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Original Article

Evaluation of nutritional composition of flour residue of mangaba processing

Avaliação dos fatos nutricionais do processamento do resíduo da farinha de mangaba

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Abstract

Among several fruits, mangaba (*Hancornia speciosa* Gomes), it aroused the interest of producers and consumers due to its attractive sensory characteristics and health beneficial properties (high nutritional value and presence of bioactive substances), thus, this work evaluates the nutritional factors of the flour residue of mangaba processing that is despised by the food industry, and the influence of temperature on its production. The mangaba processing residue was splited in two main groups: *in natura* sample (control), and other for preparation of flour that was dried at 50 °C and divided into two other groups: treatment A (flour with roasts at 110 °C and 130 °C) and treatment B (flour from drying at 50 °C). The nutritional characteristics of flours were analyzed considering the chemical parameters: pH, titratable total acidity and soluble solids, in addition to the determination of moisture content, total lipids, total dietary fiber and ash, total energy value, antioxidant activity, phytochemical screening, quantification of phenolic compounds and flavonoids, as well as technological functional properties (water absorption index (WAI), water solubility index (WSI), milk absorption index (MAI) and milk solubility index (MSI) and oil absorption index (OAI). The results showed that the bioactive compounds present in the extracts do not have significant properties of acting as free radical kidnappers. The heat treatment, performed in the flour of mangaba processing residues, influenced the nutritional factors and properties of absorption and solubility, which showed statistical differences. These results show that the flour is a viable alternative for the energy enrichment of diets, contributing to the development of new products, the reduction of the disposal of these residues and consequently to the minimization of the environmental impact.

Keywords: *Hancornia speciosa* Gomes, food industry, centesimal composition, antioxidant.

Resumo

Dentre as diversas frutas a mangaba (*Hancornia speciosa* Gomes), despertou interesse de produtores e consumidores devido às suas características sensoriais atrativas e propriedades benéficas à saúde (elevado valor nutricional e presença de substâncias bioativas), assim, o trabalho avaliar os fatores nutricionais do resíduo da farinha de processamento de mangaba que é desprezado pela indústria alimentícia e, a influência da temperatura na sua produção. O resíduo de processamento da mangaba foi dividido em dois lotes, sendo um deles utilizado para as análises *in natura* (amostra controle) e o outro para a confecção da farinha que foi seca a 50 °C, e dividida em dois lotes: tratamento A (farinha com torras a 110 °C e 130 °C) e no tratamento B (farinha oriunda da secagem a 50 °C). Analisou-se as características nutricionais de farinhas considerando os parâmetros químicos: pH, acidez total titulável e sólidos solúveis, além da determinação do teor de umidade, lipídios totais, fibra alimentar total e cinzas, valor energético total, atividade antioxidante, triagem fitoquímica, quantificação de compostos fenólicos e flavonoides, bem como as propriedades funcionais tecnológicas (índice de absorção de água (IAA), índice de solubilidade em água (ISA), índice de absorção de leite (IAL) e índice de solubilidade em leite (ISL) e índice de absorção de óleo (IAO). Na análise foi inferido que os compostos bioativos presentes nos extratos não possuem propriedades significativas de agir como sequestradores de radicais livres. O tratamento térmico, realizado na farinha de resíduos de processamento de mangaba, influenciou nos dados dos fatores nutricionais e das propriedades de absorção e solubilidade, os quais apresentaram diferenças estatísticas. Estes resultados credenciam a farinha como uma alternativa viável para o enriquecimento energético de dietas, contribuindo para o desenvolvimento de novos produtos, a redução do descarte desses resíduos e consequentemente para a minimização do impacto ambiental.

Palavras-chave: *Hancornia speciosa* Gomes, indústria alimentícia, composição centesimal, antioxidante.

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1. Introduction

Brazil has large territorial extensions and favorable conditions for agribusiness. This fact makes this country the third largest fruit producer in the world, with a total of 41.5 million tons produced (SEBRAE, 2016). The fruits are extremely perishable, thus more than half of the production is processed aiming to increasing the useful life, besides facilitating transport, and adding value to the product (Infante et al., 2013).

Popularly known as mangaíba, mangabiba and fruta-de-doente, mangabeira is a shrub with 2 to 6 meters high and 4 to 6 meters diameter of irregular canopy (Almeida et al., 1998). It is a fruit tree belonging to the class Dicotyledoneae, order Gentianales, family Apocynaceae, genus Hancornia and the species Hancornia speciosa (Lima, 2014).

