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Caracterização físico-química, compostos bioativos e atividade antioxidante de amêndoas de *Pachira aquatica* Aublet

Physical chemical characterization, bioactive compounds and antioxidant activity of *Pachira aquatica* Aublet almonds

Caracterización fisicoquímica, compuestos bioactivos y actividad antioxidante de almendras de *Pachira aquatica* Aublet

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Resumo

A *Pachira aquatica* Aublet pertencente à família Malvaceae é arvore de tamanho variável, produz anualmente grandes quantidades de frutos do tipo cápsulas, nos quais suas sementes permanecem guardadas. Mesmo sendo encontrado comumente no sul do México e no Brasil, são poucos os estudos sobre sua composição. Portanto, o objetivo deste estudo é demonstrar as características dessa fruta por meio de análises físicas e avaliar os compostos bioativos das amêndoas nas formas crua, cozida e torrada. Tipo da pesquisa laboratorial e quantitativa. As amêndoas apresentaram alto teor de lipídios (acima de 30%), proteínas (acima de 15%), pH (acima de 5,66), sólidos solúveis totais (acima de 15º Brix) e acidez total titulável (acima de 3%). A amêndoa torrada apresentou maior teor de compostos fenólicos, flavonóides e carotenóides. Na forma crua, obteve-se maior teor de atividade antioxidante, antocianinas e taninos condensados. A amêndoa cozida apresentou valores intermediários em todos os dados de compostos bioativos e atividade antioxidante.

Palavras-chave: Munguba; Composição; Processamento térmico.

Abstract

The *Pachira aquatica* Aublet, belonging to the Malvaceae family, is a tree of variable size, annually produces large quantities of capsule type fruits, in which its seeds remain stored. Even though it is commonly found in southern Mexico and Brazil, there are few studies on its composition. Therefore, the objective of this study is to demonstrate the characteristics of this fruit by means of physical analyzes and to evaluate the bioactive compounds of the almonds in the raw, cooked and roasted forms. Type of research laboratory and quantitative. The almonds showed high content of lipids (above 30%), proteins (above 15%), pH (above 5.66), total soluble solids (above 15º Brix) and total titratable acidity (above 3%). The roasted almond had a higher content of phenolic compounds, flavonoids and carotenoids. In the raw form, a higher content of antioxidant activity, anthocyanins and condensed tannins was obtained. The cooked almond presented intermediate values in all data on bioactive compounds and antioxidant activity.

Keywords: Munguba; Composition; Processing thermal.

Resumen

La *Pachira aquatica* Aublet, perteneciente a la familia Malvaceae, es un árbol de tamaño variable, produce anualmente grandes cantidades de frutos tipo cápsula, en los que sus semillas permanecen almacenadas. Aunque se encuentra comúnmente en el sur de México y Brasil, hay pocos estudios sobre su composición. Por lo tanto, el objetivo de este estudio es demostrar las características de esta fruta mediante análisis físicos y evaluar los compuestos bioactivos de las almendras en forma crudo, cocida y tostada. Tipo de laboratorio e investigación cuantitativa. Las semillas tenían un alto contenido de lípidos (superior al 30%), proteínas (superior al 15%), pH (superior a 5,66), sólidos solubles totales (superior a 15º Brix) y acidez titulable total (superior al 3%). La almendra tostada tenía un mayor contenido de compuestos fenólicos, flavonoides y carotenoides. En la forma cruda, se obtuvo un mayor contenido de actividad antioxidante, antocianinas y taninos condensados. La almendra cocida presentó valores intermedios en todos los datos sobre compuestos bioactivos y actividad antioxidante.

Palabras clave: Munguba; Composición; Procesamiento térmico.

1. Introduçtion

Among the various fruits that arouse the interest of the scientific community for the identification of nutritional compounds, we can mention the *Pachira aquatica* Aublet, also known as munguba, Maranhão's chestnut tree, chestnut tree or wild cocoa. This specie belongs to the Malvaceae family. It was introduced in urban afforestation in the second half of the 19th century by the French botanist and landscape Glaziou, and is found commonly in southern Mexico and northern Brazil, in the Amazon region (Polizelli et al., 2008).

