Anatomical aspects and phytochemical potential of *Caryocar villosum* (Aubl.) Pers. (pequiá)

**Abstract**

The knowledge of anatomical and phytochemical structures of many species has drawn the attention of researchers in several areas, because these species are characterized by the...
production of chemical compounds, mainly fixed and essential oils, which are of great industrial interest. The “pequiá” tree is a majestic tree from primary forest and represents huge economic potential. This work aimed to study the anatomical aspects, extraction and characterization of the fixed oil present in the fruit and the seed of *Caryocar villosum*. There were used fifty fruits of pequiá collected from the municipality of Tartarugalzinho (Amapá). The identification of species was made by comparison with exsiccates available in the Amapá Herbarium – HAMAB. For anatomical and phytochemical analyses, conventional methodology was used. The result in the macerate of the mesocarp corresponds to a yellow mass impregnated by lipids; in the endocarp there were registered trichomes which secret these lipids, forming an arc in all its extension. In the solvent-based phytochemical analyses of the mass of pericarp, mesocarp and fixed oil seed, favorable and satisfactory oil yields were obtained. The analyses of the acidity, saponification, ester and peroxide indexes are parameters that are related to the quality of the oil, therefore, the values obtained meet the Anvisa/2015 Resolution. It is thus concluded that the fixed oil obtained from the mesocarp/seed of *C. villosum* is indicated for alimentary purposes, with potential to reduce total cholesterol and LDL cholesterol, as well as in cosmetic industry. Therefore, anatomical analyses help phytochemical studies (CNPq/IEPA).

**Keywords:** Caryocaraceae, pequiá tree, fatty acids, lipids.

**RESUMO**

O conhecimento de estruturas anatômicas e fitoquímicas de muitas espécies chamou a atenção de pesquisadores de diversas áreas, pois essas espécies são caracterizadas pela produção de compostos químicos, principalmente óleos fixos e essenciais, de grande interesse industrial. O pequiá é uma árvore majestosa da floresta primária e representa um enorme potencial econômico. Este trabalho teve como objetivo estudar os aspectos anatômicos, extração e caracterização do óleo fixo presente nos frutos e nas sementes de Caryocar villosum. Foram utilizados cinqenta frutos de pequiá coletados no município de Tartarugalzinho (Amapá). A identificação das espécies foi feita por comparação com os exsicatas disponíveis no Herbário do Amapá - HAMAB. Para análises anatômicas e fitoquímicas, foi utilizada metodologia convencional. O resultado no macerado do mesocarro corresponde a uma massa amarela impregnada por lipídios; no endocarro, havia tricomas registrados que secretam esses lipídios, formando um arco em toda a sua extensão. Nas análises fitoquímicas à base de solvente da massa de pericarpo, mesocarpo e oleaginosas fixas, foram obtidos rendimentos de óleo favoráveis e satisfatórios. As análises dos índices de acidez, saponificação, éster e peróxido são parâmetros relacionados à qualidade do óleo, portanto, os valores obtidos atendem à Resolução Anvisa / 2015. Conclui-se, assim, que o óleo fixo obtido do mesocarro / semente de *C. villosum* é indicado para fins alimentares, com potencial para reduzir o colesterol total e o colesterol LDL, bem como na indústria cosmética. Portanto, análises anatômicas auxiliam nos estudos fitoquímicos (CNPq / IEPA).

**Palavras-chave:** Caryocaraceae, pequiá, ácidos graxos, lipídios.
INTRODUCTION

The increasing worldwide interest for Brazilian native fruits has enhanced researches in Amazon, one of the Brazilian biomes that contributes most to the supply of these fruits (Santos et al. 2006). This tendency has been intensified as research has demonstrated the beneficial effects on health of various phytochemicals naturally present in plants (Torres e Bobet, 2001).

