ISSN 0100-2945 http://dx.doi.org/10.1590/0100-29452017305

SCIENTIFIC COMMUNICATION

QUALITY CHARACTERISTIS OF FRUITS AND OILS OF PALMS NATIVE TO THE BRAZILIAN AMAZON[1]

MARY DE FÁTIMA GUEDES DOS SANTOS[2], RICARDO ELESBÃO ALVES[3], EDY SOUSA DE BRITO[3], SILVANDA DE MELO SILVA[4], MARCIA RÉGIA SOUZA DA SILVEIRA[5]

ABSTRACT –Native palm trees are highly important plant resources for the Amazon region; however, despite the great diversity and utilities, few species have been studied, requiring more comprehensive studies on quality and composition for species not yet explored. The aim of this study was to evaluate the quality of fruits and oils of palm trees from the Brazilian Amazon and to identify potential uses. Fruits from five palm trees (bacaba, buriti, inajá, pupunha, and tucumã) were evaluated for total mass, length, diameter, and yield, soluble solids (SS), titratable acidity (TA), pH, SS/TA ratio, total soluble sugar (TSS), reducing sugar (RS), total pectin (TP) soluble pectin (SP), and starch. The oils from the edible portion of fruits were evaluated for acidity and peroxide indexes, oxidative stability, unsaponifiable matter, polar compounds and fatty acids composition analyzed by gas chromatography. Pupunha showed the highest yield of the edible portion (76.38%) and starch content (24.89%). The mesocarp of palm fruits showed SS values between 7.5 and 14.3 ºBrix, low acidity (0.30%), pH (4.2 to 6.3), higher content of total sugars in tucuma and reducing sugars in bacaba and 0.81% for total pectin. The content of lipids was high, ranging from 17.0% for pupunha to 38.3% for bacaba in dry basis. In buriti, tucuma, and bacaba oils, high content of unsaturated fatty acids was found, with more than 83, 75, and 61%, respectively. Therefore, not only fruits but also oils showed excellent quality and great nutritional potential.
Index terms: *Oenocarpus bacaba* Mart., *Mauritia flexuosa* L.f, *Maximiliana maripa* Aubl. Drude, *Bactris gasipaes* Kunth and *Astrocaryum vulgare* Mart.

CARACTERÍSTICAS DE QUALIDADE DE FRUTOS E ÓLEOS DE PALMEIRAS NATIVAS DA AMAZÔNIA BRASILEIRA

RESUMO - As palmeiras nativas são recursos vegetais de grande importância na região Amazônica, mas apesar da diversidade e utilidade são pouco estudadas, sendo necessário avaliar a qualidade e a composição de espécies ainda pouco exploradas. O objetivo deste estudo foi avaliar a qualidade de frutos e óleos de palmeiras nativas da Amazônia Brasileira para identificar usos potenciais. Foram avaliados frutos de cinco palmeiras (bacaba, buriti, inajá, pupunha e tucumã), quanto à massa total, comprimento, diâmetro, rendimento, sólidos solúveis, acidez titulável, pH, açúcares totais, açúcares redutores, pectina total, pectina solúvel e amido. Nos óleos da porção comestível dos frutos, foram avaliados o índice de acidez e de peróxidos, a estabilidade oxidativa, a matéria insaponificável e os compostos polares, e a composição de ácidos graxos por cromatografia gasosa. A pupunha destacou-se pelo rendimento da porção comestível (76,38%) e pelo teor de amido (24,89%); os frutos das palmeiras apresentaram SS entre 7,5 e 14,3 oBrix; baixa acidez titulável (média de 0,30%); pH (4,2 a 6,3); maiores teores de açúcares totais no tucumã e açúcares redutores na bacaba; para pectina total 0,81%. O conteúdo de óleo nos frutos foi elevado, variando entre 17,0% na pupunha e 38,3% na bacaba, em base seca. Os óleos de buriti, tucumã e bacaba apresentam elevados conteúdos de ácidos graxos insaturados, com mais de 83; 75 e 61%, respectivamente. Portanto, tanto os frutos, como os óleos estudados apresentaram excelente qualidade, assim como grande potencial alimentício.
Termos para Indexação: *Oenocarpus bacaba* Mart., *Mauritia flexuosa* L.f, *Maximiliana maripa* Aubl. Drude, *Bactris gasipaes* Kunth e *Astrocaryum vulgare* Mart.