Munguba's fruits present a light brown colour are classified as dehiscent capsules and considered as an oleaginous species. These fruits stand out for presenting a rich composition in nutrients, resembling the sunflower and soybean, for having a high concentration of oil and proteins (Lima, 2014).

Vegetables, in addition to containing essential nutrients and micronutrients, contribute to the compounds present in leaves, fruits, films, and seeds that, from their chemical structure, promote a varied action in the body, and the profile of compounds may depend on the type, variety and degree of maturation of the plant, as well as climatic conditions, soil management and cultivation (Lemos, 2012)

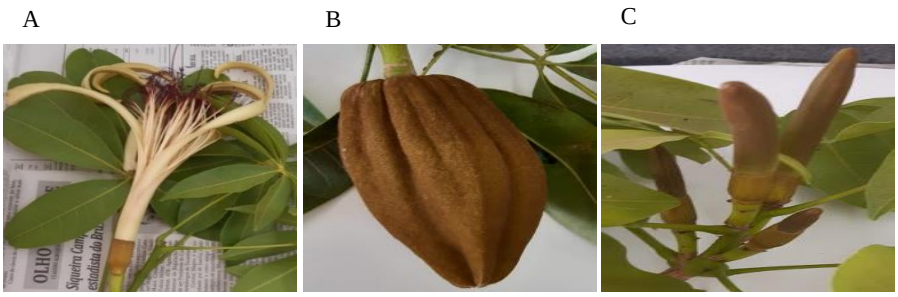
Among munguba main bioactive compounds, are anthocyanins and phenolic compounds, the processes using high temperatures and lower exposure time on heat have been more efficient and recommended to reduce the degradation of these pigments. Furthermore, thermal processing through the heat can change the vegetable matrix, with changes in chemical composition, causing changes in a way positive or negative (Lemos, 2012).

Studies has shown the characterization of *Pachira aquatica* Aublet seed by evaluating the profile of amino acids and fatty acids (Rodrigues et al., 2019; Barbosa, 2016; Souza et al., 2014). However, in the literature are few studies of other compounds, and these analyses can contribute to a better range of information in respect of munguba fruit. Therefore, that research has aimed to perform the characterization physicochemical and determined the bioactive compounds and the antioxidant activity of manguba's almonds on the forms in raw, cooked and toasted.

2. Materials and Methods

The present research used the quantitative method with descriptive purposes to determine the compounds present in the almonds of *Pachira aquatica* Aublet. The experiments were carried out in the laboratory (Pereira, et al 2018). The munguba fruits were collected for analysis in Palmas city, Tocantins, Brazil, in the month of May 2019, at coordinate 10º20'58.83"S. The exsiccates were deposited in the Herbarium of the Foundation University of Tocantins - UNITINS (Campus of Palmas/TO) for taxonomic confirmation, in which they were identified and registered in the herbarium collection of the mentioned institute, with the registration number 7186 (Figure 1).

Figure 1 - Registration in herbarium. Flowers (A), Fruit (B), and (C) Leaves with branches and buds.



Source: the authors.

Figure 1 shows the parts of the munguba plant, such as its large flower with about 5 reddish-brown petals (A), its capsule-type fruits (B) and its leaves with branches and buds (C)

The fruits were transported in plastic boxes to the Food Technology Laboratory, where the opening of fruits to release the almonds occurred spontaneously. The fruits were sanitized with a sodium hypochlorite solution at a concentration of 100 ppm and the almonds obtained were also sanitized with a 50-ppm solution of sodium hypochlorite and then processed to obtain the raw samples (Figure 2).

Figure 2 - Fruit with exposed almonds (A), almonds in the ideal ripening stage (B) and closed fruit (C).

Source: the authors.

Figure 2 shows the fruit of the munguba with a broken shell, showing the exposed almonds (A), the almonds in the ideal ripening stage (B) and their capsule type fruit still closed (C). Sixty fruits were harvested and the samples were separated in three repetitions that were treated to obtain the raw, cooked and toasted almonds. For the preparation of sample in raw form, the peel was removed manually with the aid of a knife and crushed in a food processor.

