet B contained an additional 2.8% carbohydrate as a substitute for its lower protein content. Diet A contained 5% protein from casein and 2.8% protein from dried *Jessenia bataua* fruit pulp. Diet B contained 5% casein and diets C and D contained 7.8% casein. Diet C contained 10.6% corn oil. Diet D contained 5% corn oil and 5.6% free *J. bataua* palm oil. Diet A also contained 5.6% palm oil from the dried palm pulp.

RESULTS

Table 2 presents the results of fatty acid analyses done on 12 samples of *Jessenia bataua* oil and compares the data to a published analysis of olive oil (Boniforti and Salvi, 1963). It can be seen that the chemical composition of *J. bataua* oil is similar to that of olive oil, both containing approximately 75–80% oleic acid. The only significant chemical difference of nutritional importance is that olive oil

TABLE 2. A COMPARISON OF THE FATTY ACID COMPOSITION OF *Jessenia bataua* OIL AND OLIVE (*Olea europaea*) OIL.

Fatty acid	*Jessenia bataua*[a] samples, %	Olive oil samples, %
Palmitic	13.2 ± 2.1	11.2
Palmitoleic	0.6 ± 0.2	1.5
Stearic	3.6 ± 1.1	2.0
Oleic	77.7 ± 3.1	76.0
Linoleic	2.7 ± 1.0	8.5
Linolenic	0.6 ± 0.4	0.5
Other	1.6 (range 0.2–4.6)	—

[a] Values given as the mean ± standard deviation of 12 separate samples.

TABLE 3. AMINO ACID ANALYSIS OF *Jessenia bataua* PROTEIN.

Amino acid component	Mg amino acid/g protein: mean ± standard deviation[a]	Amino acid scoring pattern[b]	% of FAO/WHO scoring pattern
Isoleucine	47 ± 4	40	118
Leucine	78 ± 4	70	111
Lysine	53 ± 3	55	96
Methionine	18 ± 6		
Cystine	26 ± 6		
Methionine + Cystine	44 ± 9	35	126
Phenylalanine	62 ± 3		
Tyrosine	43 ± 5		
Phenylalanine + Tyrosine	105 ± 7	60	175
Threonine	69 ± 6	40	173
Valine	68 ± 4	50	136
Tryptophan	9 ± 1	10	90
Aspartic Acid	122 ± 8		
Serine	54 ± 3		
Glutamic Acid	96 ± 5		
Proline	75 ± 8		
Glycine	69 ± 4		
Alanine	58 ± 4		
Histidine	29 ± 4		
Arginine	56 ± 2		

[a] Values represent mean ± standard deviation for 7 separate samples with the exception of tryptophan, for which only 3 samples were analysed.

[b] FAO/WHO provisional amino acid scoring pattern. The scoring pattern represents an "ideal protein" containing all the essential amino acids to meet requirements without excess (FAO/WHO, 1973).

has about 3 times more linoleic acid than *J. bataua* oil. A small amount of additional fatty acids in the samples was designated as other. As the percentages were minor, these were grouped together. The mean for the 12 samples was 1.6%, with a range of 0.2–4.6%. Fatty acids included in this category were myristic, arachidic and eicosenoic (gadoleic). Others appeared to be oxygenated derivatives of fatty acids.

Table 3 presents an amino acid analysis of the *Jessenia bataua* protein. When the amino acid content of this protein was compared to the FAO/WHO provisional amino acid scoring pattern (Food and Agriculture Organization of The United Nations/World Health Organization, 1973), the limiting amino acids were tryptophan and lysine. These were present at 90% and 96% of the recommended levels. These data suggest that *J. bataua* protein quality is comparable to that of good animal proteins and considerably better than most grain and legume proteins.