The mangabeira is native to several regions of Brazil extending to the Atlantic Coast from Amapá and Pará, in the coastal plains and coastal lowlands of the Northeast, to Espírito Santo, throughout the Cerrado of Central Brazil to the Pantanal, also occurring in neighboring countries such as Paraguay, Bolivia, Peru and Venezuela (Lederman et al., 2000). It occurs in regions of open vegetation, such as cerrados, sandy trays, chapadas and caatingas. Its natural occurrence favors the preservation and valorization of areas not usable for agriculture (Vieira-Neto, 2001).

This species is an important component of the ecosystems where it occurs, mainly from the cerrado and the northeastern coast, serving as food for local populations and fauna (monkeys and tamarins, birds and insects). Its natural pattern of aggregate distribution facilitates the extractivism, and the commercial and sustainable exploitation of fruits is practiced by local populations (Aguiar-Filho et al., 1998).

Soares et al. (2012), reports that the fruit has great aroma and flavor, being used mainly in the production of sweets, pulps, jams, ice cream and juices, and its industrial use is increasingly being disseminated, due to its great acceptance. The fruit is used to produce jam, for presenting excellent acidity, and for the manufacture of ice cream, due to its high gum content, giving them functional properties of aggregation, flavor retention and inhibition in the formation of crystals (Souza and Aquino, 2012; Sousa et al., 2011).

This food processing is used to increase nutritional quality, modify sensory quality, facilitate consumption, and prepare new kinds of foods (Ordóñez, 2005). However, with the increasing consumption of fruits and pulps, there is an increase in the amount of waste and almost 60% of the total weight of fruits are discarded in the environment without any treatment, after going through processing to obtain juices, pulps and sweets in agroindustries (Lima, 2014; 2015).

In according to the Solid Waste Plan of Alagoas, the fruit pulp industry generates above 1,000 tons of waste per year in the State (Alagoas, 2015). This study aimed to evaluate the nutritional content of mangaba processing residue and the influence of temperature on its production. The fruit waste may present loss of biomass and nutrients, as well as increase the polluting potential associated with inadequate disposal that, in addition to soil and water pollution throught leaching compounds, causes public health problems. On the other hand, the high cost associated with the treatment, transport and final disposal of the waste has a direct effect on the price of the final product (Rosa et al., 2011).

Agro-industrial waste like pulp, peel, seeds can be used in the development of new food products, increasing their value, as many of them are rich in minerals, vitamins, energy, proteins, fiber and bioactive compounds, widely recognized for their health promoting properties such as antioxidants and antimicrobials (Abud and Narain, 2010).

Among the various explored fruits, there is high potential for native fruits in the Brazilian agroindustrial sector (Hansen et al., 2013), such mangaba, widely used for almost 20 years, when compared to other native fruits in the Brazilian Northeast (Lederman et al., 2000).

The interest of producers and consumers in the mangaba is due to its attractive sensory characteristics and health-beneficial properties, such as high nutritional value and presence of bioactive substances. Nevertheless, a few works evaluated its biochemical-nutritional characteristics, as well as those related to the biometric characteristics of fruits and seeds, important for the valorization of the species and its insertion in the consumer market (Santos et al., 2017; Lima, 2015).

2. Material and Methods

2.1. Processing of raw material

Mangaba bagasse, seed and peel was obtained in february/2017 from a fruit pulp processing industry located in Maceió, Alagoas, immediately collected from the pulping process. The samples were packed in plastic bags and taken to the laboratory and kept at -18 °C until the production of different flours (Abreu, 2015).

The mangaba processing residue was splited into two groups, the first one (*in natura*) was used as control sample and the second for flour preparation. The second group was dried in a drying oven with air circulation at 50 °C and crushed in a knife mill with mesh screen 20 (1.7 mm). After, this second group was passed through two treatments (A and B). In treatment A, the fruit residue was roasted at 110 and 130 °C and in treatment B the fruit residue was drying at 50 °C (Table 1). The roasts were made in a drying oven (New Stylus - Layr). All samples were packed in a paper bags, repacked in plastic packaging, and stored at 7 °C, until the moment of the analyses (Abreu, 2015).

The technological functional analyses were performed in the following treatments:

2.2. Physical-chemical analysis

The analyses were performed in triplicate, according to the methodology described by the Adolfo Lutz Institute (IAL, 2008). The samples (T0 to T7) were characterized physical-chemically in terms of moisture, ash, total lipids, total dietary fiber, proteins, carbohydrates, total energy value, in addition to pH, titratable acidity and soluble solids.

Table 1. Different treatment times in functional analyses of flour residue of mangaba.