To obtain the cooked samples, they were heated directly in boiling water in two 10-minute sessions with a water change. After the process, the peeled samples were dried in an oven at 45 ° C for 4 hours and then ground. For the roasted sample, the raw materials were submitted to the oven at a temperature of 150 ° C for 20 minutes (Lemos, 2012). After this stage, peeling and crushing followed. The samples obtained were placed in glass bottles with lids, stored at room temperature, in a ventilated place, away from light

The physical characterization of the fruits and almonds was performed by determining the weight, longitudinal length and diameter with the use a universal pachymeter. Five fruits were used, totaling 100 almonds, and the average of number of almonds per fruit was obtained by counting. For the length evaluation, we considered the measurement between the apex and the base of the fruit and almond, the diameter, the largest measure perpendicular to the longitudinal direction, according to the methodology proposed by Santos et al. (2004).

The physical characterization of *Pachira aquatica* Aublet fruits and almonds is important to understand if these are influenced by edaphoclimatic conditions, crops, harvest time, genetic makeup, stage maturation and post-harvest treatment, when compared to other studies found in the literature.

Physicochemical analysis

The physicochemical analysis of almonds was performed according to the methodologies proposed by the *Association of Official Analytical Chemists* (Aoac, 2000). The pH was determined by the weighing 10g of the sample, solubilised with 40 ml of distilled water, and the reading performed in digital potentiometer. The titratable total acidity (TTA) expressed in % citric acid was determined by titration utilizing sodium hydroxide 0,1mol. The total soluble solids (TSS) were determined with the aid of a digital refractometer, whose results were expressed in °Brix at 25°C.

The total soluble sugars were determined by the Antrone method (Dische, 1972) and reducing sugars determined by the dinitro salicylic acid (DNS) method according to Vasconcelos et al. (2013). The color of the samples was determined with the use a digital colorimeter (Minolta CR4000-CIELAB) and the results were expressed by the color parameters L*, a*, b*, angle Hue (H*) and Chroma (C*).

In the centesimal composition, the humidity of the samples was determined in a drying oven 105°C until constant weight (Aoac, 2000). The determination of lipids was performed in the dry sample using the hexane solvent in the Soxhlet apparatus, subsequent having the extraction of oils and greases at 105°C for 4 hours (Aoac, 1995).

The protein determination was performed by the Kjeldahl method, using the dry and degreased sample with catalytic mixture of zinc sulfate and copper sulfate in the proportion of 1:1 and later digestion with H_2SO_4 at a 420ºC for 4 hours. After the digestion, the sample was heated a nitrogen distiller with NaOH in 40%, followed by titration with 0.1 N HCL solution, and was used a conversion factor of 6.25 for the protein of calculation (Aoac, 2000).

To determine the crude fiber content, a dry and defatted sample was used, placed in a non-woven bag -TNT, digested with 1.25% H2SO4 and 1.25% NaOH using the fiber digester, with subsequent drying in an oven at 105 ° C until constant weight (Kamer & Ginkel, 1952). For the ash determination the samples were placed in a muffle furnace at 550°C for 5 hours and after cooling they were weighted (Aoac, 2000).

The glycidic fraction or non-nitrogenous extract (g.100g-1 of integral matter) was calculated by the difference where: % Glycidic fraction = 100 - (% humidity + % stereo extract + % crude protein + % crude fibre + % ash fraction), considering the integral matter (AOAC, 2000). As for the metabolizable energy, was calculated from the energy coming from the nutrients, considering the conversion factors of Atwater: Kcal = (4 x g of carbohydrates) + (9 x g of lipids) + (4 x g of proteins) (Mahan & Escott-Stump, 2002).

The study of the physicochemical characteristics of exotic fruits is important to verify the impact of several factors, such as maturation stage, post-harvest handling and thermal processing. In addition to being decisive for the quality and food safety of the fruits.

Antioxidant activity and bioactive compounds

For the antioxidant activity and phenolic compounds determination the almond extracts were prepared as recommended by Rufino et al. (2007). The quantitative evaluation of the antioxidant activity was performed by monitoring the consumption of the free radical 2.2-diphenyl-1-picryl-hydrazyl (DPPH) by the samples, by measuring the decrease in absorbance of solutions of different concentrations to determination the concentration that induces half of the maximum effect (EC50). The measures were carried out in spectrophotometer at 515 nm, following the methodology proposed by Brand-Willians et al. (1995), with the adaptation of Abrahão et al. (2012).

