Extraction and characterization of oil from the pulp of pequi (*Caryocar brasiliense*) produced manually in the allotment Piauzinho Municipality of Pium - TO

Extração e caracterização de óleo de pequi (*Caryocar brasiliense*) produzido artesanalmente no loteamento Piauzinho Município de Pium – TO

Extracción y caracterización de aceite de pequi (*Caryocar brasiliense*) producido a mano en el fraccionamiento Piauzinho Municipio de Pium - TO

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Abstract
Research with the oil extracted from pequi can collaborate with the improvement of the extraction process, commercialization and generation of employment and income of this extractive activity. The objective of this work

was the biometric characterization of the fruit and physicochemical analysis of the oil extracted from the pequi pulp produced by hand in the Piauzinho TO subdivision, comparing the results obtained in research carried out in the Tocantins region. An experimental study was carried out by harvesting the fruits and extracting the oil from the pequi pulp in the field. The physicochemical analyzes of the oil were carried out in the laboratory of the Federal Institute of Food Science and Technology Education - IFTO, Paraíso do Tocantins campus. The fruits were harvested, selected and transported for analysis in the laboratories. The results of the physical-chemical and biometric analyzes were submitted to analysis of variance. There were significant differences by Tukey's test ($p < 0.05$) in fruits and oils. The studied fruits show increases of 16.1% in height, 4.3% to 14.7% in longitudinal diameter, 3.5% to 21.2% in equatorial diameter, 3.6% to 36.7%, in fruit mass and 7.9% to 35.9% in the number of pyrenes in relation to the literature. The extracted oil presented density, acidity, peroxide and saponification with lower values and higher humidity and viscosity than those found in the literature. The oil analyzed in the study presented values for acidity and peroxide indexes within the established by current legislation and can be consumed and applied as raw material in industrial applications.
Keywords: Extractivism; Biometry; Tocantins; Food.

Resumo
Pesquisas com o óleo extraído do pequi podem colaborar com o melhoramento do processo de extração, comercialização e geração de emprego e renda dessa atividade extrativista. O objetivo desse trabalho foi a caracterização biométrica do fruto e análises físico química do óleo extraído da polpa do pequi produzido artesanalmente no loteamento Piauzinho TO. Foi desenvolvido um estudo experimental realizando colheita dos frutos e extração do óleo da polpa do pequi no campo. As analises físico químicas do óleo foram realizadas no laboratório do Instituto Federal de Educação Ciências e Tecnologia de Alimentos – IFTO, campus Paraíso do Tocantins. Os frutos foram colhidos, selecionados e transportados para analises nos laboratórios. Os resultados das análises físico-químicas e biométricas foram submetidos à análise de variância. Houve diferenças significativas pelo teste de Tukey ($p < 0,05$) em os frutos e óleos. Os frutos estudados apresentam aumentos de 16,1% na altura, 4,3% a 14,7% no diâmetro longitudinal, 3,5% a 21,2% no diâmetro equatorial, 3,6% a 36,7%, na massa do fruto e 7,9% a 35,9% no número de pirênios em relação a literatura. O óleo extraído apresentou densidade, índices de acidez, peroxido e saponificação com valores inferiores e umidade e viscosidade superiores aos encontrados na literatura. O óleo analisado no estudo apresentou valores para índices de acidez e peroxido dentro do estabelecido pela legislação vigente podendo ser consumidos e aplicados como matéria prima em aplicações industrias.
Palavras-chave: Extrativismo; Biometria; Tocantins; Alimentação.

Resumen
La investigación con el aceite extraído del pequi puede colaborar con la mejora del proceso de extracción, comercialización y generación de empleo e ingresos de esta actividad extractiva. El objetivo de este trabajo fue la caracterización biométrica del fruto y el análisis fisicoquímico del aceite extraído de la pulpa de pequi producida artesanalmente en el fraccionamiento Piauzinho TO, comparando los resultados obtenidos en investigaciones realizadas en la región de Tocantins. Se realizó un estudio experimental cosechando los frutos y extrayendo el aceite de la pulpa del pequi en campo. Los análisis fisicoquímicos del aceite se realizaron en el laboratorio del Instituto Federal de Educación en Ciencia y Tecnología de Alimentos - IFTO, campus Paraíso do Tocantins. Los frutos fueron cosechados, seleccionados y transportados para su análisis en los laboratorios. Los resultados de los análisis físico-químicos y biométricos fueron sometidos a análisis de varianza. Hubo diferencias significativas por la prueba de Tukey ($p < 0.05$) en frutas y aceites. Los frutos estudiados mostraron incrementos de 16,1% en altura, 4,3% a 14,7% en diámetro longitudinal, 3,5% a 21,2% en diámetro ecuatorial, 3,6% a 36,7% en masa de fruto y 7,9% a 35,9% en el número de pirenos en relación con la literatura. El aceite extraído presentó densidad, acidez, peróxido y saponificación con valores menores y mayor humedad y viscosidad que los encontrados en la literatura. El aceite analizado en el estudio presentó valores de índices de acidez y peróxido dentro de lo establecido por la legislación vigente y puede ser consumido y aplicado como materia prima en aplicaciones industriales.
Palabras clave: Extractivismo; Biometría; Tocantins; Alimentación.