Control: in natura seed
T1 – Treatment 1: dry at 60 °C.
T2 – Treatment 2: roast in eletric oven at 110 °C for 10 minutes.
T3 – Treatment 3: roast in eletric oven at 110 °C for 20 minutes.
T4 – Treatment 4: roast in eletric oven at 110 °C for 30 minutes.
T5 – Treatment 5: roast in eletric oven at 130 °C for 10 minutes.
T6 – Treatment 6: roast in eletric oven at 130 °C for 20 minutes.
T7 – Treatment 7: roast in eletric oven at 130 °C for 30 minutes.

2.3. Antioxidant activity

The evaluation of antioxidant activity, cold extracts of mangaba residue *in natura* and flour were obtained. The macerated method consists of a cold extraction of mangaba residue with solvent to avoid thermal degradation and was performed in according by Mezzomo et al. (2011). In 250 mL erlenmeyer flasks, 44 g of raw material were immersed in 160 mL of solvent at 25 °C for 3 non-consecutive days. After, a simple filtration with cellulose paper was performed, and the solvent was recovered by rotoevaporation. Ethanol, hexane, chloroform and methanol were used in an increasing polarity gradient.

2.4. DPPH method

The samples were diluted at 25, 50, 75 and 100 µg/mL. For each concentration, the test was performed in triplicate. In 3 mL of each sample, 0.1 mL of free radical DPPH (2,2-diphenyl-1-picrilhydrazil) ethanolic solution was added and incubated for 30 minutes at 25 °C in the dark. The absorbances of the different samples was obtained at 517nm. The control absorbance was obtained using an aliquot of 0.1 mL of etanolic solution of DPPH added to 3 mL of ethanol (Silva et al., 2012). To evaluate the free radical capturing activity, the inhibition percentage was calculated using de follow Equation 1.

$$\%\ \text{inhibition} = \left(\frac{\text{Abs}_{\text{control}} - \text{Abs}_{\text{sample}}}{\text{Abs}_{\text{control}}} \right) \times 100 \quad (1)$$

The antioxidant potential was determined by the DPPH method, according to Brand-Williams et al. (1995), with modifications according to Borguini et al. (2013). Extracts in ethanol, methanol, hexane and chloroform solutions were determined spectrophotometrically and the results were expressed as % discoloration using the equation 2 where Abs sample is the absorbance of the sample; Abs blank is the absorbance of blank; Abs control is the absorbance of the control (75µL of methanol + 1.5mL of DPPH). The method consists of the ability of DPPH to be reduced by antioxidant agents, losing its violet color.

2.5. Determination of effective concentration

The EC_{50} is a concentration of a drug that produces a biological response. Absorbance values (AAO%) and the concentrations (250, 150, 50, 10 and 5 µg/mL) were related using Excel®, and for each sample, the line equation was constructed. Replacing the Y value for 50 will result in EC_{50} value, which is the concentration required to produce 50% of estimated maximum effect of 100% for plant extract.

2.6. Phytochemical screening

Phytochemical screening uses several specific reactions that qualitatively indicate the presence of certain metabolites, either by color change, precipitation, gas formation or fluorescence. When chemical studies of the analyzed species are not avaiable, preliminary phytochemical analysis may indicate the relevant secondary metabolites (Veloso, 2015).

Phytochemical tests were carried out according to the methodology proposed by Matos (1998) with some adaptations, to prospect the following alleloquimics: phenols, pyrogallic tannins, flobafenic tannins, anthocyanins and anthocyanidines, flavones, flavonols, xanthones, chalconas, auronas, flavononols, leukoanthocyanidins, catechins, flavonones, xanthones, steroids, triterpenoids and saponins.

2.7. Quantification of phenolic compounds

The obtained ethanol extract was used to determine the total phenolic contents, according to Sousa et al. (2011), by spectrophotometric method using the Folin-Ciocalteau reagent (Merck) and by calibration curve constructed with gallic acid patterns (10 to 350 µg/mL) and expressed as mg of Gallic Acid Equivalents (GAE) per g of extract.

The phenolic content in ethanol extracts were determined in spectrophotometer (Biospectro SP-220), at 700 nm, using the Folin-Ciocalteau reagent, according to Zieliński and Kozłowska (2000). The results were expressed in mg of Gallic Acid Equivalents (GAE) per 100 g of sample. The Folin-Ciocalteu reagent has tungstate, molybdate and phosphoric acid of yellow color in its oxidized form and is reduced by phenolic compounds, assuming the blue color (740 nm).