The determination of the total phenolics (TF) contents was performed employing the Folin-Ciocalteu rGAEent. The blue color reaction produced by the reduction of the Folin-Ciocalteu rGAEent by the phenolics compounds was measured by spectrophotometry, at a wavelength of 760 nm and the absorbance was compared with a calibration curve made with gallic acid. The TF content was expressed like mg gallic acid equivalent (GAE) per g of dry sample (Waterhouse, 2002).

The determinations of total anthocyanins (ANT) and flavonoids (FLV) were performed according to Francis' methodology (1982) using an extractor solution of ethanol 95% + HCI 1,5 mol. L^{-1} (85:15), proceeding the absorbance readout at 535 nm for anthocyanins and 374 nm for flavonoids. The results were expressed in mg.100g-1 pulp.

The total carotenoid content was determined according to the methodology proposed by Higby (1962), with readout on spectrophotometer at 450 nm. For the quantification calculation, was used the equation described below and the results were expressed in mg of total carotenoids per 100 g of sample:

$$C = \frac{A \times 100}{250 \times L \times W} \qquad (1)$$

Where: (C) corresponds to the carotenoid content, (A) corresponds to the absorbance, (L) corresponds to the cuvette width, and (W) corresponds to the original quotient between the

initial sample and the final dilution volume. The results were expressed in mg total carotenoids per 100 g sample.

For the quantification of condensed tannins was used the butanol-HCl method and the samples were read in a spectrophotometer at 550 nm, being the white of each sample the same components, but not submitted to the water bath. The content of condensed tannins was determined by interpolation of the absorbance of the samples in a calibration curve made with purified tannin of *Pinus pinaster at* concentrations of 10 to 300 µg/mL and expressed as µg of tannin/mL of the samples (Schofield, 2001).

The evaluation of the presence of antioxidants and bioactive compounds in the almonds of *Pachira aquatica* Aublet can indicate whether this fruit has the potential to be used as a medicinal source.

Statistical analysis of the data

Completely Randomized design (CRD) were carried out, being three processes (raw, baked and toasted), analyzed in three repetitions. For the physical analyses, were obtained the mean values and standard deviation. For the physicochemicals analysis, bioactive compounds and antioxidant activity, the datas obtained were submitted to analysis of variance and the Tukey test was applied to identify significant differences between the means, with 5% significance by SISVAR software.

3. Results and Discussions

Physical analysis

In the Table 1 shows the means obtained for the main physical's greatness of munguba fruits and their almonds.

Table 1 - Physical characterization of *Pachira aquatica* fruits at harvest point.

	Fruit	**Almond**
Weight (g)	578.00 ± 2.47	6.36 ± 0,84
Length (mm)	195.00 ± 1.85	34.00 ± 4.17
Diameter (mm)	78.16 ± 1.94	23.00 ± 2.85
Number of almonds per fruit	21.00 ± 3.70	-

*Mean content ± standard deviation. Source: the authors.

According to Table 1, the fruits had an average weight of 578.0 grams, an average length of 195 millimetres, an average diameter of 78.176 millimetres and an average number of 21 almonds per fruit. Almonds presented average weight of 6.36 grams and, average length of 34 mm and diameter of 23 mm.

Similar characteristics in the length of this fruit can be seen in the table above in comparison with that pointed out by Peixoto & Escudeiro (2002), who described the munguba fruit as being generally 180 mm in length, being less in relation to the diameter found of 130 mm and average similar to the length of the almonds in which, they point out that they can be from 25 to 40 mm in length. Saluci et al. (2014) in their study on the physical aspects of munguba found values closer to the one found, being 189.5 mm for the length, 80 mm for the diameter of the fruits and lower than the average number of almonds 16.5 in each fruit.

The munguba is a large and long capsule, similar to cocoa, brown in color and slightly velvety (figure C); their almonds are wrapped in a white paina (figure A), are of various sizes and shapes and, at the point of ripeness, the fruit opens and releases the almonds spontaneously (figure B).

Chemical characteristics and instrumental colour

The chemical characteristics of munguba almonds *(Pachira aquatica)* are presented in Table 2 with the variables pH, total titratable acidity (TTA), total soluble solids (TST), total soluble sugars (TSS) and reducing sugars (RS).

Table 2 - Chemical characteristics of *Pachira aquatic* almonds.