Fig. 4 presents the results of a 5-wk feeding study in which *Jessenia bataua* protein was compared to casein and *J. bataua* oil to corn oil. Diet A contained 50% *J. bataua* dried pulp ground in a large blender. During the first 2 wk, the weanling rats appeared to have difficulty in consuming the diet, which may have been related to the physical characteristics of the pulp, or to its taste or smell. During the last 3 wk of feeding, this difficulty disappeared and the animals grew at a rate similar to animals fed Diet C containing 7.8% casein. This feeding test suggests that the biological value of the *J. bataua* protein was similar to that of casein. Final weights of rats fed *J. bataua* oil were similar to those of rats fed

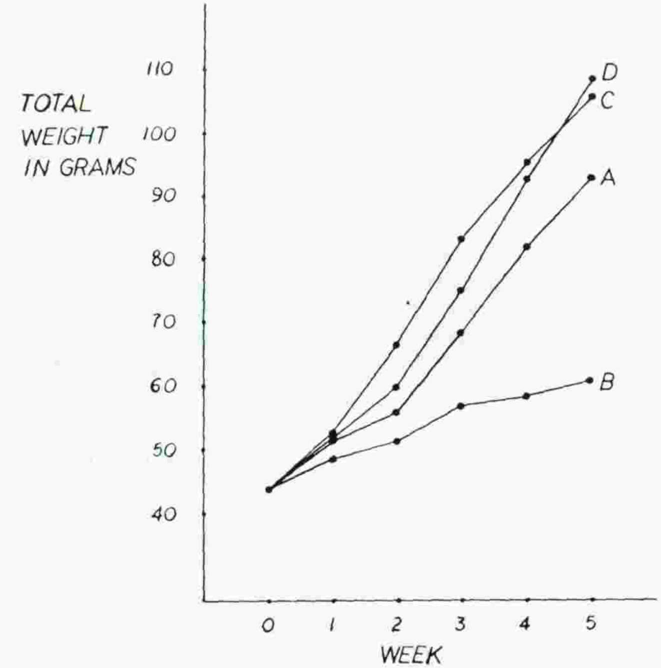

Fig. 4. Growth of rats fed with diets described in Table 1. Diet A contained 5% casein with 2.8% protein and 5.6% oil from *Jessenia bataua* pulp; Diet B with 5% casein; Diet C with 7.8% casein; Diet D with 7.8% casein and 5.6% *Jessenia bataua* oil. Final mean rat weights ± standard error in grams for the diets were as follows: A. 93 ± 5; B. 60 ± 3; C. 106 ± 6; D. 108 ± 4.

diets containing only corn oil. Autopsy of the rats revealed no abnormalities associated with feeding either the *J. bataua* oil or the pulp.

DISCUSSION

The present study furnishes data on the nutritional value of a plant not in commercial cultivation. It is clear from the studies done here and from the experience of Indians in the Amazon Valley, *Jessenia bataua* fruit may have untapped nutritional potential for man. *Jessenia bataua* is restricted to the lowlands, up to an altitude of about 1,000 m. This palm has never been cultivated on a wide scale, and thus basic agronomic data such as growth requirements, yields, and longevity of the tree, are lacking. There is no information on the time required to produce fruit under cultivation, although growth is known to be slow in the wild. Lack of knowledge concerning this oleaginous palm is reminiscent of the similar situation involving the African oil palm (*Elaeis guineensis*) at the beginning of this century before it was domesticated—indeed many parallels can be drawn between the 2 species.

TABLE 4. A COMPARISON OF FAT-PROTEIN-CARBOHYDRATE CONTENT OF MILK OR MILK-LIKE BEVERAGES.

Approximate percentage calories from each component	*Jessenia bataua* milk	Human milk[a]	Cow milk[a]	Soybean milk[a]
Fat	55.3	45.9	49.8	37.6
Protein	7.4	5.6	20.9	37.9
Carbohydrate	37.3	48.5	29.3	24.5

[a] U.S.D.A., 1963.