2.8. Quantification of flavonoids

From a methanolic solution of the extract, the flavonoid content was quantified. In glass tubes, 200 µL of the ethanol solution (1.0 mg/mL) and 100 µL of the 2% aluminum chloride ($AlCl_3$) solution was added. The tube was kept in the dark for 30 minutes, then spectrophotometer reading was performed. A quercetin calibration curve was constructed with test solutions at concentrations ranging from 0.00125 mg/mL to 0.03 mg/mL. From the line equation and the mean absorbance of the sample, the flavonoid content was expressed in mg equivalent of quercetin/g of dry extract. In the test, Al^{3+} is linked to present flavonoids in the sample, inducing the formation of the stable flavonoid-Al^{3+} complex that has yello color (425 nm).

2.9. Technological functional analyses

The Water Absorption Index (WAI), Water Solubility Index (WSI), Milk Absorption Index (MAI), Milk Solubility Index (MSI) and Oil Absorption Index (OAI) were determinate in according to Santana (2005). All analyses were performed in triplicate.

2.10. Statistical analysis

To determine the biological potential, quantification of phenolic compounds and flavonoids, the line equation was constructed with identification of the linear determination coefficient. The obtained data with different times at the temperatures of 110 °C and 130 °C of roasting were submitted to variance analysis and compared by the Scott-Knott cluster test. All analyses were performed using the GENES software.

3. Results e Discussion

3.1. Flours nutritional characteristics

The results of the chemical characterization of mangaba residue flour at different treatments, are presented in Table 2.

Comparing the results of the parameters of the T0 sample with the mangaba residue flour, submitted to different treatments (T1 to T7), there was a increase of concentration in the values of ash, lipids, fibers, proteins, carbohydrates, pH, total titratable acidity, soluble solids and total energy value due to water loss during the drying process.

Table 2 show that the moisture and lipid contents of mangaba residue flour in samples T1 to T7 did not differ statistically by the Scott-Knott test at 5% probability.

In the ash contents, it is observed that T2, T3, T6 and T7 did not differ statistically by the Scott-Knott test at 5% probability, an analogous case occurred with T1 and T5.

The fibers content in mangaba processing residue flour show that the T2, T5, T6 and T7 samples did not differ statistically by the Scott-Knott test at 5% probability. The same occurring with the T3 and T4 samples. For Proteins and Carbohydrates T3, T4 and T7 did not differ statistically by the Scott-Knott test at 5% probability, an analogous case occurred with T2 and T6. Finally, in the Energy Value T2, T5, T6 and T7 did not differ statistically by the Scott-Knott test at 5% probability, the same occurring coma the Samples T3 and T4.

3.2. pH, titratable acidity and soluble solids

The pH values (Table 2) found in mangaba processing residue flour (T1 to T7) ranged from 4.32 to 4.56, with the mean value 4.41. Abud and Narain (2010) obtained with guava the pH of 4.88, higher than the samples T1 to T7, acerola (3.87) and umbu (3.12). Silva et al. (2012) obtained pH of 4.03 for dry mangaba residue flour at 40 °C and sterilized at 121 °C, and Abud and Narain (2010) reported at 55 °C, 4.21 for passion fruit, and therefore obtained similar values to samples T1 to T7.

Regarding the total titratable acidity observed in the mangaba processing residue flour, they ranged from 0.04% to 0.07%, with the mean value 0.06%. However, other authors found values of total titratable closer to samples T1 to T7 (Table 2). Abreu (2015) using the same drying and roasting process of this research for mangaba seed flours, obtained an average value of 0.10%; Abud and Narain (2010) reported the following values for dehydrated fruit residues at 55 °C: guava (0.08%), acerola (0.14%), umbu (0.27%) and passion fruit (0.15%). Silva (2017) in the physicochemical characterization of dry waste flours at 60 °C and 70 °C found values of 0.94% and 0.91% for umbu cajá and 0.65% and 0.71% for acerola.

The acidity content determines the quality of the flour. The higher the acidity, the lower its quality and, when it

Table 2. Mean values of the nutritional composition of different samples of mangaba processing residue.

Sample	pH	Titratable acidity (% citric acid)	Soluble Solids (°BRIX)	Lipids (%)	Fibers (%)	Proteins (%)	Carbohydrates (%)	Moisture (%)	Ashes (%)	Energetic content (kcal/100g)
T0	3.71	0.04	1.70	6.3959B	10.2173C	6.5700D	13.4497E	62.5254A	0.8417D	137.64D
T1	4.56	0.04	1.90	22.0256A	7.1846C	12.1450A	50.5809A	5.9108B	2.1531A	449.13A
T2	4.44	0.05	1.90	21.3371A	25.5906A	10.4050C	30.8864C	9.9185B	1.8624C	357.20C
T3	4.43	0.06	1.90	23.0531A	16.0375B	11.2600B	38.3483B	9.4295B	1.8716C	405.91B
T4	4.41	0.06	1.90	23.7158A	17.7959B	11.2600B	37.2184B	8.0105B	1.9995B	407.35B
T5	4.35	0.06	1.90	22.5090A	29.0018A	12.2000A	25.0775D	9.1003B	2.1114A	351.69C
T6	4.36	0.07	1.90	21.9656A	24.4151A	10.3200C	33.6255C	7.7787B	1.8951C	373.47C
T7	4.32	0.06	1.80	20.6841A	20.5969A	11.2850B	38.5512B	7.0412B	1.8418C	385.50C

Means with the same letter in the column do not differ to 5% probability by the Scott-Knott test.

is used as a raw material, it will directly interfere with the final product.