[1](Paper 002-15). Received May 05, 2015. Accepted November 09, 2015.
[2]Researcher. D.Sc., Institute of Scientific and Technological Research of the State of Amapá and Professor at Estácio University of Macapá. Macapá-AP. Email: mary_guedes_ap@hotmail.com
[3]Researcher. D.Sc., Embrapa Agroindústria Tropical. Fortaleza-CE. Email: ricardo.alves@embrapa.br; edy.brito@embrapa.br
[4]Professor, Ph.D., Federal University of Paraíba. Areia-PB. Email: silvasil@cca.ufpb.br
[5]Analyst. Msc., Embrapa Agroindústria Tropical. Fortaleza-CE. E-mail: marcia.silveira@embrapa.br

Due to its wide distribution and diversity of uses by Amazonians, native palm trees are considered one of the most important botanical families in the Amazon. However, for better use and incorporation into the list of commercial crops, it is necessary to expand studies, including the evaluation of fruit quality.

Studies on the characterization of Amazonian fruits are still scarce and have often been directed to species that have economic expression in the region, such as açaí and cupuaçu (CARVALHO, MULLER, 2005), although there are other potential species, among them bacaba, buriti inajá, pupunha and tucumã (NEVES et al., 2015, DIDONET et al., 2015).

The demand for vegetable oils with special composition is increasing, and oils obtained from native palm fruits can be considered as new sources that will surely have their commercial value increased (SANTOS et al., 2013). Studies with some species (SANTOS et al., 2013, SANTOS et al., 2015) have indicated that these oils have unsaturated fatty acids, phytosterols, β-carotene, tocopherols, among others, in their composition.

Works related to the composition and quality of fruits and oils of native palm trees are important to add value to species still little explored in the region and consequently encourage the creation of new markets. The aim of this study was to evaluate the quality of fruits and oils from palm trees native to the Brazilian Amazon and to identify potential uses.

Fruits from native palms, bacaba (*Oenocarpus bacaba* Mart.), buriti (*Mauritia flexuosa* L.), inajá (*Maximiliana maripa* (Aubl.) Drude), pupunha (*Bactris gasipaes* Kunth) and tucumã (*Astrocaryum vulgare* Mart.) were harvested in January and February 2009, and January and February 2010, at the point of maturation suitable for consumption, in different localities of the State of Amapá, Brazilian Amazon (Table 1). Then, fruits were transported to the Laboratory of Physicochemical Analysis of the Institute of Scientific and Technological Research of Amapá, Macapá-AP, for selection and physical analysis. Subsequently, fruits were conditioned and transported by air to the Laboratory of Post-Harvest Physiology and Technology of Embrapa Agroindústria Tropical, Fortaleza-CE, for processing and physicochemical analyses. Subsequently, the edible portions were lyophilized for the extraction of oils and analyses of the fatty acids composition at the Laboratory of Instrumental Analysis of Embrapa Agroindústria Tropical.

For physical analyses, 30 intact fruits were used, in the case of buriti, inajá, pupunha and tucumã, and for bacaba, due to the mass of fruits, 60 fruits were used. In the evaluation of the physicochemical characteristics, three repetitions of 12 fruits were used for buriti, inajá, pupunha and tucumã, totaling 36 fruits of the same plant; while for bacaba, to obtain a sufficient sample, 25 fruits were used per repetition, totalizing 75 fruits.

The following evaluations were carried out: fresh mass and yield of the edible portion, using semi-analytical scale; length and diameter using a digital caliper. pH was determined, as well as soluble solids (SS%) using digital refractometer according to AOAC (1992); titratable acidity (TA -% of citric acid) according to IAL (2005); SS / TA ratio obtained by the quotient between SS and TA; reducing sugars (RA) through dinitrosalicylic acid (DNS) dosing according to Millller (1959); total soluble sugars (TSS) by Antrona, according to Yemn and Willis (1954); total pectin (TP) and soluble pectin (SP), according to Blumenkrantz and Asboe-Hansen (1973) and extractions according to Mccready and Mccomb (1952); starch (AM), extraction by acid hydrolysis, according to AOAC (1992).

Lipids were extracted from 5 g of lyophilized samples in three replicates using Soxhlet with hexane to determine the total amount of lipids (AENOR, 1991). Thereafter, the solvent was evaporated under vacuum to constant weight.