Variables*	Raw almond	Cooked almond	Toasted almond
Ph	5.66 ± 0.37 [b]	6.79 ± 0.27 [a]	6.72 ± 0.02 [a]
ATT (%)	3.66 ± 0.09 [a]	3.81 ± 0.14 [a]	1.98 ± 0.11 [b]
SST (°Brix)	21.33 ± 0.24 [a]	15.,33 ± 0.78 [c]	18.00 ± 0.81 [b]
AST (%)	10.44 ± 0.48 [a]	9.55 ± 0.34 [b]	7.61 ± 0.05 [c]
RA (%)	0.37 ± 0.01 [c]	0.43 ± 0.06 [b]	0.50 ± 0.02 [a]

*Mean contents ± standard deviation. Means followed by different letters on the same line differ from each other by Tukey's test ($p<0.05$). Source: the authors.

The Table 2 shows the process of cooking and roasting of the almonds caused a significant increase in the values of pH. However, significant difference was not observed between cooked and toasted almonds ($p>0.05$), which are classified as low acid food because they have a pH higher than 4.5, but lower than 7 (low acidity range) (Mortimer & Machado, 2009). The determination of pH and acidity of a food is very important, and may determine quality control and nutritional assessment. Food that present pH close to neutrality favor the growth of microorganisms that may cause their deterioration (Moura & Moura, 2014).

Rodrigues et al. (2019) found mean pH values of 6.69in munguba, a value close to that found for toasted almonds. In comparison with the study by Silva et al. (2014) the pH values found for munguba raw almonds in this study were lower than values found in tucumã (6.16) and for babaçu flour (6.61), being higher than values found in cupuaçu (4.28).

Samples of raw and cooked almonds showed no significant difference ($p>0.05$) for the variable total titratable acidity, however was a significant reduction in the acid content in the toasted sample (Table 2). Rodrigues et al. (2019) cited mean values titratable acidity of 1.30% for the munguba raw almond, being this value lower than found in the present study. In the evaluation of toasted almonds of baru, Lemos (2012) observed that the toasted almonds presented higher acidity compared to raw almonds (1.1% and 0.8% respectively), however, this difference was not significant.

As for soluble solids, the mean content observed for raw almonds (21.33°Brix) was significantly higher than for toasted almonds (18°Brix) in turn, toasted almonds showed significantly higher values than those found for cooked almonds (15.33°Brix). According to Nascimento et al. (2008) the decrease in soluble solids content, even when not significant,

may be related to the loss of organic acids, volatilization of some compounds and natural carbonization of a pyrolytic roasting process.

In relation to total soluble sugars, it was observed a reduction in the values when the almonds were submitted to thermal treatments for roasting and cooking, as the contents varied to 10.44% for raw almonds, 9.55% for cooked almonds and 7.61% for toasted almonds. Pereira et al. (2001) found similar values when evaluating naturally toasted coffee beans (sun-dried) with percentages of total soluble sugars varied from 7.28% to 8.44%.

Raw almonds presented mean value of 0.37% of reducing sugars, significantly lower than cooked almonds (0.43%), which was significantly lower than toasted almonds (0.50%). The reducing sugars have group carbonylic and free acetonic, and are capable of oxidizing in the presence of oxidizing agents in less acidic or alkaline solutions (Silva et al., 2003).

The evaluation of instrumental color in the system CIELAB was used to analyse the colour of samples almonds of raw, boiled and toasted munguba. The results of the color parameters (L*, a*, b*, C* and H) are presented in Table 3.

Table 3 - Mean values of *Pachira aquatica* colorimetric variables.

Variables*	Raw almond	Cooked almond	Toasted almond
L*	90.16 ± 0.85 ^{a}	61.92 ± 0.78 ^{b}	58.10 ± 0.50 ^{b}
a*	0.12 ± 0.17 ^{b}	0.09± 0.15 ^{b}	10.81 ± 0.18 ^{a}
b*	21.66 ± 0.22 ^{ab}	19.12± 0.22 ^{b}	24.41 ± 0.24 ^{a}
C*	24.30 ± 0.24 ^{b}	19.84 ± 0.22 ^{b}	38.84 ± 0.38 ^{a}
H	89.39 ± 0.40 ^{a}	89.77 ± 0.37 ^{a}	71.98 ± 0.18 ^{b}

L* represents the luminosity., a* quantifies the coloring of red-green and b* the coloring of yellow-blue, C* represents the chroma and H* are the values of Hue. Means followed by different letters on the same line differ each other by Tukey's test ($p<0.05$). Source: the authors

The Table 3 shows that L values were significantly higher in the raw almond when compared with the boiled and toasted samples.