All samples showed a low pH values, that provides greater stability, hindering the development of microorganisms, because fungi generally prefer acid pH (4.5-5.0) and bacteria prefer pH close to neutrality (Abud and Narain, 2010)

Soluble solids indicate the content of sugars and organic acids of a sample, considered as an important parameter in the quality of a product. High values of soluble solids suggest lower addition of sugar to a product, higher yield, lower energy expenditure for processing, consequently in greater savings (Abreu, 2015; Silva et al., 2012).

The soluble solids contents of mangaba processing residue flour ranged from 1.80 °BRIX to 1.90 °BRIX (Samples T1 to T7) and the average value 1.89 °BRIX. Silva et al. (2012) obtained the value of 1.08 °BRIX for dry mangaba residue flour at 40 °C and sterilized at 121 °C, and Abreu (2015) using the same drying and roasting process of this research for mangaba seed flours, obtained an average value of 1.67 °BRIX, which were similar to the samples T1 to T7 in this analysis.

3.3. Moisture

The moisture contents (Table 2) found in mangaba processing residue flour (T1 to T7) ranged from 5.91% to 9.92%, lower than the 15% established by the legislation in force (Brasil, 2005b) for flours, cereal starch and bran. According to Sabino et al. (2017), lower moisture content higher the resistance to microbial attacks and reduction of enzymatic reactions. The T0 sample (in natura) presented 62.52% humidity, therefore above the limits defined in the legislation.

Souza and Aquino (2012) reported 6.00% of moisture in mangaba seed flour, Silva et al. (2012) of 6.03% for dry mangaba residue flour at 40 °C and sterilized at 121 °C, and Abreu (2015) using the same drying and roasting process of this research, obtained 2.74% of moisture for the flours of mangaba seeds.

However, similar values and in agreement with brazilian legislation (Brasil, 2005b) were found by Abud and Narain (2010) at 55 °C: guava (8.65%), acerola (7.02%), umbu (8.88%) and passion fruit (8.85%). Silva (2017) in the physicochemical characterization of dry waste flours at 60 °C and 70 °C, found 9.46% and 9.72% for umbu cajá and 8.95% and 9.04% for acerola. Maia (2016) found 9.30% for dehydrated mangaba.

The maintenance of the water content up to this limit is important because flours with water content above 15% tend to form lumps, impairing the production process (Bertagnolli et al., 2014). In addition, excess water content may increase the possibility of developing microorganisms, such as fungi and bacteria (Chaves et al., 2004).

3.4. Ashes

Regarding the ash contents (Table 2), in mangaba processing residue flour, the samples (T1 to T7) ranged from 1.84% to 2.15%, indicating a higher percentage of inorganic residue compared to that found by Silva et al. (2012), 0.98% (dry mangaba residue flour at 40 °C and sterilized at 121 °C).

The mean value found by Abreu (2015) in the determination of ashes (2.75%) for mangaba seed flours, as well as the results obtained by Abud and Narain (2010) for dehydrated fruits: umbu (12.50%) and passion fruit (4.41%); and Silva (2017) for dry waste flours of umbu cajá at 60 °C (4.83%) and at 70 °C (5.10%), were higher than samples T1 to T7 (Table 2).

Brazilian laws establish a maximum limit of 2.5% for ash content in wheat flour (Brasil, 2005a), as well as the Brazilian table of food composition (UNICAMP, 2011) show values between 0.2 and 1.7% attributed to various types of flours (rice, wheat, bread, corn and rye). Thus the mean value found in this study (1.96%) is consistent with the legislation (Brasil, 2005a) and has a higher ash content when compared to conventional wheat flour type 1 (59.18%) and type 2 (28.57%), and lower than the integral (21.60%).

Ashes indicate the amount of fixed mineral residue present in the food, emphasizing that it does not always represent the total amount of oxides, since some may undergo volatilization during incineration. The presence of these minerals can positively influence the nutritional potential. Forthe production of bakery products, flours with high ash content have low technological quality, generating products with reduced volume (Silva et al., 2012).