The fatty acids composition was determined by gas chromatography–mass spectrometry (GC-MS) after transesterification of oils. A Shimadzu QP-2010 instrument, equipped with DB-5MS methylpolysiloxane column (30 m in length x 0.25 mm and 1.0 μm in thickness, J & W Scientific Inc., Folsom, USA) was used. The identification of compounds was performed by comparing the chromatogram peaks with those of a fatty acid standard, analyzed in the same sample method; by analysis of the fragmentation patterns exhibited in the mass spectra, confirmed by comparison with spectra present in the database provided by the equipment (NIST02 - 147.198 compounds), in addition to data in literature.

The results of analyses were submitted to a descriptive statistical analysis, obtaining average values and standard deviation for each fruit species analyzed.

The mass of fruits of the different species of native palm trees is shown in Table 2, with buriti showing the highest value (55.48g). The mean value found for tucumã (23.89g) was lower than that obtained by Carvalho and Muller (2005), of 34.50g, whereas in the other species, the fruit mass results were higher than those reported by these authors. For inajá, Bezerra et al. (2006) reported average values

of 26.6g and 32.9g, and the value found in this study for inajá (31.07g) is within this range. For pupunha, Carvalho et al. (2013) observed mass ranging from 16.06 to 39.17g, and the average value obtained in this work (24.65g) is within the variation range.

In the yield of the edible portion, there was a great difference among fruits, with variation from 20.48 to 76.38%. For bacaba and tucumã, the edible portion composed of the mesocarp + epicarp represented, respectively, 37.07 and 32.66% of the fruit mass, the rest being composed of the seed. In buriti, inajá and pupunha, the edible portion (mesocarp) represented, respectively, 20.48; 31.79 and 76.38%, of the fruit mass. The average pulp yield for inajá was close to value found by Bezerra et al. (2006), with 29.90% of the fruit mass. Among the factors that may have interfered for the low yield, especially in the case of buriti, is the difficulty of manual pulp extraction. The differences found in the biometry of palm fruits of this study compared to other studies, especially for pupunha, may be due to the high variability of species, which is manifested in size, shape and color of fruits (Carvalho et al., 2013).

In relation to soluble solids (SS), buriti showed the highest average content (14.3 ºBrix) and bacaba the lowest (7.5 ºBrix), much higher than those observed by Canuto et al. (2010) and Neves et al. (2015) in buriti and bacaba pulps, respectively. Pupunha, inajá and tucumã presented similar mean values (Table 2). SS values found for inajá (9.17 ºBrix) were much lower than those observed by Bezerra et al. (2006), who found values in the order of 21 ºBrix. Leitão (2008) evaluated tucumã from the State of Amazonas and found SS value of 14.50 ºBrix, higher than the average value obtained in this study for fruits harvested in the State of Amapá, which was 11.60 ºBrix.

For titratable acidity, among evaluated fruits, buriti showed higher average value (0.56%). For inajá and tucumã, the lowest values were observed, with averages of 0.14% and 0.16%, respectively. For pupunha, the average acidity value obtained (031%) was lower than that observed by Silva et al. (2013), of 0.53%.

The pH values for inajá (6.35) and tucumã (6,12) were higher when compared to those of Bezerra et al. (2006) and Yuyama et al. (2008), respectively, who found average pH values of 5.22 and 5.89; on the other hand, the pH value found for pupunha was similar to the average value (5.63) observed by Silva et al. (2013). In general, the pH of palm fruits studied can be considered low, ranging from 4.16 to 6.35.

The high content of soluble solids and the low acidity justify the high SS / TA ratio obtained for tucumã and inajá (Table 2). Comparing the SS content among palm fruits studied, it was observed that tucumã and inajá are sweeter than the others. The SS / TA ratio reflects the sweetness of fruits (NEVES et al., 2015).

Regarding the contents of total soluble sugars (TSS) (Table 2), tucumã showed the highest content (6.48%), with value well above that found by Yuyama et al. (2008) in Amazonian tucumã (1.99%). The average contents obtained for bacaba, buriti and inajá were 3.7; 3.2 and 3.7%, respectively, and no previous references were found on the TSS contents for these fruits. Several factors influence the sugar content of fruits, such as genetic characteristics, climatic conditions, soil type, plant nutrition, etc. (Carvalho et al., 2008). Regarding the content of reducing sugars (RS), for bacaba, buriti and tucumã, the average values found were similar (2.78, 2.43 and 2.63%), respectively. Yuyama et al. (2008) evaluated tucumã from the State of Amazonas and found RS content of 1.27%, lower than the mean value found in this study. The mean RS values in relation to total sugars represent approximately 77.65% in bacaba, 74.77% in buriti, 50.27% in inajá, 60.42% in pupunha and 40.59% in tucumã, indicating that the difference is due to the amount of non-reducing sugars.