In this scenario is the pequiá tree, which has significant socioeconomic value and is a majestic tree from primary forest that can reach large dimensions, such as 40 to 50m in height. It belongs to the Caryocaraceae family, highlighting the species *Caryocar villosum* (Aubl.) Pers. Its fruit is edible after cooking and is highly appreciated by the traditional Amazonian population because of the taste and the unusual smell of the pulp (Dickinson 1990; Clay et al. 2000). In addition, its fruit and leaves are used in the treatment of several diseases, being one of the species with medicinal potential of the Amazonian flora (Vieira and Martins 2000). The oil extracted from the fruit is traditionally used to relieve muscle pain and rheumatism (Clay et al., 2000). Although pequiá is exploited extractively as a raw material for oil extraction for various purposes, little is known about its characteristics of industrial interest. Thus, the objective of this work was to identify the anatomical aspects of the fruit and seed and investigate its phytochemical potential, as well as the yield of the fixed oil of the fruit and the seed of *C. villosum* (Aubl.) Pers.

MATERIAL AND METHODS

2.1 AREA OF STUDY

The samples were collected in three areas near the municipality of Tartarugalzinho, in primary forest, at 0° 1' S (latitude) and 51° 42' W (longitude), in the state of Amapá, 230km away from the capital, Macapá (Figure 1). The option for these areas was motivated by the abundant occurrence of the species in the region. Fifty fruits of pequiá (Figure 2) were collected for each registered area, totaling 150 fruits, from which 50 were selected by weight and maturation for the procedures, being 10 designated for anatomical studies and 40 to phytochemical analyses. The identification of species was made by comparison with exsiccates available in the Amapá Herbarium – HAMAB, being later stored with the numbers 2956, 5027, 7555 and 1255, in the Botanical Division of the Institute of Scientific and Technological Research of the State of Amapá – IEPA.
2.2 ANATOMICAL PROCEDURES

The fruits were fixed in F.A. A (40% Formaldehyde, acetic acid and 50% ethyl alcohol 1:1; 18 v/v) and 70% alcohol GL (Johansen 1940; Zass 1951; Gerlach 1977). The following regions were shown: pericarp (rind), mesocarp (pulp) and seed, which is surrounded by the thorny endocarp (Figure 3). The tissue was macerated with the aid of Sudan IV (Jensen 1962).

After mesocarp removal, transverse and longitudinal sections were made at the apex of the seeds. The apices were sectioned into cubes (Figure 3). These cubes were fixed for 48 hours in F.A. A (50%) and dehydrated in increasing alcoholic series (50%, 70%, 95%, 100%, in 2 hours each); until becoming pure acetate; followed by paraffin embedding, sectioning on a rotary microtome, slides drying in an oven (40 °C), decreasing series of pure acetate to 50% alcohol, double staining of sections with Astrablau and Basic Fuchsin (1%), increasing series of 50% alcohol to pure acetate and blade assembly with Canada balsam (Johansen 1940).

The drawings referring to the pequiá fruits were elaborated with the aid of a light chamber coupled to a Zeiss magnifying glass in different increases of micrometer-scale and later placed in nanquim. The photodocumentation of the sections was done in a photomicroscope of Zeiss Light with Kodak Asa 100 film in different increases and micrometer-scale, where they were photographed and enlarged in the same optical conditions used.

2.3 HISTOCHEMICAL TESTS

Transverse and longitudinal sections and scraping (maceration) of fresh material were made in the pericarp, mesocarp and seed, with the aid of common blades. The cutinized, suberized walls and the lipids (separately) were analyzed with the reagent Sudan IV; an aqueous solution of 0.02% Ruthenium Red was used for the mucilage; the starch was visualized with potassium iodide (Jensen 1962). A saturated solution of picric acid was used for protein analysis (Johansen 1940); ferric chloride solution for phenolic compounds (Jensen 1962); Astra blue for cellulose and 0.05% Safranin for lignin (Gerlach 1977). Sections were temporarily assembled on glycerin and photographed in a Zeiss light photomicroscope, Kodak film, Asa 100.
2.4 BIOMETRIC AND CHEMICAL STUDIES

The 40 fruits were weighed and separated in pericarp, mesocarp and seed (Figure 3), with verification of the total weight and percentage/average equivalent to each correspondent part.

