CHEMICAL COMPOSITION OF THE FRUIT MESOCARP OF THREE PEACH PALM (*Bactris gasipaes*) POPULATIONS GROWN IN CENTRAL AMAZONIA, BRAZIL

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SUMMARY: The percent composition, soluble and insoluble food fibers, oil fatty acids and minerals were determined in the mesocarp of fruits of three peach palm (*Bactris gasipaes* Kunth) populations grown in Central Amazonia, Brazil. Amino acids were also determined in one of the populations. The mean protein levels ranged from 1.8 to 2.7%, lipid levels ranged from 3.5 to 11.1%, the nitrogen free fraction ranged from 24.3 to 35%, food fiber ranged from 5.2% to 8.7%, and energy ranged from 179.1 to 207.4 kcal %. All essential, as well as nonessential, amino acids were present, with tryptophan and methionine presenting the lowest mean concentrations. The mono-unsaturated oleic acid predominated in the oil, ranging from 42.8 to 60.8%, and palmitic acid was the most abundant saturated fatty acid, ranging from 24.1 to 42.3%. Among the essential fatty acids, linoleic acid was the most abundant, with a maximum of 5.4% in Pampa-8. The most important mineral elements were potassium, selenium and chromium, respectively corresponding to 12%, 9% and 9% of daily recommended allowances. Considering the nutritional potential of the fruit, we suggest its more frequent incorporation into the diet of the Amazonian population.

INTRODUCTION

Peach palm (*Bactris gasipaes* Kunth, Palmae) is a caespitose palm tree that was domesticated in Tropical America for its fruit (Mora Urpí et al., 1997), although all parts of the plant were utilized by native peoples (Patiño, 1963). Today, fruit utilization is essentially limited to direct consumption (after cooking), although some producer associations are processing a flour for bread and pastry preparation for markets in Rio Branco, Acre, Porto Velho, Rondônia, Costa Rica, and, more recently, in Manaus, Amazonas. Peach palm flour can substitute other products destined for human consumption, especially corn and sorghum flours, which are difficult to grow and process in Amazonia. Fruits of second quality could also be used for animal feed (Clement & Mora Urpí, 1987), and for vegetable oil extraction, although the economic viability of these projects depends on breeding programs (Clement & Arkcoll, 1991). The productivity of peach palm ranges from 10 to 30 ton/ha of fresh fruit, depending on genetic resources and agronomic management (Clement & Mora Urpí, 1987). Nonetheless, despite this potential, peach palm is currently utilized principally for the extraction of its heart-of-palm (Mora Urpí et al., 1997).

The fruits have good nutritional potential because of their carotenoid and energy contents (Aguiar et al., 1980; Arkcoll & Aguiar, 1984), with the carotenoids being highly bioavailable (Yuyama et al., 1991; Yuyama & Cozzolino, 1996). They also may have important amounts of minerals (Yuyama et al., 1997). Both the nutritional and industrial potential of peach palm was investigated in Costa Rica (CIPRONA, 1986; Blanco Metzler et al., 1992) and Colombia (Piedrahita & Velez, 1982). Although an extensive literature is available about the chemical composition of the peach palm fruit mesocarp, most studies are based on only one or two samples, with no information about the collection site or a definition of the population (Clement & Arkcoll, 1991).

The variation observed demonstrates the importance of determining the chemical composition within each landrace and/or population of potential interest to consumers or to agro-industry, both of whom are interested primarily in fruit quality and not in fruit variability. This type of study was started by Garcia Torres (1989), Fernández-Piedra et al. (1995) and Clement et al. (1998), but their reports did not include complete analyses of percent composition, protein quality, oil quality or minerals. Over the last few years there has been a growing interest in the determination of several essential and nonessential mineral elements in foods and diets (Underwood, 1977), both to improve adequacy and to monitor this. The objective of the present study was to determine the chemical composition of the fruit mesocarp of three peach palm samples from three populations grown in Central Amazonia with potential for use by agro-industry.

METHODS

Peach palm fruits were obtained from the Yurimaguas Germplasm Collection, maintained at the Tropical Fruit Experiment Station of the Instituto Nacional de Pesquisas da Amazônia (INPA - National Research Institute for Amazonia), km 40 of the BR-174 highway, municipality of Manaus, Amazonas, Brazil. This collection is a mixture of the Pampa Hermosa landrace and of the hybrid population of Yurimaguas, Peru (hereafter Pampa-40). Fruits were also obtained from the Vale Verde farm (Yurimaguas hybrid germplasm; hereafter Pampa-8), km 8 of the BR-174 highway, Manaus, and from the Carapana farm (germplasm of Rio Preto da Eva, Amazonas, of the Pará landrace; hereafter Pará-85), km 85 of the AM-010 highway, municipality of Rio Preto de Eva, Amazonas, Brazil. In each case, fruits were collected from different plants and mixed to form a composite sample of the cultivated population.