For total pectin (TP), the average levels found were similar among the analyzed species, ranging from 0.71 to 0.97%. Neves et al. (2015) observed 0.13% in the pulp of bacaba, a value much lower than value obtained in this study (0.85%), and no data were found in literature on the TP content for the other palm trees studied. However, comparing the mean value obtained in this study for TP (0.81%) with that found in literature for açaí (0.67%), which is considered a fruit rich in pectin, the result was higher. For soluble pectin (SP), there was a close relationship among the analyzed species, with mean values between 0.12 and 0.24%. Based on the results obtained, the evaluated species can be classified as rich in pectin. High pectin levels are important for the post-harvest conservation of fruits, since they influence the texture of fruits and consequently their conservation. Pectin is also important as a raw material for the industry, mainly for the elaboration of jams and sweets, reducing the processing cost due to the lower addition of commercial pectin and reducing the manufacturing time (ANTUNES et al. et al. 2006).

For starch, in general, the species studied are good sources, highlighting the high percentage found in pupunha (24.89%), which although low in sugars, is rich in energy value due to the high starch content.

This characteristic can be an indicative for the use of pupunha in the production of flours.

The oil content in fruits was 17.04% for pupunha; 26.60% for tucumã, 28.27% for buriti; 35.20% for inajá and 38.29% for bacaba, on dry basis. Bacaba and inajá stood out for their high oil content, while pupunha showed the least oil. These results are similar to those obtained by Rodrigues et al. (2010) for inajá (35.52%) and lower for buriti and tucumã (38.42 and 38.50%), respectively.

Buriti, tucumã and bacaba oils presented high contents of unsaturated fatty acids, mainly oleic acid (C18: 1), with values of 83.16; 75.34 and 61.65%, respectively (Table 3). On the other hand, inajá and pupunha oils are characterized by their high content of saturated fatty acids, of 46.42 and 56.54%, respectively, and the main difference between them was the presence of significant amounts of myristic (C14: 0) and palmitic (C16: 0) fatty acids in inajá oil, with 9.99 and 36.42%, respectively, whereas for pupunha oil, the predominant saturated acid was palmitic acid. All oils have oleic acid as major fatty acid. Due to the high concentrations of this fatty acid in bacaba, buriti and tucumã, these oils can be considered monounsaturated, characterized as having high nutritional value, being liquid at room temperature and less susceptible to oxidation compared to oils with high amounts of linoleic acid. Inajá and pupunha oils are characterized by their high content of saturated acids, greater than 40%, so they are solid at room temperature. The composition of fatty acids found is similar to those reported for bacaba, tucumã, buriti (Rodrigues et al., 2010) and pupunha (SANTOS et al., 2013). For inajá, Rodrigues el al. (2010) reported lower values for myristic and palmitic acids (7.60 and 20.10%), respectively, whereas the values found for oleic acid (52.40%) were similar to those obtained in this study.

In short, due to the low acidity and high SS / TA ratio, the natural consumption of inajá and tucumã is favored, as well as industrialization. The high content of starch and pectin present in pupunha gives this fruit potential for the elaboration of flour to be used in baking, porridge and sauces. Bacaba, inajá, buriti and tucumã are species suitable as sources of oils, with percentages around 38, 35, 28 and 26%, respectively. Bacaba, buriti and tucumã oils are rich in unsaturated fatty acids, with percentages higher than 61.65%; whereas inajá and pupunha oils have high content in saturated fatty acids, above 46.42%.

TABLE 1 - Maturation characteristics of native palm tree fruits from different locations in the State of Amapá, in the Brazilian Amazon.

Fruit	Maturation characteristics	Local de colheita
Bacaba	Dark purple bark and white to brown pulp	Porto Grande
Buriti	Pulp of yellow orange color	Mazagão
Inajá	Pulp of yellow-cream color	São Joaquim do Pacuí
Pupunha	Lightly orange pulp	Colônia do Matapí
Tucumã	Peel and pulp of intense orange color	Curiaú

TABLE 2 - Mean values of physical and physicochemical characteristics obtained in fruits from palm trees native to the Brazilian Amazon (mean ± standard deviation).