1. Introduction

According to Pereira *et al.* (2021), the Cerrado occupies 24% of the area of the national territory, close to 2,000,000 km^2, located in several Brazilian states and the 2nd largest biome in Brazil. Also according to the authors, it has a flora formed by herbaceous vegetation, shrubs, plants with a height usually less than 2 meters, small trees and soil with little fertility. According to Batista and Sousa (2019), the great biodiversity of the variety of fruit plants in the Cerrado biome is vast and has enormous extractive potential.

According to Pereira *et al*. (2021), Nunes *et al*. (2021) and Colares *et al*. (2021) the pequi tree (Caryocar brasiliense) is a perennial tree with oleaginous fruit, harvested between November and February in the states of Goiás, Pernambuco, Bahia, Piauí used by the food, pharmaceutical and fuel production industries. According to Batista & Sousa (2019) and Barros *et al*. (2019), Caryocar brasiliense contributes significantly to the preservation and maintenance of the biome through the regeneration of destroyed areas, environmental conservation, species maintenance, food, job creation, income for the local extractive community through the marketing of fresh fruits and oil extracted manually from the pulp. According to Barros et al. (2019), pequi pulp has a wet base composition of approximately 0.6% minerals, 2.0% proteins, 19% carbohydrates, 35% oil and a total energy value of 292 (Kcal/100 g), constituting a food of high caloric value and supplier of nutrients for human consumption.

According to Cunha *et al.* (2020) it is possible to extract the oil from the pequi pulp to be used in the manufacture of moisturizing creams and soaps for the body and economical and less polluting biofuel. Nunes *et al.* (2021) highlights that the oil extracted from pequi pulp has the potential to capture fragrances and active principles, and can be used in emulsions with stable stability, associating the water-soluble and/or fat-soluble active phases, for topical use used in the cosmetics industry. Pereira *et al*. (2021), emphasize that pequi has a large amount of antioxidants, proteins and bioactive compounds and can be used in the production of medicines and in food, pequi oil, replacing soybean oil in the kitchen. Nunes *et al*. (2021) and Colares *et al*. (2021), highlight that pequi has a typical smell and taste, is highly appreciated by the consuming population in areas where pequi trees occur, has a large amount of vitamin A, fatty acids and carotenoids responsible for the prevention of cancer, skin diseases, increased immune response and anti-aging. Pequi oil has anti-inflammatory, healing of skin lesions, antioxidant, antimicrobial, antifungal and reduces cardiovascular problems. in the treatment of broncho-respiratory infections and help in muscle recovery of individuals who practice weight training and attend gyms (Pereira *et al*., 2021).

According to Barros *et al.* (2019), the artisanal process for acquiring the oil from the pequi pulp is a lengthy procedure of approximately 8 hours of boiling the pequi pyrenes in water. Also according to the authors, the oil obtained is transported to another container and heated to remove excess moisture and then stored in PET plastic bottles. Silva (2017) emphasizes that the extraction process by cooking is a simple and artisanal way, in which the difference in density between oil and water is used, after cooking the seeds of the pequizeiro fruit, to obtain the oil. of pequi pulp. Also according to the author, cooking pequi seeds reduces the percentage of oil extracted due to the increase in the moisture content of the fruit pulp.

Therefore, research on the oil extracted from pequi can collaborate to improve the exploitation of this natural resource, search for new possibilities for its exploitation, improve the extraction process, commercialization and generation of employment and income for the sustenance and feeding of the communities that benefit from this extractive activity.