The fruits were processed in the Nutrition Laboratory, Health Sciences Dept., INPA, as follows: boiling for one hour in order to destroy antinutritional factors, such as calcium oxalate crystals (Arkcoll & Aguiar, 1984) and trypsin inhibitor(s) (Murillo et al., 1983); removal of the peel and extraction of the seed; the pure mesocarp thus obtained was ground and dried in an oven with forced air circulation at a controlled temperature of 60ºC until constant weight; the ground mesocarp was pulverized and stored in polyethylene flasks until analysis.

An aliquot of the dried mesocarp of Pará-85 was sent to the Faculty of Medicine of Ribeirão Preto, Department of Medicine, Ribeirão Preto, São Paulo, for amino acid analysis. Aliquots of the dried mesocarp of Pampa-8, Pampa-40 and Pará-85 fruits were sent to the

Nuclear Energy Research Institute, São Paulo, SP, and Adolfo Lutz Institute, São Paulo, SP, for mineral element analysis and fatty acid analysis, respectively.

Percent composition, except for moisture, was determined in triplicate by methods recommended by AOAC (1995). Soluble and insoluble fibers were quantified by the enzymic-gravimetric method of Asp et al. (1983), and mineral elements by instrumental neutron activation (AANI), as described by Yuyama et al. (1997). The following reference materials were analyzed to verify the precision of the equipment: Citrus-Leaves (NBS SRM 1572), Oyster Tissue (NIST-SRM-1566A) and Total Diet (NIST-SRM-1548).

Lipids were extracted with ethyl ether by the Soxhlet method (IAL, 1985). The oil fatty acids were transformed to fatty acid methyl esters (IAL, 1985), which were analyzed with a Shimadzu model GC-17^{A} gas chromatograph equipped with a flame ionization detector. The compounds were separated on a 50 m CP-Sil 88 capillary fused silica column 0.25 mm in internal diameter and with a 0.20 µm film thickness. Operating conditions were as follows: programmed column temperature, 80 to 220ºC (5ºC/min); injector temperature, 230ºC; detector temperature, 240ºC; carrier gas, hydrogen; gas linear velocity, 40 cm/s; ratio of sample division, 1:50. The fatty acids were identified by comparing the retention times of pure methyl ester standards of fatty acids and of the samples. Quantification was performed by area normalization.

Amino acid analysis was performed by ion-exchange chromatography using sodium citrate solvents. The stationary phase was a column containing cationic resin and the mobile phase was sodium citrate buffer. The resin was Durrum DC-6A (Pierce Chemical, USA). The sodium citrate buffers were of the following compositions: A, 0.20 N sodium citrate, pH 3.25; B, 0.20 N sodium citrate, pH 4.25; C, 0.37 N sodium citrate, pH 5.25. The flow of the mobile phase was 0.60 mL/min and the column eluate was mixed with the ninhydrin reagent which was bombarded at a flow of 0.30 mL/min, passing through a heating bath at 97ºC for 30 minutes, the time needed for the full processing of the reaction between amino acid and reagent, and then through a detector in which the amino acids were read at 570 and 440 nm. The graph of each amino acid was obtained with a recorder. Quantification was performed by comparing the peak area of each amino acid in the sample to the area of the corresponding amino acid standard (Pierce Chemical, USA) of the protein hydrolysate of known concentration (4 nanomoles).

The three peach palm populations were compared in a completely randomized design, with three repetitions. The significance of the differences among population means was tested with the Tukey method at 5% probability.

RESULTS AND DISCUSSION

Percent composition

Protein concentration in the peach palm fruit mesocarp ranged from 1.8 to 2.7% and was considered to be relatively low (Table 1). This variation is similar to that reported by Garcia Torres (1989) and is within the range of 1.5 to 4.9% reported by Pechnik et al. (1962), Aguiar et al. (1980), Arkcoll & Aguiar (1984), and Clement et al. (1998) for fruits in Amazonia.
The highest lipid concentration was detected in Pará-85 fruits, followed by Pampa-8 and Pampa-40 (Table 1). These data are similar to those reported by Garcia Torres (1989), considering the standard deviation. The high lipid concentration in Pará-85 supports the statement

of Clement & Arkcoll (1991) that more primitive landraces have oilier fruits, because selection for fruit size favored starch accumulation, which is negatively correlated with oil content.