2.5 LIPID EXTRACTION

The mesocarp was pressed with a benchtop hydraulic press, being extracted a yellowish oil to obtain the yield. Hexane was used for solvent extraction. The obtainment of the fixed oil from the regions was facilitated by the rupture of the tissues and cell walls that compose the mentioned parts through grinding, except the mesocarp. The mass of the tissues of the pericarp and the seed were grinded separately, whereas the mesocarp did not undergo this process, due to its pasty consistency. Then, the pericarp and the seed were dehydrated in an oven with air circulation for 10 minutes at 40 °C (Moretto and Fett, 1998).

In the extractor it was obtained the fixed oil of the pericarp, mesocarp and seed; first, about 90 g of pericarp were weighed, divided into six portions of approximately 15 g each; 60 g of mesocarp into six portions of 10 grams each and; 60 g of seed mass divided into six portions of 10 grams each. All portions were wrapped in filter paper, placed in separate flasks, then 70 ml of hexane was added to each one of them to assist in oil extraction. The extraction process lasted for about 75 minutes, being 30 minutes of solvent heating at 100 °C, 30 minutes for the extraction itself, which consisted of immersing the portions in the already heated solvent, and the remaining 15 minutes for the evaporation of the solvent which was mixed with the oil. The total weight of the extracted oil was obtained by the difference of flask weights, which were measured before and after the extraction (Moretto and Fett, 1998).

2.6 DETERMINATION OF FATTY ACIDS

The fatty acids were methylated by the method of Hartman and Lago (1973) and determined by high-resolution gas chromatography. A Philips gas chromatograph model Pye Unicam PU 4550 was used, equipped with a flame ionization detector, split injector, 100:1 ratio, fused silica capillary column, 50 m long x 0.25 mm internal diameter containing 0.2 mm polyethylene glycol (CP-Sil, Crompack WCOT, Netherlands) and software data acquisition (Borwin, JMBS Developments). Chromatographic conditions were column temperature at 180 °C (isothermal); carrier gas, hydrogen at a flow rate of 2.0 ml/min, make-up gas, nitrogen at
30 ml/min; injector temperature at 270 °C and; detector temperature at 200 °C. The physicochemical indexes of the lipids were determined through the analyses of acidity, refraction, iodine, saponification, ester and peroxides indexes according to the usual methodology described by Moretto and Fett (1998).

2.7 PHYTOCHEMICAL SCREENING

Phytochemical screening was performed through prospection of the ethanolic extract of the pericarp, the mesocarp and the seed, which was obtained after these parts were left in rest for 72 hours in 65% alcohol. After this period, the extract was filtered through filter paper and deposited in a flask until complete separation from the mass in contact with the extract itself. In order to perform the phytochemical screening, seven portions (one for each test) of the ethanolic extract of the pericarp, the mesocarp and the seed of 4 ml each were separated in test tubes. Tests were performed for phenols, tannins, anthocyanin, anthocyanidin, flavonoids, flavonols, flavanones, flavanonols, xanthones and alkaloids according to Moretto and Fett (1998).

3 RESULTS AND DISCUSSION

A pequia tree in the forest does not usually produce fruits every year. Most trees "rest" in one year and produce fruits in the other. Only 20% to 30% of pequiá trees produce fruits every year. Each fruit contains one or two seeds; however, it is possible to find fruits with up to four seeds, being two large and bulky and two very small (Figures 1, 2). The pericarp (rind) is thin, brownish gray and moderately soft, representing about 60% of the weight of the fruit (Figures 1, 2). Couto (2007) obtained flour from the pericarp (rind) of Caryocar brasiliense for loaf bread production, used to feed the Cerrado population. This species presents similar characteristics to the nutritional properties of the species studied in this work.