The objective of this work was the biometric characterization of the fruit and physicochemical characterization of the oil extracted from the pequi pulp produced by hand in the allotment Piauzinho Municipality of Pium - TO, comparing the results obtained in research carried out in the Tocantins region.

2. Methodology

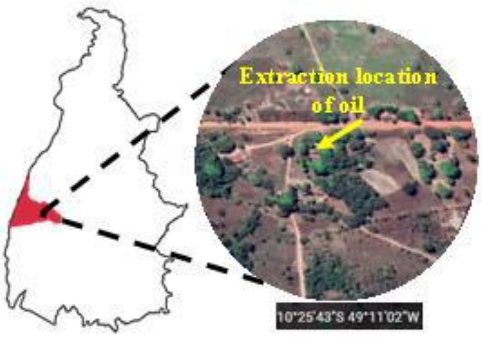
2.1 Type of study

A laboratory and experimental study was carried out, performing the harvesting of the pequi tree fruits and extracting the oil from the pequi pulp in the field. The physicochemical analyzes of the pequi pulp oil were carried out in the Analytical Chemistry laboratory and the biometric analysis of the fruits in the Fruit and Vegetable Processing Laboratory of the Federal Institute of Food Science and Technology Education - IFTO, Paraíso do Tocantins campus. According to Pereira, & Shitsuka (2018), the study carried out is characterized as an analysis of a quantitative nature.

2.2 Location and sampling of pequi fruits and extraction of oil from pequi pulp.

The pequizeiro fruits were harvested in the Piauzinho allotment in the municipality of Pium - TO (figure 1) in October 2021. After collection, 100 fruits without injuries were selected, presenting a certain sphericity. After selection, the fruits were transported in thermal boxes, with ice, for biometric analysis, 24 hours after selection, at the IFTO Fruit and Vegetable Processing Laboratory. The surplus of the selected fruits was transported in a trailer attached to motor vehicles to the Piauzinho allotment to extract the oil from the pulp of the fruits.

Figure 1. Location of fruit harvest and oil extraction.



Source: Authors (2022)

2.3 Extracting the oil from the pequi pulp.

The extraction of oil from the pequi pulp was carried out in an artisanal way, through the cooking of pequi seeds in water, by the residents of the subdivision who use the oil in their food and sell them in the region's open fairs. The fruits were added to a metal container with water and boiled for 50 minutes. After cooking, the seeds were separated and cooled. After cooling, the pulp and pits were mechanically separated. The crude pulp was heated, at boiling point, with the addition of water, at room temperature, to extract the oil due to the difference in density and immiscibility between the oil and water. The oil suspended on the surface of the water was transferred to another metallic container where it was heated again and consequently concentrated the oil through the evaporation of the water. The process of artisanal extraction of oil from pequi pulp is shown in the flowchart below (Figure 2).

Figure 2. Flowchart of pequi oil extraction.

1. Harvesting the fruit.
2. Ripe pequi fallen on the ground.
3. Pequi peeling.
4. Preparation for oil extraction.
5. Mechanical oil extraction process.
6. Water emulsion is oil.
7. Application of heat..
8. Oil separation.
9. Oil extracted from pequi.

Source: Authors (2022)

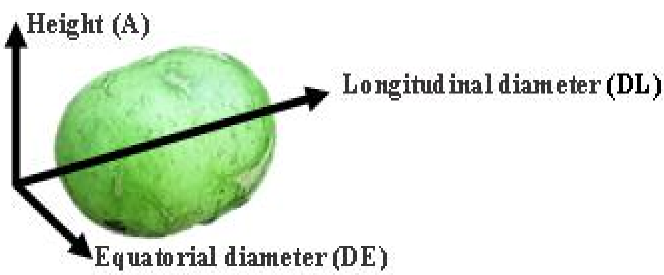
2.4 Biometric characterization of the pequi tree fruit.

In the Fruits and Vegetables Processing Laboratory of the IFTO campus Paraiso, the cleaning with water and detergent was carried out to remove the dirt from the fruits. The biometric characterization of fruit mass, fruit height, fruit longitudinal diameter, fruit equatorial diameter, number of pyrenes per fruit, fruit volume and percentage sphericity followed the methodological procedures below where:

● fruit mass (MF): Direct reading on a semi-analytical scale (Bess et al, 2020);

● height (A), longitudinal diameter (DL) and equatorial diameter (DE): The dimensions of the fruit (figure 3) were obtained through direct reading with a caliper (Bess *et al*, 2020);

Figure 3. Measures considered in pequi fruits.