The fruits of Pampa-40 presented the highest carbohydrate (N-free extract) concentration (Table 1), although the others were not much different and all were within the range of variation reported by Arkcoll & Aguiar (1984). Mora Urpí et al. (1997) showed that peach palm from the Pacific coast of Colombia and from Costa Rica had higher carbohydrate means than those from Amazonia. The ash content did not vary much among the populations studied (Table 1), although they were lower than those reviewed by Mora Urpí et al. (1997).

There was a predominance of insoluble food fiber over soluble fiber (Table 1), with the highest food fiber content being detected in Pampa-8. Total fiber varies widely in the literature (Pechnik et al., 1962; Aguiar et al., 1980; Arkcoll & Aguiar, 1984; Clement et al., 1988; Garcia Torres, 1989), probably as a function of landrace variation and the methodologies used.

The peach palm fruit was characterized by its abundance of energy, which ranged from 179.1 to 206.7 kcal per 100 g of the edible portion (Table 1). Even though these values were lower than those detected by Aguiar et al. (1980), these peach palm fruit were richer in energy than most other fruits listed in regional food composition tables (FIBGE, 1981; Aguiar, 1996). However, there are fruits with higher energy concentrations than peach palm fruit, such as the oily "patauá" (Jessenia bataua, Palmae) and "piquiá" (*Caryocar villosum*, Caryocaraceae) (Aguiar, 1996). In Amazonia, the most important dietary deficiency is energy, not protein (Shrimpton & Giugliano, 1979; Yuyama et al., 1992; Yuyama et al., 1997), so that a more frequent incorporation of peach palm fruit into the diet of the Amazonian population is suggested in order to minimize the nutritional deficiencies diagnosed in the population.

Table 1. Percent composition (% fresh weight) of 100 g of the mesocarp of the peach palm (*Bactris gasipaes*) fruit from three populations produced in Central Amazonia.

	Pampa-8	Pampa-40	Pará-85	mean ± SD
Moisture	49.5	53.0	56.5	53.0 ± 2.9
Protein	2.7 ± 0.02	1.8 ± 0.05	2.4 ± 0.01	2.3 ± 0.4
N-free extract	29.8 ± 0.2	35.0 ± 0.6	24.3 ± 0.1	29.7 ± 0.2
Lipids	8.6 ± 0.02	3.5 ± 0.01	11.1 ± 0.1	7.7 ± 3.2
Ashes	0.7 ± 0.05	0.6 ± 0.1	0.5 ± 0.2	0.6 ± 0.1
Soluble fiber	0.8 ± 0.3	1.6 ± 0.6	0.8 ± 0.04	1.1 ± 0.4
Insoluble fiber	7.9 ± 0.8	4.3 ± 0.2	4.4 ± 0.07	5.5 ± 1.7
Total fiber	8.7 ± 1.1	6.0 ± 0.4	5.2 ± 1.1	6.6 ± 1.5
Energy	207.4 ± 5.6	179.1 ± 2.2	206.7 ± 5.0	197.7 ± 13.2

Amino acids

Although the protein content of peach palm fruit mesocarp was within expected limits (Table 1), all amino acids analyzed were present in lower amounts than previously reported

(Zapata, 1972; Piedrahita & Velez, 1982; Zumbado & Murillo, 1984) and lower than those recommended by FAO/WHO (1973), particularly lysine, methionine and tryptophan. Because of the absence of comparative data in Amazonia, it is impossible to explain the data obtained in the present study.

Delgado et al. (1988) reported that isoleucine and methionine were the amino acids present in lowest concentrations, in agreement with our results. In contrast to the levels observed here, in other studies lysine concentration was high and comparable to that of the maize (*Zea mays*) Opaco-2 variety (Zapata, 1972; Piedrahita & Velez, 1982; Zumbado & Murillo, 1984). While tryptophan was present, it was at lower concentration than that reported by Piedrahita & Velez (1982).

Among non-essential amino acids, glutamic acid, aspartic acid and alanine were particularly outstanding (Table 2). The same tendency was observed by Zapata (1972), Piedrahita & Velez (1982) and Zumbado & Murillo (1984).

Table 2. Amino acid composition of the protein in the mesocarp of peach palm (*Bactris gasipaes*) fruits from the Pará 85 population sample produced in Central Amazonia, with comparisons to FAO/WHO recommendations and the literature means.