On analysis, *Jessenia bataua* oil is similar to olive oil. Interestingly, the analyses done by liquid-gas chromatography, confirm the observations and chronicles of Italian and Spanish missionary priests, living in the Amazon before modern nutritional science developed, who described *J. bataua* as New World olive oil. The oil of this plant, if it could be produced on a large scale, or a system developed for its rational exploitation from the wild, would provide a product of appeal not only to people in developing countries but to those in the industrialized world as well.

Because the major nutritional problem of people living in developing countries, most of which are tropical, is protein-calorie malnutrition, we have been particularly concerned with the oil and protein content and quality of this fruit. Surprisingly the protein, both by amino acid analysis and rat feeding trials, has a biological value equivalent to that of the best animal proteins. Unfortunately, the level of protein in the pulp following oil removal is relatively low. However, as shown from first hand observations in the Amazon Valley, it is an excellent food for poultry and pigs.

A milk produced from the fruit pulp is widely consumed in the Amazon. Analysis of the caloric content of the milk prepared in the laboratory—compared to human, cow and soybean milk—is presented in Table 4.

It is clear from data concerning the quality of the protein and oil that the beverage made from this plant is of high nutritional value. *Jessenia bataua* milk is most comparable in fat-protein-carbohydrate composition to human milk. Since the human protein requirement can be met by a diet containing less than 10% of its calories from high quality protein, the protein level in *J. bataua* milk is more attractive than that supplied by soybean milk. Furthermore, the biological value of the *J. bataua* protein is about 40% higher than that of soybean. On the basis of our very limited rat-feeding studies and anecdotal information acquired during field work in regions where *J. bataua* oil and milk are consumed by people and its pulp by animals, there is presently no evidence that this food contains toxic materials.

An increasing concern of nutritionists who have done studies among rice-, corn-, and wheat-eating populations in which approximately 70% of the calories are supplied by grain, has been the low caloric density of the diets consumed. Even when adequate supplies of grain exist, children may not eat sufficient food to meet their caloric requirements. For this reason, a food with the high caloric density of *Jessenia bataua* is very attractive. Studies in man and animals indicate that the intake of essential fatty acids required to prevent deficiency lie within the range of 1–2% of total calories (National Academy of Sciences, 1980). *Jessenia bataua* milk contains approximately 1.5% of its calories from linoleic acid.

Those nutritionists who feel that health advantages accrue from a high ratio of polyunsaturated fatty acids may be slightly disappointed by the composition of *Jessenia bataua* oil, even though most of the fatty acid contained in the oil is the atherogenic neutral oleic acid. It may be possible that other species of palm fruit in the closely related genus *Oenocarpus* will provide oil with higher levels of polyunsaturated fatty acids. We obtained one sample of *O. mapora*, and analysis showed the protein to be of the same high quality as in *J. bataua*. However, the fatty acid content of its oil was somewhat different, with the major changes being 19.6% palmitic acid, 64% oleic acid and 10.9% linoleic acid.

In conclusion, we feel that studies by botanists, agronomists and nutritionists designed to evaluate little-known foods consumed in developing countries may provide important new sources of food proteins for combating world hunger. This work has languished in the past, while full attention and support were directed towards developing the standard grain and legume crops for introduction into rural development schemes. The mixed successes achieved make it apparent that the world food supply can not be totally dependent on only a few crops. The foundation upon which agriculture is built must be widened to include marginally used crops with further potential, such as shown in the example of *Jessenia bataua*.

ACKNOWLEDGMENTS

The authors wish to thank Drs. R. E. Schultes and T. Swain for their suggestions concerning the manuscript and Dr. R. Kleiman for his assistance with the chemical analyses. The work of this study was supported in part by the Tufts University Nutrition Institute, the Anderson and Atkins Funds of Harvard University, Centro De Desarrollo "Las Gaviotas," United Brands Co., the U.S. Agency for International Development, and the National Science Foundation (Projeto Flora Amazônica).

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