3.5. Lipids

Table 2 shows that lipid contents (ranging from 20.68% to 23.72%), found in mangaba processing residue flour (T1 to T7) do not differ statistically by the Scott-Knott test at 5% probability. These results indicate that the heat treatment did not interfere in the lipids content.

The samples (T1 to T7) presented a mean percentage of lipids of 22.18%. Similar results were found by Souza and Aquino (2012), 23.00% (mangaba seed flour) and Silva et al. (2012) of 8.1% (drymangaba residue flour at 40 °C and sterilized at 121 °C).

Abreu (2015) using the same drying and roasting process of this research, obtained for mangaba seed flours, the average value of 29.90% for lipids reaching a higher result than the samples T1 to T7.

However, Abud and Narain (2010) reported a lower lipid content of dehydrated fruit residues at 55 °C: guava (16.25%), acerola (5.23%) umbu (10.75%) and passion fruit (19.05%). Silva (2017) in the physicochemical characterization of dry waste flours at 60 °C and 70 °C who found 2.71% and 2.76% for umbu cajá and 0.87% and 1.07% for acerola. Maia (2016), studying dehydrated mangaba found 11.00%.

The mean values (22.18g) for the samples is equivalent to 40.34% of the daily nutrient reference values (NRVs) of a 2000 kcal diet (Brasil, 2003), and lower than the values of rice flours, wheat, bread, corn and rye (between 0.3 and 1.8g), quoted in the brazilian table of food composition (UNICAMP, 2011).

ANVISA RDC no. 54 (Brasil, 2012) provides that a product to be considered low lipid content must contain a maximum amount of 3 g of fat in each portion. The sample analyzed does not fit this classification, because it contains 11.09 g per section of flour (50 g).

3.6. Fibers

It was observed in mangaba processing residue flour (samples T1 to T7) a ranging from 7.18% to 29.00%, and the mean value 20.09%.

Silva et al. (2012) verified the content of 31.73% of fibers for dry mangaba residue flour at 40 °C and sterilized at 121 °C, and Abud and Narain (2010) reported the following values for dehydrated fruit residues at 55 °C: guava 42.68% fiber, acerola 14.26%, umbu 13.52% and passion fruit 47.00%.

Comparing the samples with the values in the brazilian table of food composition (UNICAMP, 2011), which presents values between 0.6 and 15.5% of fibers in 100g, attributed to various types of flours (rice, wheat, bread, corn and rye), the mean value found in this study presents higher fiber content than all the flours mentioned in the Taco table. The mean values obtained from the samples (20.09%) equivalent to 80.36% of the daily nutrient reference values (NRVs) of a diet of 25g of dietary fiber (Brasil, 2003).

3.7. Proteins

The obtained values for protein content ranged from 10.32% to 12.20% from T1 to T7, thus higher than the values found by Silva et al. (2012) of 9.95% (dry mangaba residue flour at 40 °C and sterilized at 121 °C); Souza and Aquino (2012), 10.25% (mangaba seed flour); and Abud and Narain (2010), guava (0.58%), acerola (0.52%), umbu (0.43%) and passion fruit (0.41%). Similar to Maia (2016) 11% (dehydrated mangaba). Abreu (2015) using the same drying and roasting process of this research for mangaba seed flours, found 12.53% (mean) of protein.

Brazilian legislation establishes a minimum limit of 8.0% for protein content in wheat flour (Brasil, 2005a), however, the Brazilian table of food composition (UNICAMP, 2011) exposes values between 1.3 and 12.5%, in a composition of 100g, attributed to various types of flours. Thus, the mean value found in this study (11.27%) is consistent with the legislation (BRASIL, 2005a) and has a higher protein content when compared to conventional wheat flour type 1 (33.45%), type 2 (29.01%) and integral (29.01%).

3.8. Carbohydrates

Regarding the amount of carbohydrates (Table 2), in mangaba processing residue flour, the samples (T1 to T7) ranged from 25.08% to 50.58%, with the average value of 36.33% higher than Abud and Narain (2010) for dehydrated guava (29.52%), passion fruit (20.31%) and Maia (2016), 29.00% (dehydrated mangaba), and lower than the mean value found by Abreu (2015) in the determination of carbohydrates (52.09%) for mangaba seed flours, as well as Souza and Aquino (2012) results of 58.66% (mangaba seed flour).

3.9. Antioxidant activity

The extracts in ethanol, hexane, chloroform and methanol obtained for each concentration (μg/mL) and their respective absorbance (AA0%) are shown in Table 3.

Better results were obtained respectively for concentrations of 500 μg/mL, 600 μg/mL, 600 μg/mL and 700 μg/mL (Table 3). Based on these results, the extracts were inefficient against free radicals, even at the highest concentrations, although studies with mangaba seed flour, submitted to drying temperature of 60 °C (Abreu, 2015) indicate such activity (326.49 μg/mL in ethereal extract).