Amino acids	Pará 85 (% g N)	FAO/WHO (% g N)	FAO/WHO (%)	Means[1] (% g N)
Essential				
Leucine	3.14 ± 0.03	7.0	45	3.6 ± 1.4
Phenylalanine	2.04 ± 0.02	6.0	34	2.0 ± 0.6
Lysine	1.67 ± 0.06	5.5	30	4.3 ± 0.2
Valine	2.83 ± 0.09	5.0	57	3.1 ± 0.4
Isoleucine	1.70 ± 0.05	4.0	42	2.3 ± 0.6
Threonine	2.71 ± 0.08	4.0	68	3.0 ± 0.4
Methionine	0.80 ± 0.01	3.5	23	1.5 ± 0.1
Tryptophan	0.45 ± 0.02	1.0	45	0.9
Non-essential				
Proline	2.57 ± 0.08			2.8 ± 0.1
Áspartic acid	4.33 ± 0.19			4.8 ± 0.2
Serine	2.72 ± 0.31			3.7 ± 0.1
Glutamic acid	4.98 ± 0.33			5.5 ± 0.8
Glycine	2.87 ± 0.06			4.3 ± 0.9
Alanine	3.51 ± 0.21			3.9 ± 0.2

[1]Mean±standard deviation of Piedrahita & Velez (1982), Zapata (1972), and Zumbado & Murillo (1984).

From a nutritional viewpoint, the protein of peach palm fruit is of low biological value, a common occurrence in products of plant origin, with methionine and lysine being the most limiting amino acids. This conclusion is contrary to the frequently cited NRC (1975) affirmation that peach palm fruits contain 'quality protein'.

Fatty Acids

The monounsaturated oleic fatty acid (C18:1) is the fatty acid most frequently detected in nature, with highest concentrations in olive oil (Olea europaea), and was observed to be present in large amounts in peach palm mesocarp oil (Table 3). The highest unsaturated fatty acid concentration was observed in Pampa-8, followed by Pará-85, both being close to the mean value for peach palm mesocarp oil (Mora Urpí et al., 1997). The 0.27 ratio of polyunsaturated to saturated fatty acids (P/S) observed in Pampa-8 was above the mean value reported by Mora-Urpí et al. (1997) and below the value reported by Fernandez-Piedra et al. (1995). This ratio is below the 0.5 to 1 range recommended by the WHO (1990). The consumption of monounsaturated fatty acids, such as oleic acid, leads to a reduction of total cholesterol, low density lipoprotein (LDL) and blood triglycerides, without altering high density lipoprotein (HDL) or very low density lipoprotein (VLDL) (Spiller et al., 1992; Aviram & Elias, 1993). Thus, the oil of these peach palm fruit samples is a good option for human consumption.

Table 3. Composition of the major fatty acids in the oil extracted from the mesocarp of peach palm (*Bactris gasipaes*) fruits from three population samples produced in Central Amazonia (as % oil) and compared with the literature.

Fatty acids	Pampa-8	Pampa-40	Pará 85	Mean[1]
Palmitic - C16:0	24.1 ± 0.2 [c]	42.3 ± 0.8 [a]	35.2 ± 0.3 [b]	38.2
Palmitoleic - C16:1	7.4 ± 0.5 [a]	3.9 ± 0.2 [c]	5.2 ± 0.2 [b]	7.4
Stearic - C18:0	0.8 ± 0.2 [c]	3.5 ± 0.2 [a]	1.63 ± 0.07 [b]	1.0
Oleic - C18:1	60.8 ± 0.8 [a]	42.8 ± 0.9 [c]	51.7 ± 0.9 [b]	46.3
Linoleic - C18:2	5.4 ± 0.4 [a]	2.5 ± 0.3 [b]	4.9 ± 0.2 [a]	6.2
Linolenic - C18:3	1.4 ± 0.1 [a]	0.0	1.2 ± 0.06 [a]	1.4
Saturated fatty acids	24.9 ± 0.5	46.0 ± 1.0	36.8 ± 0.4	39.2
Monounsaturated fatty acids	68.2 ± 1.0	46.7 ± 1.0	56.9 ± 1.0	53.7
Polyunsaturated fatty acids	6.8 ± 0.5	2.5 ± 0.3	6.1 ± 0.3	6.9
P/S ratio	0.27	0.05	0.17	0.18

[1]. Mora-Urpí et al. (1997). Identical letters in the rows do not differ at 5% probability by the Tukey test.

Essential Minerals

The concentrations of mineral elements in the mesocarp of the three peach palm fruit populations were similar only for magnesium and zinc (Table 4) and differed for the other minerals. Considering that the two Pampa populations are not more similar to each other than they are to the Pará population, these differences are probably due to the soil at each location and to the management used, especially with respect to fertilization.