The mesocarp is oily, moderately thick and dense, beige and creamy yellow and has thorns projected by the endocarp, representing about 15% of the fruit's weight. The endocarp is hard and contains thorns (trichomes) located in the inner layer surrounding the chestnut (seed), representing about 20% of the weight of the fruit. The seed is small, white and oily, and represents about 5% of the fruit's weight (Figures 1,2).

The presence of a yellow mass impregnated with large amounts of lipids (Figures 5 and 6) was observed in transverse and longitudinal sections of the pequiá fruit; in the seed
there was found a more rigid mass of lipids (Table 1) and endocarpic trichomes which secret these lipids, forming an arc in all its extension, very similar to thorns (Figure 7); the presence of proteins and phenolic compounds (Table 1). Due to the strong dark coloration in cotyledons, it was possible to observe the presence of abundant tannin, as well as in the pericarp (Table 1).

Tannins are responsible for numerous biological activities due mainly to their ability to complex with proteins, polysaccharides, alkaloids, metal ions and because they have antioxidant and free radicals scavenging activities. Those substances contribute to the defense of plants against insect attack and have been related to the inhibition of microorganism growth and/or anti-tumor activity (Haslam et al. 1989; Okuda et al. 1989; Mila et al. 1996; Lee et al. 2000).

Several types of tannin are used in leather industry, in adhesive production and in wood industry (Georgi 1929; Thorenstensen 1969). The pericarp of pequiá presents a great amount of tannin, which can turn out to be an important product in dye industry.

Secretory trichomes were found forming an arc surrounding the entire endocarp, secreting abundant lipids. These trichomes are around the cotyledons. Secretory trichomes are quite variable appendages of the epidermis, including glandular and non-glandular hairs, scales, papillae and absorbent hairs; and they have a variety of functions (Esau 1977; Fahn 1985). The hook-shaped glandular trichomes (secretory) of some species stick insects and larvae and also provide chemical defense (Raven et al. 2005).

The production of a secretory structure is closely linked to the formation, accumulation and degradation of innumerable organic substances found within the cells that form the various plant tissues. These structures are associated with the production of active principles found in plants and with many of the secretory phenomena that occur in these structures, which are highly specialized in the production of specific substances (Esau 1977; Fahn 1979).

The representation of the results of histochemical tests can be observed in Table 1. From these data we can state that the cells present in the fruit can secrete several substances, such as salts, sugars, starch and compounds that can be metabolic end products, such as phenols, tannins, flavonoids, lignin and others. Secretions cover the processes of formation, segregation and release of substances that can be destined to storage (Esau 1977; Cutter 1978; Fahn 1985).

The exaggerated presence of lipids in the pericarp and mesocarp gives a higher energetic value to pequiá, which is widely used in complementing the diet of the low income
population during harvest (Almeida e Silva 1994). From the nutritional point of view, it is known that the mesocarp (pulp) and the seed (almond) of pequiá have a high lipid content, comparable to those found in avocado (Tango et al 2004), in açaí (Simões et al 2001) and in buriti (Almeida and Silva 1994), fruits in which oleic and palmitic fatty acid prevails (Lima 1980, Hiane et al., 1992 and Lima et al., 2007). In addition, chemical and physicochemical characteristics were studied in Caryocar coriaceum Wittm, the pequí from Cerrado (Oliveira et al., 2010), whose results are similar to those presented in the Amazonian pequiá.

The oils of the mesocarp and the seed of pequiá are quite similar to the oil of the mesocarp of palm (Elaeis guineensis), being suitable for use in food industry and as raw material in the manufacture of soaps, detergents and biodegradable softeners, even in biofuel production.

In relation to proteins, the contents found by Ferreira et al. (1988) and Oliveira (1988) exceed from 6.71% to 13.5% those found in avocado, whose average corresponds to 1.80% (Franco 1992). In addition, 14% of fibers and 11% of carbohydrates were also found for pequiá (Aguiar et al., 1980). The presence of mucilage in certain plants may be related to some phytotherapeutic effects, such as healing, antiinflammatory, laxative, expectorant and antispasmodic. The presence of this constituent in the fruit of pequiá is abundant (Carvalho 2004; Almeida et al, 2012).