One reason for this result would be the processing that can remove antioxidants. Andreo and Jorge (2006) conclude that several factors can interfere in the extraction, being, the polarity of the solvent used, the time and the extraction temperature, since loss or destruction of antioxidant compounds may occur. Rufino et al. (2010) apud Abreu (2015), in characterization of bioactive compounds and antioxidant capacity of brazilian fruits, found high antioxidant capacity in the fruit of mangaba, CE_{50} of 3385 g/g DPPH.

3.10 Energetic content

Regarding the energy value of mangaba processing residue flour, Table 4 shows that the values from T1 to T7 ranged from 351.69 kcal/100g to 449.13 kcal/100g.

In the studies conducted by Abreu (2015) using the same drying and roasting process of this research for mangaba seed flours, the energy value of 527.59 kcal/100g (average) was obtained, resulting in a value higher than those of samples T1 to T7. Abud and Narain (2010) reported the following energy values for dehydrated fruit residues at 55 °C: guava (266.65 kcal/100g), acerola (332.53 kcal umbu (314.17 kcal/100g) and passion fruit (254.36 kcal/100g), which are lower than the values obtained for samples T1 to T7 (Table 2).

The mean values obtained for the samples (390.04 kcal/100g) is equivalent to 19.50% of the daily nutrient reference values (NRVs) of a 2000 kcal diet (Brasil,

Table 3. Antioxidant activity of mangaba residue flour subjected to drying at 50 °C.

Extract	Concentration (μg/mL)							DC*
Solvent	750	700	650	600	550	500	250	R^2
Ethanol	4.9911	0.0594	3.2086	4.0404	1.7231	6.8330	2.1985	0.0002
Hexane	1.2817	2.0725	2.0725	5.3995	0.0000	0.0000	2.3998	0.4876
Cloroform	4.1475	7.1685	6.4772	7.4757	6.7076	5.3507	5.4531	0.0082
Methanol	1.1469	2.6968	0.0000	1.8599	0.0000	0.0000	0.0000	0.8617

*Determination coeficient.

2003), being higher than the values of rice flours, wheat, bread, corn and rye (336 kcal/100g to 371 kcal/100g) mentioned in the brazilian table of food composition (UNICAMP, 2011). This demonstrates that flours are a viable alternative for the energy enrichment of diets (Sabino et al., 2017).

3.11. Phytochemical screening

The phytochemical tests performed on the extract revealed the absence of secondary metabolism constituents for mangaba residue flour submitted to drying at 50 °C.

3.12. Quantification of phenolic compounds

It was observed that the curve of the galic acid presented the coefficient of determination (R^2) 0.9865 which shows that the line equation represents 98% of the behavior of the galic acid regarding to absorbance. This data allows us to use this line equation to determine the percentage of phenolic compounds present in the sample.

By interpolating the line equation, it was possible to quantify the phenolic compounds in the mangaba residue, which presented 123.71±16.95 mg equivalent of galic acid per gram of residue. It was observed that the mangaba residue presented a higher phenolic compound content than that reported in Perfeito et al. (2015) referring to the pulp of this fruit (115.84 mg of c. alic/100g fresh fruit), but lower in mangaba seed flour, subjected to drying temperature of 60 °C (Abreu, 2015), 540.14 (mg EAG/100) in ethanolic extract.

Factors such as position and hydroxylation degree, polarity, solubility, reduction potential, phenolic stability to processing and radical stability can influence the activity of phenolic compounds (Abreu, 2015).

3.13. Quantification of flavonoids

It was observed that the quercetin curve presented the coefficient of determination (R^2) 0.9909 which shows that the equation of the line produced represents 99% of the quercetin behavior regarding to absorbance. This data allows us to use this equation of the line to determine the percentage of flavonoids present in the sample. By interpolating the line equation, it was possible to quantify the flavonoid compounds in the mangaba residue that presented 0.31±0.19 mg equivalent of quercetin per gram of residue.

Almeida et al. (2011) and Rufino et al. (2010), studying fruits native to the Brazilian cerrado, report that in addition to the high concentration of vitamin C (190 mg/100 g), mangaba also has considerable amounts of phenolic compounds (169 mg/100 g) that have antioxidant activity. Compounds such as vitamin C, carotenoids, flavonoids (anthocyanins) promotes a high quality to fruits and have important functions for human health, mainly because they act as antioxidants, capable of helping to reduce the risk of diseases such as cancer and cardiovascular diseases (Lima, 2016)

3.14. Technological functional analyses

The values found for the functional properties studied for mangaba processing waste flour are presented in Table 4.