Source: Authors (2022)

● number of pyrenes per fruit (NP): direct count in the fruit (Bess et al, 2020);

2.5 Physicochemical characterization of pequi oil.

The physical-chemical analyzes of density, acidity, iodine, peroxides and saponification, humidity and viscosity were performed in triplicate at the Laboratory of Analytical Chemistry of IFTO/Campus Paraíso and followed the methodological procedures below where:

● Density: direct reading in a pycnometer (g.cm-3) (IAL, 2008);
● Acidity Index: determined by titration, expressed in mg KOH/g (IAL, 2008);
● Peroxide index: titrimetric determination, expressed in meq of O2 per 1000g of the sample (IAL, 2008);
● Saponification index: titrimetric determination, expressed in 1mg of KOH/1g of sample (IAL, 2008);
● Moisture: determined by direct drying in an oven at 105° C (IAL, 2008);
● Viscosity: determined directly on the Brookfield viscometer (AOCS, 1995)

2.6 Statistical analysis.

The results of the physical-chemical and biometric analyzes were submitted to analysis of variance (ANOVA). And to verify if there was a significant difference in the data, the t-means, Tukey tests were applied at the level of 5% of significance in the variables, through the SISVAR program version 5.6 (Ferreira, 2019).

3. Results and Discussion

Researches on the biometry and physical-chemical characterization of the pequi pulp oil were carried out in the regions of Minas Gerais, Goiás and Mato Grosso, but few studies were found in the state of Tocantins.
The average values obtained in the determination of the biometric and physicochemical analysis performed on the fruit and oil extracted from the pequi pulp are shown in the tables: Table 1. Biometric characteristics of pequi fruits from the Piauzinho allotment, municipality of Pium -TO.; Table 2. Comparison between the fruits of the Piauzinho allotment with the literature; Table 3. Physicochemical characteristics of the oil extracted from pequi pulp in the Piauzinho allotment, Pium -TO. and Table 4. Table 4. Comparison between the physical-chemical analyzes performed on the oils extracted from pequi pulp.

Table 1. Biometrics of pequi fruits from the Piauzinho subdivision, municipality of Pium -TO.

Biometric analysis	Minimum (a)	Maximum (a)	Average	Standard deviation	Coefficient of variation (%)
Height (mm)	61.03	80.98	70.56	5.98	8..48
Longitudinal diameter (mm)	69.49	93.66	81.36	6.98	8.58
Equatorial diameter (mm)	64.13	80.75	71.58	4.74	6.63
Fruit mass (g)	170.55	277.51	219.07	31.23	14.25
Number of pyrenes per fruit	1.00	4.00	2.03	0.26	13.01

Source: Authors (2022)

Table 1 shows the averages of the results of the biometric analysis of the pequizeiro fruits analyzed at the Fruit and Vegetable Processing Laboratory of the Federal Institute of Food Science and Technology Education - IFTO, Paraíso do Tocantins campus.

Table 2. Comparison between the fruits of the Piauzinho allotment with the literature.

Biometric analysis	Allotment Piauzinho Pium	Alves et al., (2014) Nova Rosalândia, Pium, São Felix	(Moura et al., 2013) Center Tocantins	Duboc et al., (2013) Miracema e Pequizeiro
Height (mm)	70.56 ± 5.98 B	59.2 ± 5.56 C		71.03 ± 5.18 A
Longitudinal diameter (mm)	81.36 ± 6.98 A	72.4 ± 11.80 C	69.37 D	77.86 ± 12.30 B
Equatorial diameter (mm)	71.58 ± 4.74 A	56.4 ± 5.07 D	57.64 C	69.03 ± 6.58 B
Fruit mass (g)	219.07 ± 31.23 A	138.7 ± 39.39 D	138.89 C	210.6 ± 62.54 B
Number of pyrenes per fruit	2.03 ± 0.26 A	1.3 ± 0.64 D	1.87 B	1.56 ± 0.19 C

Means with different letters in the line mean that the pequi tree fruits differed from each other by the Tukey test ($p < 0.05$).
Source Authors (2022)

Table 2 presents the comparisons of the averages of the biometric analyzes between the fruits of the pequi tree found in the Piauzinho allotment in the Municipality of Pium - TO and those found by Alves *et al*. (2014), Moura *et al*. (2013) and Duboc *et al*. (2013) who performed biometric tests with pequi tree fruits in the regions of Nova Rosalândia, Pium, São Felix, Miracema, Pequizeiro and central Tocantins.