In terms of the daily allowances recommended for an adult man in the 25-50 year age range (NAS/NRC, 1989), the mean contribution of these peach palm fruits for mineral elements was low (Table 4). The trace mineral elements, especially iron and zinc, were present at much lower concentrations than those observed by Blanco-Metzler et al. (1992), while the calcium content of the Pampa-40 sample was identical to that reported by these investigators and the calcium content of the remaining populations was higher. In contrast, magnesium and potassium levels were higher than those reported by Blanco-Metzler et al. (1992).

Table 4. Essential mineral macro- and microelement content in 100 g of the mesocarp of the fruits of three peach palm (*Bactris gasipaes*) population samples produced in Central Amazonia.

Mineral	Pampa-8	Pampa-40	Pará-85	RDA[1]	Mean contribution[2]
Calcium - Ca (mg)	24.7 ± 2.1	10.2 ± 0.5	21.8 ± 2.4	800 (mg)	2%
Potassium - K (mg)	289.3 ± 0.1	225.8 ± 0.3	206.4 ± 3.3	2000 (mg)	12%
Sodium - Na (mg)	0.2 ± 0.02	0.2 ± 0.01	12.6 ± 2.0	500 (mg)	1%
Magnesium - Mg (mg)	16.9 ± 0.5	16.9 ± 0.6	17.6 ± 1.0	350 (mg)	5%
Chloride - Cl (µg)	10.2 ± 0.4	7.6 ± 0.8	30.7 ± 3.7	750 (mg)	2%
Manganese - Mn (µg)	84.3 ± 6.1	115.1 ± 3.3	82.6 ± 8.7	2.0-5.0 (mg)	5%
Zinc - Zn (µg)	277.7 ± 5.5	258.5 ± 18.8	278.3 ± 30.4	15 (mg)	2%
Selenium - Se (µg)	3.5 ± 0.1	3.3 ± 0.2	11.4 ± 0.7	70 (µg)	9%
Iron - Fe (µg)	565.6 ± 15.1	470.0 ± 9.4	739.3 ± 130.5	10 (mg)	6%
Chromium - Cr (µg)	8.2 ± 0.4	12.2 ± 0.9	13.9 ± 0.9	50-200 (µg)	9%

[1]RDA (NAS/NRC. 1989) based on the recommended daily allowances for adult men in the 25-50 age range.

[2]Mean contribution of peach palm fruits for mineral requirements in terms of RDA (NAS/NRC 1989).

Non-essential Minerals

The biological importance of non-essential minerals present in peach palm fruit is unknown (Table 5), however, traces can be found in animal and plant tissues (Underwood, 1977). Of all elements analyzed, rubidium (Rb) was present at highest concentrations, especially in the Pampa-8 population (Table 5). The highest barium (Ba) concentration was detected in Pampa-40, but was lower than the concentration detected in Brazil nuts (Bertholletia excelsa) (Underwood, 1977). In view of the lack of information about these mineral elements in peach palm fruit, the present data are presented for the sake of future comparisons.

Table 5. Non-essential mineral element content in 100 g of the mesocarp of the fruits of three peach palm (*Bactris gasipaes*) population samples produced in Central Amazonia.

Mineral	Pampa-8	Pampa-40	Pará-85
Gold - Au (ng)	30.3 ± 6.1	ND	57.8 ± 2.2
Barium - Ba (µg)	121.7 ± 2.5	164.5 ± 75.2	103.9 ± 2.6
Bromine - Br (µg)	189.4 ± 1.0	34.3 ± 0.1	143.5 ± 8.7
Cerium - Ce (µg)	1.3 ± 0.3	1.3 ± 0.2	2.1 ± 0.4
Scandium - Sc (ng)	8.3 ± 0.5	7.0 ± 0.9	10.4 ± 2.6
Protactinium - Pa (µg)	ND	56.4 ± 18.8	60.9 ± 21.7
Antimony - Sb (ng)	99.0 ± 3.0	31.0 ± 5.2	56.5 ± 17.4
Lanthanum - La (ng)	ND	70.5 ± 2.3	521.8 ± 87
Rubidium - Rb (µg)	924.1 ± 55.6	578.1 ± 42.3	491.4'± 39.1

ND-Not detected by the method used.

We conclude that the peach palm fruit mesocarp is highly caloric, with significant levels of alimentary fiber. Despite its low protein content, it contains all essential amino acids, with methionine and lysine being present at lower than recommended levels. Peach palm provides few essential minerals, with emphasis on potassium, selenium and chromium, which are present in amounts corresponding to 12%, 9% and 9% of recommended daily allowances, respectively. We suggest that the peach palm fruit be used more frequently in the diet of the Amazonian population.

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