Characteristics	Bacaba	Buriti	Inajá	Pupunha	Tucumã
Mass (g)	3.71±0.1	55.48±1.9	31.07±0.7	24.65±0.8	23.89±0.3
Length (mm)	19.44±0.2	53.83±2.9	59.11±0.4	38.47±0.2	42.85±0.8
Diameter (mm)	17.17±0.2	48.54±0.6	30.78±0.2	32.94±0.6	31.70±0.2
Yield (%)	37.07±0.7	20.48±1.3	31.79±2.3	76.38±2.5	32.66±1.2
SS (°Brix)	7.47±0.9	14.27±0.9	9.17±0.7	10.83±0.5	11.60±0.4
TA (% ac. cit.)	0.36 ±0.0	0.56±0.1	0.14±0.0	0.31±0.0	0.16±0.0
pH	4.61 ±0.1	4.16±0.1	6.35±0.2	6.15±0.3	6.12±0.0
SS/TA	21.27±2.1	25.10±0.2	67.48±4.7	34.80±1.8	72.60±4.6
TSS (%)	3.58±0.1	3.25±0.5	3.74±0.2	0.96±0.10	6.48±0.7
RS (%)	2.78±0.1	2.43±0.3	1.88±0.2	0.58±0.10	2.63±0.0
TP (%)	0.85±0.1	0.71±0.1	0.75±0.1	0.97±0.10	0.75±0.1
SP (%)	0.18±0.1	0.12±0.0	0.12±0.0	0.16±0.10	0.24±0.0
Starch (%)	8.59±0.2	2.15±0.2	4.61±0.4	24.89±2.14	10.49±0.9

TABLE 3 - Composition of the main fatty acids (%) of oils extracted from the mesocarp of palm fruits native to the Brazilian Amazon.

Fatty acids	Bacaba	Buriti	Inajá	Pupunha	Tucumã
Myristic (C14:0)	*NE	NE	9.99 ± 0.2	NE	NE
Palmitic (C16:0)	28.43± 0.5	16.84 ± 2.3	36.42 ± 2.3	56.54 ± 1.1	24.66± 0.2
Stearic (C18:0)	1.84 ± 0.0	NE	NE	NE	NE
Oleic (C18:1)	61.65± 0.5	83.16 ± 2.1	53.59 ± 1.0	43.46 ± 1.3	75.34± 1.0
Linoleic (C18:2)	8.09 ± 0.2	NE	NE	NE	NE

* NE = Not estimated

REFERENCES

AENOR. Asociación Española de Normalización. **Catálogo de normas UNE**. Madrid, 1991.

ANTUNES, L.E.C.; GONÇALVES, E.D.; TREVISAN, R. Alterações de compostos fenólicos e pectina em pós-colheita de frutos de amora-preta. **Revista Brasileira de Agrociência**, Pelotas, v.12, n.1, p.57-61, 2006.

AOAC – Association of Official Analytical Chemistry. **Official methods of analysis of the Association of Official Analytical Chemistry**. 11th ed. Washington, 1992. 1115p.

BEZERRA, V.S.; FERREIRA, L.A.M.; PEREIRA, S.S.C.; CARIM, M.J.C. O inajá (*Maximiliana maripa* (Aubl.) Drude) como potencial alimentar e oleaginoso. In: CONGRESSO BRASILEIRO DE PLANTAS OLEAGINOSAS, ÓLEOS, GORDURAS E BIODIESEL, 3., 2006, Varginha. **Anais...** Lavras: Universidade Federal de Lavras, 2006.

BLUMENKRANTZ, N.; ASBOE-HANSEN, G. New method for quantitative determination of uronics acids. **Analytical Biochemistry**, New York, v.54, n.2, p.484-489, 1973.

CANUTO, G.A.B.; XAVIER, A.A.O.; NEVES, L.C.; BENASSI, M.T. Caracterização físico-química de polpas de frutos da Amazônia e sua correlação com a atividade anti-radical livre**. Revista Brasileira de Fruticultura**, Jaboticabal, v.32, n.4, p.1196-1205, 2010.

CARVALHO J.E.U.; MULLER, C.H. **Biometria e rendimento percentual de polpa de frutas nativas da Amazônia**. Belém: Embrapa Amazônia Oriental, 2005. 5p. (Comunicado Técnico, 139).