According to Table 1, the fruits showed height, average of 70.56 mm, ranging from 61.03 mm to 80.98 mm. The percentage variations of the heights in the samples presented 46% between 60 to 70 mm, 50% between 70 to 80 mm and 4% above 80 mm. The longitudinal diameter exhibited an average of 81.36 mm, with a variation between 69.49 mm to 93.66 mm and 4% between 60 to 70 mm, 40% between 70 to 80 mm, 43% between 80 to 90 mm and 13 % above 90 mm. The equatorial diameter had an average of 71.58 mm in a range of variation between 64.13 and 80.75 mm, with 41% between 60 and 70 mm, 54% between 70 and 80 mm and 5% above 80 mm. The average mass was 219.07g, ranging from 170.55g to 277.51g, with 43% from 170 to 210g, 36% from 210 to 250g and 21% from 250 to 280g. The variation for the number of pyrenes was from 1 to 4 pyrenees with an average equal to 2.03, with 1% having 1 pyrene, 96% with 2 pyrenes, 2% with 3 pyrenes and 1% with 4 pyrenes.

According to Leandro *et al*. (2018), biometric investigations of fruits is very relevant for understanding the commercial exploitation of fruits, as it allows the determination of quality and yield parameters, in addition to helping to dimension machines, equipment and evaluate programs for the genetic improvement of the species.

According to Table 2, it appears that there were significant differences in all biometric variables studied. These variations observed in this study can be explained by the climate, soil, which induces the variability in the physical and chemical characteristics of the fruit. According to Moura *et al*. (2013), the pequi tree is a native extractive crop, not commercially cultivated, which, due to the soil and climate conditions of the fruit's location, presents physical variation between fruits of the same and different trees. The biometric analyzes of fruit heights (mm) performed in the Piauzinho allotment were higher than those found by Alves *et al*. (2014), Moura *et al*. (2013) and lower than that analyzed by Duboc *et al*. (2013).

The measurements longitudinal diameter (mm), equatorial diameter (mm), fruit mass (g), number of pyrenes per fruit performed showed higher values than those found by Alves *et al*. (2014), Moura *et al*. (2013) and Duboc *et al*. (2013) who performed biometric tests with fruits harvested in the regions of Nova Rosalândia, Pium, São Felix, Miracema, Pequizeiro and central Tocantins.

The fruits harvested in the Piauzinho allotment showed an increase of 16.1% in height in relation to the fruits evaluated by Alves *et al*. (2014) and a reduction of 0.6% compared to Duboc *et al*. (2013).

The longitudinal diameter of the fruits presented percentages of 11%, 14.7% and 4.3% higher than those found by

Alves *et al*. (2014), Moura *et al*. (2013) and Duboc *et al*. (2013). The equatorial diameter showed an increase of 21.2%, 19.4% and 3.5% in relation to those surveyed by Alves *et al.* (2014), Moura et al., 2013) and Duboc et al. (2013).

The fruit mass showed an increase of 36.7%, 36.6% and 3.6% in relation to the masses found by Alves *et al*. (2014), Moura *et al*. (2013) and Duboc *et al*. (2013). The number of pyrenes calculated in the present study was 35.9%, 7.9 and 23.2% higher than those found by Alves *et al*. (2014), Moura *et al*. (2013) and Duboc *et al*. (2013).

According to Moura *et al*. (2013), the results found in the comparisons of biometric analyzes suggest that the fruits differ in mass and volume between collection sites. According to Alves *et al.* (2014), the phenotypic variety of the native flora of the cerrado is strongly influenced by the components, the anthropic condition, the soil, the climate, the age of the plants and also by the genetic differences between the individuals. Considering that part of the biometric characteristics are genetic in nature, then, there are great alternatives to select species to produce better quality fruits for consumption.

According to Moura *et al.* (2013) the regional influence is greater than the influence of the time effect (years) on the biometric characteristics of the fruits. Also according to Moura *et al.* (2013), the variation between the biometric values found in the fruits indicates the exploitation in breeding and domestication programs of the species for the fruit mass that presented significant variation between the fruits collected on the same tree.

Table 3. Physical and chemical characteristics of pequi oil from the Piauzinho allotment, Pium -TO.