The great biodiversity in Brazil has stimulated research and studies on new potential sources for oil production. In addition, works with plant species which study the use of vegetable oil sources are already in advanced stages, aiming agriculture, as botanical insecticides (Kawanishi and Raffauf 1986), as well as their use in cosmetic industry, as a pharmaceutical product and as biodiesel (Clay et al. 2000).

The results obtained in the physical characterization of the fruits of pequiá are presented in Table 2. The values presented are the average obtained from each characteristic.

The physical characterization of the fruit showed 60.93% of pericarp, 8.75% of mesocarp and 22.12% of seed, with 8.2% of loss of the final product. The fruits of this species vary in size, weighing between 150 g and 750 g, with an average of 300 g (Marx et al., 2004). In this study the average weight of the fruit was around 235.25 g. The characteristics of fruits such as color, size, weight, seed and mesocarp (pulp) may vary according to the place of collection, maturation point, age of individuals, as well as environmental factors. The evaluation and viability of the use of native plants such as tucumã, urucuri, murumuru, buriti, inajá, pracaxi, andiroba and pequiá for production in industries present components of multiple
use in most of the Amazon. From North to South, Brazil presents possibilities in oilseed planting, lacking to adjust the soils and temperatures (Batistella et al., 2002).

Table 3 demonstrates the amount of oil extracted by pressing the pequiá mesocarp and its yield.

From the total of 40 fruits, a mass (mesocarp) equivalent to 8.75% was obtained, of which 1.57% were pressed. These values characterize a reasonable yield, because when the extraction is done by pressing there is some loss, not obtaining a satisfactory result. At the end of this process, the mass used still contains oil that can be extracted with solvent (Pereira and Pedroso 1972).

Regarding the oil content of the mesocarp, the values reported by Marx et al. (1997) for *C. villosum* (31.1%) were higher than those found in avocado (16.0%), babaçu (19.50%) and raw peanut (48.46%) (Franco 1992). This fact was confirmed in this study, since the oil yield in the mesocarp was around 38.25% (Table 3).

The pequiá oil has several applications, besides its use in cooking, the central focus of use of this product. It is utilized in cosmetic industry (creams), cleaning (soaps and detergents), and in pharmaceutical industry (Oliveira et al. 1970), even without the existence of information from research.

In Table 4 it is demonstrated the amount of oil extracted by solvent from the parts of pequiá cited above and its respective yield.

These values suggest a satisfactory result, because depending on the quantity used, the percentage will always be proportional to the equivalent to the fruit with the best use in a sample, characterizing with this, total expected yield without oil loss (Pereira and Pedroso 1972).

The pressing extraction method was less efficient when compared to the hexane extraction to obtain the best yield of the pequiá mesocarp oil, which occurs due to the loss during the pressing process. In addition, the hexane solvent is a volatile compound of lipophilic nature, that is, it has great ability to absorb the largest possible number of lipids contained in a sample, which characterizes total yield, without loss.

The chemical composition of fixed oils depends very much on the conditions and quality of the fruits, including harvest period, season, geographic conditions, plant phenotypes, soil type, climate, temperature, among other environmental factors, including distillation techniques (Pereira and Pedroso 1972), which contribute to the quality and quantity of the fixed oil extracted.
Fatty acids occur in nature as free and stratified substances. Most of these natural acids are stratified with glycerol (1,2,3-trihydroxypropane), forming triglycerides or triacylglycerols (e.g., 2), components of edible oils and fats. Fatty acids differ from one another basically by the length of the hydrocarbon chain and by the number and position of the double bonds, that is, the more unsaturations present in a fatty acid-containing substance, the more it is suitable for alimentary purposes (Moretto and Fett 1998; Villarreyes 1998).

Table 5 shows the results of the Gas Chromatography techniques, which are fundamental for verifying the length of fatty acid chains.