The treatment performed in the samples to obtain the mangaba residue flour influenced the data of the absorption and solubility properties, which presented statistical differences (Table 4). Regarding the water solubility index (WSI), the Treatments T2, T4 and T6 when compared to the T0 sample, did not change its properties. The same occurred for samples T1, T4, T5 and T6 in milk solubility index (MSI).

It can be observed that the heat treatment affected the absorption properties of T1 to T7 samples to absorb water, milk and oil.

Regarding the water solubility index (WSI) T2, T4 and T6 when compared to the T0 sample (in natura) did not change its properties. The same occurred for samples T1, T4, T5 and T6 in relation to the solubility index in milk (MSI).

Regarding WAI, MAI and OAI, the T1 sample provided better results (3.30, 3.74 and 2.22 g of hydrated sample/g of the dry sample, respectively). Abreu (2015) reported the WAI, MAI and OAI statistically stable in all samples of mangaba seed flours, with values 3.01, 3.21 and 0.92 g of hydrated sample/g of the dry sample.

Heat treatment according to Khattab and Arntfield (2009), in samples (canola seeds, flaxseed and soybean) analyzed after roasting, at 180 °C for 15 minutes increased

Table 4. Average values of the water absorption index (WAI), milk (MAI), oil (OAI) of mangaba processing residue samples and mean values of water solubility index (WSI) and milk (MSI) of different samples of mangaba processing residue.

Sample	WAI*	MAI*	OAI*	WSI (%)	MSI (%)
T0	1.6747C	1.8845D	1.6796B	6.13B	92.83B
T1	3.3012A	3.7480A	2.2245A	13.27A	93.66B
T2	3.3278A	2.6460C	2.1385A	9.96B	126.71A
T3	2.9110B	2.7934C	2.1519A	12.37A	119.17A
T4	2.8938B	3.1014B	2.1088A	9.24B	102.17B
T5	2.6698B	2.8734B	2.1088A	12.09A	98.07B
T6	2.6661B	2.7252C	2.0605A	8.42B	86.86B
T7	2.6718B	2.9384B	2.0079A	10.75A	158.32A

Means with the same letter in the column do not differ to 5% probability by the Scott-Knott test. *g of wet sample/g dry sample).

the OAI. The levels found were higher in flaxseed (218.1 g/100 g), canola (231.85 g/100 g) and soybean (240.45 g/100 g).

Regarding the WSI, the samples T1, T3, T5 and T7 do not differ statistically, with the highest value found in T1 with 13.27%. Lower WSI result was found in a study with cagaita seed flour, 7.82%, however, in mangaba seed flour, a superior result was obtained, 15.90% (Abreu, 2015).

Finally, the MSI, the T2, T3 and T7 samples do not differ statistically. Highest values were found in T7 with 158.33%. However, when we deal with the ISL found in a study with cagaita seed flours and mangaba seed flours, 128.76% and 143.31%, respectively, the result is lower, and the ISL is similar when it is obtained from mama-cadela flour samples, 156.49% (Abreu, 2015).

4. Conclusions

The determination of lipids in fruit flour aiming at its use as an ingredient in formulations becomes important, because lipids play an important role in the quality of food, contributing with attributes such as texture, flavor and energy value.

The low moisture, and acid pH values provides greater stability, thus hindering the development of microorganisms, because fungi generally prefer acid pH and pH bacteria close to neutrality. The mangaba residue flour, a raw material with pH closer to neutral was obtained, which positively influences the quality of the final product, because the acidity content determines the quality of the flour.

In the analysis it was inferred that the bioactive compounds present in the extracts do not have significant properties against free radicals.

The heat treatment performed in mangaba processing waste flour influenced the data of nutritional factors and absorption and solubility properties, which showed statistical differences.

The mean energy value of mangaba processing residue flour was 390.04 kcal/100g and is 19.50% of the daily nutrient reference values (NRVs) of a diet of 2000 kcal, being higher than the values of rice flours, wheat, bread, corn and rye (336 kcal/100g to 371 kcal/100g) cited in the brazilian table of food composition. Anothers constituints are in accord to NRVs: Carbohydrates 36.33g (12.11% NRV); Proteins 11.27g (15.02% NRV); Lipids 22.18g (40.34% NRV) and dietary fiber 20.09g (80.36% NRV).

In addition to presenting moisture (8.02%) and ashes (1.95%) within the limits of brazilian legislation, these results show that the flour as a viable alternative for the energy enrichment of diets, contributing to the development of new products, the reduction of the disposal of these residues and consequently to the minimization of the environmental impact.

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