Physical-chemical analysis	Oil extracted in the allotment Piauzinho	IN Nº. 87, of march 15, 2021
Density (g/mL)	2.62 ± 0.05	--
Acidity index (mg KOH/g)	1.85 ± 0.16	4,0
Peroxide index (meq/Kg)	4.44 ± 0.88	10,0
Saponification index (mg KOH/g)	35.68 ± 2.16	--
Moisture (%)	0.46 ± 0.02	--
Viscosity (cP)	60.20 ± 0.28	--

Source Authors (2022).

Table 3 informs the averages of the results of the physical chemical analysis of the oil extracted by hand from the pulp of the fruits of the pequi tree analyzed at the Laboratory of Analytical Chemistry of the Federal Institute of Education Sciences and Technology of Food - IFTO, Paraíso do Tocantins campus.

Table 4. Comparison between the physical-chemical analyzes performed on the oils extracted from pequi pulp.

Physical-chemical analysis	Allotment Piauzinho	Babaçulândia*	Araguaína**	Jalapão***
Density (g/mL)	2.62 ± 0.05^{A}	2.74 ± 0.02^{B}	2.74 ± 0.02^{C}	2.74 ± 0..03^{C}
Acidity index (mg KOH/g)	1.85 ± 0.16^{A}	5.45 ± 0.05^{B}	3.33 ± 0.05^{C}	1.43 ± 0.05^{D}
Peroxide index (meq/Kg)	4.44 ± 0.88^{C}	16.31 ± 0.05^{A}	9.38 ± 0.05^{B}	9.38 ± 0.05^{B}
Saponification index (mg KOH/g)	35.68 ± 2.16^{D}	73.72 ± 0.08^{C}	74.44 ± 0.03^{B}	190.63 ± 0.1^{A}
Moisture (%)	0.46 ± 0.02^{A}	0.29± 0.001^{B}	**0.07** ± 0.02^{C}	0.15± 0.03^{D}
Viscosity (cP)	60.20 ± 0.28^{A}	14.827± 0.02^{B}	19.313± 0.03^{C}	20.581± 0.02^{D}
Viscosidade (cP)	60.20 ± 0.28^{A}	14.827± 0.02^{B}	19.313± 0.03^{C}	20.581± 0.02^{D}

(Silva, 2017) *, **, ***. Means with different letters in the line mean that the oil extracted from the pequi pulp differed from each other by the Tukey test. ($p < 0,05$). Source Authors (2022).

Table 4 presents the comparisons of the averages of the physical chemical analyzes of the oil extracted by hand in the Piauzinho allotment in the Municipality of Pium - TO and those found by Silva, (2017) who performed physical chemical analysis on oils extracted by hand in the regions of Babaçulândia, Araguaína and Jalapão.

According to table 3, the oil extracted from pequi pulp in the Piauazinho allotment had an acidity index and peroxide index within the limits recommended by Normative Instruction No. 87, of March 15, 2021 of the National Health Surveillance Agency (ANVISA 2021) . This regulation establishes the maximum values of acidity and peroxide index for vegetable oils and fats. Silva, (2017) conducting research with oil extracted from the pulp of pequi in an artisanal way in Tocantins cities found values for the peroxide and acidity indexes above the recommended in IN N° 87/2021.

The physical and chemical parameters density, saponification index, moisture and viscosity do not have limits specified in the referred legislation. Possible causes that may affect the physical-chemical parameters analyzed and the quality of the oil are prolonged storage in inappropriate containers and areas, processing of the oil extraction and inherent properties of the local climate and soil.

Table 4 informs that there were significant differences by the Tukey test ($p < 0.05$) in the oils extracted by hand in the Piauzinho allotment and found by Silva (2017) in the cities of Babaçulândia, Araguaína and Jalapão.

The pequi pulp oil extracted in the Piauzinho allotment showed lower density, acidity, peroxide and saponification values, and higher humidity and viscosity than those found by Silva (2017) in the cities of Babaçulândia, Araguaína and Jalapão.