Reduction in luminosity observed with the heat treatments is justified by roasting as well as baking, but no significant difference was observed when comparing the cooked and toasted sample values ($p>0.05$).

According to Lemos (2012) in chestnuts and almonds with high carbohydrate content, roasting contributes positively to the formation of antioxidant products such as melanoidins resulting from the Maillard reaction.

These antioxidants act compensating for the negative effects of oxidation and improving thermo-oxidative stability, in addition to giving the products a dark color.

For the intensity of red (*a), an increase was observed only in the toasted samples, being the mean values statistically equal in the raw and cooked form ($p>0.05$). For the intensity of yellow (*b), the increase occurred only in the cooked form, being equal in the toasted and raw almonds ($p>0.05$), indicating that roasting significantly influenced the reddish color, while cooking influenced the yellowish color of the munguba almonds, thus being able to relate the changes due to the presence of heat, characteristics of the Maillard reaction (Table 3).

According to Lopes et al. (2017) when evaluating the coloring of munguba's toasted almonds, found values lower than in the present study, being 64.24 for the luminosity of the almonds, 8.89 for the color parameter a* and 34.86 for b* color.

About the chroma (C*) the mean values observed for the samples of raw and cooked almonds were equal ($p>0.05$) and significantly lower than the mean values of the toasted samples, indicating a more intense colouring in the toasted almond (Table 3).

The Chroma's value indicates the distance from the axis of luminosity, which is like as one point of origin for comparison to the other axes (Minolta, 2007).

As for the variable Hue angle, the significantly higher value for raw and cooked samples represents their proximity to the yellow shade compared to toasted almonds, since the Hue value indicates, on a scale from 0 to 90 degrees, the proximity of the shade of the red tone color (0°) to yellow (90°) (Minolta, 2007).

Digital color analysis allows you to distinguish areas subject to color variation. This characterization of the color is decisive, since it is the first criterion used in the acceptance or rejection of the product by the consumer.

Proximal composition

The centesimal compositions of munguba’s almonds in the raw, cooked and toasted forms are presented in Table 4.

Table 4 - Components of Centesimal Composition of *Pachira aquatica* almonds.

Components*	Raw almond	Cooked almond	Toasted almond
Humidity (g.100 g-1)	5.55 ± 0.19 [a]	5.93 ± 0.39 [a]	3.26 ± 0.23 [b]
Lipids (g.100 g-1)	31.35 ± 0.53 [c]	34.20 ± 1.52 [b]	40.93 ± 2.22 [a]
Proteins (g.100 g-1)	15.39 ± 0.84 [a]	15.04 ± 0.92 [b]	15.57 ± 1.83 [a]
Ash (g.100 g-1)	4.10 ± 0.16 [a]	4.07 ± 0.24 [a]	4.02 ± 0.03 [a]
Crude fibre (g.100 g-1)	17.75 ± 0.13 [b]	16.70 ± 0.33 [c]	19.72 ± 2.07 [a]
Glycidic fraction (g.100 g-1)	25.83 [a]	24.05 [a]	16.48 [b]
Calories (kcal)	447.10 [c]	464.23 [b]	496.62 [a]

*Mean contents ± standard deviation. Means followed by different letters on the same line differ from each other by Tukey's test ($p<0.05$). Source: the authors.

According to the results presented in the Table 4, there was no significant difference in the mean moisture values of the raw and cooked almonds. However, the toasted almonds presented significantly lower mean moisture values (3.26%). All almonds, regardless of heat treatment, had moisture results below 15%, and the samples were classified as low moisture foods, which ensures greater stability and microbiological safety (Rodrigues et al., 2019; Lopes et al., 2017).

The content average of lipid of toasted almonds was significantly higher than that found in boiled almonds. Raw almonds presented mean values significantly lower than the other samples, with mean values near to reported by Rodrigues et al. (2019). Values higher than the present study were reported by Martini et al. (2004) for cocoa almonds (49.2%), cupuaçu (54.2%), and cupui (59.8%). Higher contents, were also observed for oilseeds such as nuts, almonds and cashew nuts (Yang, 2009).