CARVALHO, A.V.; BECKMAN, J.C.; MACIEL, R.A.; FARIAS NETO, J.T. Características físicas e químicas de frutos de pupunheira no estado do Pará. **Revista Brasileira de Fruticultura**, Jaboticabal, v.35, n.3, p.763-768, 2013.

CARVALHO, G.L. de.; LIMA, L.C.O.; SILVA, J.D.; SIQUEIRA, H.H.; MORAIS, E.C. Concentrações de cloreto de cálcio e tempos de armazenamento nos teores de açúcares redutores de uvas cv Red Globe (*Vitis vinifera* L). **Ciência e Agrotecnologia**, Lavras, v.32, n.3, p.894-899, 2008.

DIDONET, A.A.; FERRAZ, I.D.K. O comércio de frutos de tucumã (*Astrocaryum aculeatum* G. Mey – Arecaceae) nas feiras de Manaus (Amazonas, Brasil). **Revista Brasileira de Fruticultura**, Jaboticabal, v.36, n.2, p.353-362, 2014.

INSTITUTO ADOLFO LUTZ-IAL. **Normas analíticas do Instituto Adolfo Lutz**: métodos químicos e físicos para análises de alimentos. 3.ed. São Paulo: Instituto Adolfo Lutz, 2005. 533 p.

LEITÃO, A.C. **Caracterização morfológica e físico-química de frutos e sementes de *Astrocaryum aculeatum* Meyer (Arecaceae), de uma floresta secundária**. 2008. 104 f. Tese (Doutorado) - Instituto Nacional de Pesquisas da Amazônia, Manaus, 2008.

MACCREADY, R.M.; MCCOMB, E.A. Extraction and determination of total pectic material in fruits. **Analytical Chemistry**, Washington, v.24, n.12, p.1586-1588, 1952.

MILLER, G.L. Use of dinitrosalicylic acid reagent for determination of reducing sugar. **Analytical Chemistry**, Washington, v.31, n.3, p.426-428, 1959.

NEVES, L.T.B.C.; CAMPOS, D.C.S.; MENDES, J.K.S.; URNHANI, C.O.; ARAÚJO, K.G.M. Qualidade de frutos processados artesanalmente de açaí (*Euterpe oleracea,* MART.) e bacaba (Oenocarpus bacaba MART.). **Revista Brasileira de Fruticultura**, Jaboticabal, v.37, n.3, p.729-738, 2014.

RODRIGUES, A.M.C.; DARNET, S.; SILVA, L.H.M. Fatty Acid profiles tocopherol of buriti (*Mauritia flexuosa*), patawa (*Oenocarpus bataua*), tucumã (*Astrocaryum vulgare*), mari (*Poraqueiba paraensis*) and inajá (*Maximiliana maripa*) fruits. **Journal of the Brazilian Chemical Society**, São Paulo, v.21, n.10, p.2000-2004, 2010.

SANTOS, M.F.G; ALVES, R.E.; ROCA, M. Carotenoid composition in oils obtained from Amazonian palms fruits. **Grasas y Aceites**, Madrid, v.66, n.3, p.086-093, 2015.

SANTOS, M.F.G; ALVES, R.E.; RUíZ-MENDÉZ, M.V. Minor componentes in oils obtained from Amazonian palms fruits. **Grasas y Aceites**, Madrid, v.64, n.5, p.531-536, 2013.

SANTOS, M.F.G; BRITO, E.S; ALVES, R.E.; DOBARGANES, M.C. Major componentes in oils obtained from Amazonian palms fruits. **Grasas y Aceites**, Madrid, v.64, n.3, p.328-334, 2013.

SILVA, L.M.M.; SOUZA, F.C.; CASTRO, D.S.; NUNES, J.S.; ALMEIDA, F.A.C. Avaliação das características físicas e fiico-químicas da pupunha. **Revista Verde**, Pombal, v.8, n.3, p.5-8, 2013.

YEMN, E.W.; WILLIS, A.J. The estimation of carbohydrate in plant extracts by anthrone. **Biochemical Journal**, New York, n.57, p.508-517, 1954.

YUYAMA, L.K.O.; MAEDA, R.N.; PANTOJA, L.; AGUIAR, J.P.L.; MARINHO, H.A. Processamento e avaliação da vida de prateleira do tucumã (*Astrocaryum aculeatum Meyer)* desidratado e pulverizado**. Ciência e Tecnologia de Alimentos**, Campinas, v.28, n.2, p.408-412, 2008.