According to Moreira (2017), being a characteristic physical property of each substance, density plays a fundamental role in the food industry, as it allows the verification of adulteration in products. Also according to Moreira, the density of an oil depends on the temperature to which it is subjected, being able to interfere in the destination and in the product in which this oil will be applied. Silva (2017) performing density analysis, at room temperature, in oils extracted from pequi pulp in an artisanal way in the regions of Araguaína, Babaçulândia and Jalapão found values ranging between 2.74 ± 0.03 g.mL^{-1}, being considered by him with a satisfactory value. According to Deus (2008), carrying out studies with pequi oil, the increase in temperature promotes the dilution of the density caused by the loss of mass of the product. According to Costa (2006) the values of oil densities decrease linearly with the increase in temperature, because this decreasing behavior in face of the increase in temperature is typical of Newtonian fluids.

According to Silva (2017), the acidity index is directly related to nature, degree of purity, quality, processing and especially to the oil conservation conditions, as the decomposition of glycerides is accelerated by heating and light. Also according to the author, the determination of the acidity index is extremely important in the evaluation of the state of deterioration of pequi oil, since the increase in the acidity index will indicate breaks in its chains and the release of free fatty acids.

According to Moretto and Fett (1998), in parallel with the increase in the temperature of the fruit seeds during inappropriate storage, there is an increase in acidity in their oil content. According to Aquino *et al*. (2010), oil with a moisture content of less than 1%, are characterized as good quality oils. most of the vegetation, which can cause low moisture values in oils extracted in dry regions.

According to Messias *et al*. (2020), the peroxide number is a great indicator to determine the initial stages of the oxidative process, since the value of the peroxide number is maximum at the beginning of the oxidation process. The peroxide index is a parameter that calculates the degradation steps through the exposure time of the food in the binomial time and temperature (Bobbio & Bobbio, 2007). According to Mendonça *et al*. (2008), the increase in the peroxide index evidences the development of degenerative hydrolytic, thermal and lipid oxidative reactions, generating peroxides, which can compromise the aroma, color and flavor of the oil, signaling the emergence of carcinogenic compounds (Mendonça *et al*., 2008).

According to Moretto and Fett, (1998), The saponification index is defined as the amount of potassium hydroxide (KOH) necessary to saponify the fatty acids generated in the hydrolysis of the sample. It is inversely proportional to the average molecular weight of the fatty acids of the triglycerides present, that is, the lower the molecular weight of the fatty acid, the higher the value of the saponification index. With regard to food, the higher the value of the saponification index, the better the oil for food. According to Freire (2001), the oil extracted from pequi pulp in the Piauzinho allotment had a saponification index (35.68 ± 2.16 mg KOH/g) below the stipulated for oils for food purposes, which must have index values of saponification between 177 to 187 mg KOH/g.

According to Vieira (1994), the moisture content in oils quantifies the mass of uncombined water in the sample, taken at 105ºC, during a certain time interval, characterizing the quality and durability of the oil. According to Cechi (2003). the determination of the moisture content is related to the stability, quality and composition of the oil. According to Santos *et al*. (2001), pequi oil is classified as type 1 industrial oil when it has a moisture content lower than (≤) 0.5%. The oil analyzed in this study is classified as a type according to the classification by Santos et al. (2001)

According to Rodrigues (2011), oil viscosity is directly related to the chemical characteristics of lipids, degree of unsaturation and the size of the fatty acid chain that constitutes triacylglycerols. It can vary as a function of temperature, showing a tendency to increase or decrease depending on the characteristics of the oil. According to Abramovic & Klofutar (1998), the decrease in the density value is associated with the degree of unsaturation (double and triple bonds) present in the oil and increases with polymerization (Rodrigues, 2011).

4. Conclusion

With the results of the biometric characterization of the fruit and the physicochemical characterization of the oil from the pulp of pequi in the Piauzinho allotment and subsequent comparison with data from the literature in the state of Tocantins, it can be said that there were significant differences between the regions where the samples were collected. fruits and oil extraction. The fruits analyzed in the study present smaller size and greater mass and number of pyrenes in relation to those found in the literature in the state of Tocantins. There is significant phenotypic variability among the biometric characters of pequi tree fruits in the analyzed regions. The oil analyzed in the study presented values for acidity and peroxide indexes within the established by current legislation and can be consumed and applied as raw material in industrial applications. It presented lower values for density, acidity, peroxide, saponification and higher values for moisture and viscosity in relation to the values found in the literature in the State of Tocantins.

Further studies are suggested on the existence of other biometric parameters and the verification of the influence of the transition region (cerrado /Amazon Forest) on the physicochemical, proximate and microbiological parameters in pequi oil extracted by hand and marketed in the State of Tocantins.

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