The increase content lipid is expected when drying and roasting occur processes, since with the heating, the moisture content is reduced, but the temperature used in the process is not sufficient to remove fatty acids (Lemos, 2012). Higher contents of lipid in munguba samples after drying were also obtained by Azevedo (2008) (46.37%), Silva et al. (2010) (46.62%), and Lopes et al. (2017) (52.76%).

Protein content varied significantly ($p<0.05$) only for cooked samples, and was not observed significant difference between raw and toasted samples. In addition, all protein contents found were above to 15%, values higher than those reported by Rodrigues et al. (2019), who observed 12.06% for munguba's almonds. Silva et al. (2015) found a mean value

of 13.75% and Jorge & Luzia (2012) reported a mean value of 11.86%, both analysing munguba seeds.

Regarding the ash content, was not observed significant difference between the samples of almonds submitted to different heat treatments ($p>0.05$). The values found indicate an important mineral contribution, corroborating with Lopes et al. (2017), who found 7.49% of ash in dried munguba seeds, higher than the value of present study. The values found by Azevedo (2008), and Silva et al. (2010) were close to the present study, with mean values of 4.83% and 4.89%, respectively. Rodrigues et al. (2019) when analyzing munguba seeds found in its mineral composition, potassium (1461.84 mg / 100g DW) in which was the main mineral, followed by magnesium and calcium (304.00 and 158.37 mg / 100 g of DW), respectively.

In relation to fiber content, the raw seed present content of 17.75%, with an increase in the roasting process (Table 5). Rodrigues et al. (2019) find 12.38% of crude fiber content in raw munguba, classifying it as high in fiber. Fibers play an important role in human metabolism, such as postprandial glycemia control, cholesterol levels reduction, and may minimize some cardiovascular diseases, in addition to reducing intestinal transit time (Mahan & Escott-Stump, 2002).

Regarding the glycidic fraction there was not significant statistical difference ($p>0.05$) between the raw and cooked almonds samples. However, the toasted almonds differed significantly ($p<0.05$) (table 4). The toasted almonds presented a significantly higher caloric value than the other samples. The energy value of the foods is related to the lipid, protein and carbohydrate contents, and the lipid content has a direct influence, as it has the highest energy density, according to Atwater conversion factors (Aoac, 2000).

Antioxidant activity and bioactive compounds

The results for antioxidant activity, total phenolic compounds, condensed tannins, flavonoids, anthocyanins, and carotenoids are shown in Table 5.

Table 5 - Antioxidant activity and bioactive compounds of *Pachira aquatica* almond.

Variables*	Raw almond	Cooked almond	Toasted almond
AA (g of fruit/g of DPPH)	7.88 ± 0.11 [b]	8.08 ± 0.19 [a]	8.17 ± 0.23 [a]
TPC (mg equivalent of gallic acid (GAE)/100g sample)	4.31 ± 0.51 [c]	6.21 ± 0.42 [b]	11.91 ± 0.11 [a]
Condensed tannins (mg/g)	12.02 ± 0.54 [a]	5.96 ± 0.28 [b]	4.66 ± 0.36 [c]
Anthocyanins (mg/g)	1.42 ± 0.18 [a]	1.28 ± 0.19 [b]	1.24 ± 0.047 [b]
Flavonoids mg/100g	29,40 ± 0.14 [c]	30.82 ± 0.32 [b]	33.70 ± 0.06 [a]
Carotenoids (mg total carotenoids/100g sample)	0,37 ± 0.005 [c]	1.89 ± 0.21 [b]	2.61 ± 0.019 [a]

*TPC: Total phenolic compounds; AA: Antioxidant capacity; Mean contents ± standard deviation. Means followed by different letters on the same line differ from each other by Tukey's test ($p<0.05$). Source: the authors.

Table 5 shows that was not observed significant differences ($p>0.05$) regarding the antioxidant activity between the cooked and toasted almonds. The raw sample showed the lowest EC_{50}, meaning greater antioxidant activity, Barbosa (2016) stated that after being submitted to the roasting process, the almonds and seeds can maintain their antioxidant activity unchanged.

Raw almonds presented mean values of total phenolics significantly lower than those found in cooked and toasted almonds, being 6.21 mg GAE/100g for boiled and 11.91 mg GAE/100g in toasted form. According to Lemos (2012) during thermal treatments may occur oxidation of some phenolic compounds and volatilization of organic acids, such as acetic acid, reducing bitterness, astringency and acidity, improving the palatability of the products.

According to Xu & Chang (2008) the heat treatment of vegetable foods, by cooking or roasting causes the intracellular water evaporation, triggering chemical reactions that can alter the lignocellulosic structure in addition to promoting the denaturation of proteins, which can result in greater availability of phenolic compounds in the plant matrix. Therefore, different changes can be expected in the face of heat treatment, which can affect the nutritional and bioactive characteristics of foods.

In the determination of condensed tannins, the almonds in raw form had an average content of 12.02 mg/g, this value being significantly higher than the those found in almonds

subjected to thermal treatments of roasting heat treatment (4.66 m/g) and cooking (5.96 mg/g) (Table 5). Lower values were found by Barbosa (2016), who studied different seeds species from Brazil, and found 6.9 mg/g for raw munguba seeds using ethanolic extract. Flavonoids are known to fight free radicals produced during oxidation processes, being the main antioxidant agents in plants (Khaled-Khodja et al., 2014).

Tannins are anti-nutrients that belong to the group of polyphenolic compounds, as they can cause a decrease in protein and carbohydrate digestibility, due to the formation of insoluble resistant-enzyme complexes. In addition, polyphenols can react with proteins and enzymes, and are also prone to act as trypsin and amylase inhibitors (Rodrigues, et al, 2019).

The anthocyanin contents show that the samples of raw almonds had significantly higher mean values. There was no significant difference in anthocyanin contents between cooked and toasted almonds samples ($p>0.05$). March, Poppi and Scarmino (2008) stated that rapid degradation of the anthocyanins occurs when the food is subjected to heat treatment during food processing, with a positive correlation between the heating temperature and the anthocyanin destruction. However, processes that use high temperatures and shorter exposure time to heat have been more efficient and recommended to reduce the degradation of these pigments (Barbosa, 2016).

For the mean contents of flavonoids and carotenoids were observed significant increases in values in the heat-treated samples. For raw almonds was found an average content of 29.40 mg/100g of flavonoids, close to that found by Alves et al. (2014) in catanduva seeds, which was 27.64 mg/100g. This indicates that the cooking and roasting processes significantly influence the content of these compounds (Table 5). The content of total carotenoids was significantly higher in toasted munguba almonds than in raw and cooked almonds (Table 5). Carotenoids, along with phenolic and tocolic compounds, are natural antioxidants that have received greater attention because they are more effective when compared to synthetic antioxidants (Barbosa, 2016).

Research shows that, with the significant presence of its bioactive compounds, the consumption of munguba almonds (*Pachira aquatica)* may have a hypoglycemic effect in the treatment of diabetes and its symptoms. In addition, they state that the consumption of this plant may, in the context of a varied diet, collaborate in obtaining nutrients essential to health (Pinheiro, 2013; Bocage & Sales, 2002; Rodrigues, et al, 2019). However, it is necessary to carry out more comprehensive studies to know the possible risks, even before encouraging the consumption of the fruit without prior knowledge of the other properties. It is not

recommended be rely only on the nutritional potential, without also checking the toxicological potential.

4. Final Considerations

This study brings important scientific notes about *Pachira aquatica* Aublet, an exotic and little-known fruit. The biometric characterization of munguba fruits and almonds showed typical characteristics and provided taxonomic confirmation, however variation in shape and size was observed.

Munguba almonds had a high content of lipids and proteins. Raw almond presented higher content of anthocyanins, condensed tannins and higher antioxidant activity, while the roasting contributed to increase the contents of phenolic compounds, flavonoid and carotenoid. It was also found that the heat treatments reduced the luminosity of the almonds.

Therefore, the physicochemical characterization, the determination of bioactive compounds and the antioxidant activity of almonds in raw, cooked and toasted forms showed that munguba has the potential to be exploited industrially for having remarkable bioavailability of nutrients. However, it is necessary to carry out more comprehensive studies in order to know how to verify its toxicological potential.

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