The analytical results showed that the pequiá oil presents different fatty acids in its chemical composition (Table 5), being compatible with a study with *Caryocar brasiliense* Camb., a plant which is very similar to *C. villosum* (Magalhães 1988, Perez 2004; Yamaguch *et al*, 2017) From these results, these species demonstrate to be a good source of monounsaturated fatty acid, with the potential to modulate, favorably, the lipid profile, reducing total cholesterol and LDL (Lima *et al.*, 2007).

The literature states that there is no significant difference between the chemical composition of the oils of both species, since the fruit oils contain myristic, palmitic, stearic, oleic, linoleic and palmitolytic acids, with melting points around 37 °C, which makes them interesting for cosmetic industry (Prance 1990; Castanheira 2005). Some studies report the use of fruits as raw materials in cosmetic industry, such as the development of bar soaps with buriti oil (Bighetti *et al* 2008) and cosmetic emulsions with pequi oil, species obtained from the Cerrado (Pianovski *et al*. 2008).

Oleic acid (omega 9) is an essential fatty acid to the human organism that participates in metabolism and is fundamental in the synthesis of hormones, besides being widely used as an additive in cosmetic soaps, soaps and emulsions due to its emolliency, lubricity properties to recover oiliness in dry skin and as a regenerator and protector of damages caused by solar rays (Piatti 2007). Andiroba oil has similar characteristics to pequiá oil regarding its composition in fatty acids (Table 5), presenting 30% in the content of palmitic acid and 52% in oleic acid (Deus e Silva 2008). This fact is similar in pequiá, which presented 44.63% in palmitic acid and 43.66% in oleic acid.

The pequiá holds an amount of oil in the mesocarp and seed that exceeds 30% for palmitic and oleic acid, fitting as an oleaginous rich in a greasy substance similar to palm oil (*Elaeis guineensis*), which is a commercial oil.
Chromatographic techniques are the procedures used to separate and determine the length of the most widely used saturated and unsaturated fatty acid chains nowadays in order to determine edible oils, being one of the most used methodologies for the study of vegetable oils (Almeida et al., 1998).

Works using vegetable sources in the production of edible oils and biodiesel characteristic from Brazil are already in advanced stages (Batistella et al., 2002), and the chromatographic techniques of both mesocarp and seeds show that the pequiá oil presents satisfactory results as a potential for biofuel.

The oil conservation state is strictly related to the nature and quality of the raw material, the oil quality and purity degree, the processing and, especially, the storage conditions, as the glyceride decomposition is accelerated by heating and light, while rancidity is almost always in conjunction with the formation of free fatty acid (Ribeiro and Seravalli 2004).

The high acidity level of a crude oil increases the loss of neutralization, and is also an indicative of poor quality samples, improper handling and storage or unsatisfactory processing (Angelucci et al., 1987). Oils with an acidity of less than 1% are classified as type 1 and when the oil has a maximum of 2.5% of free acidity, it is considered as type 3, according to Anvisa/2004 (Brasil 1999; Santos et al. 2001). The results on the acidity level showed that the mesocarp oil has a total acidity around 1.45%, being considered as type 3, whereas the seed oil is type 1.

Concerning the saponification index, it should be noted that this is important to demonstrate the presence of oils and fats of high proportion of low molecular weight fatty acids in mixtures with other oils and fat. This means that the more saturated is the lipid present, the higher the saponification index, which varies with the nature of the fatty acids constituting the fat, which is verified according to the iodine index obtained and the composition of fatty acids present in the oil (Moretto and Fett 1998; Morón-Villarreyes 1998; Yamaguch et al., 2017).

These values indicate that the oil obtained from the pequiá is saponifiable and high, that is, the lower the molecular weight of the fatty acid, the higher the saponification index. This is significant for vegetable fats, since the higher the saponification index, the more useful they are for alimentary purposes and the manufacture of soaps, detergents and softeners (Moretto and Fett 1998). These analyses were not performed in the pericarp, because the oil yield obtained was not satisfactory for such procedures.
The iodine index is the measure of the unsaturation degree of the fatty acids present in the fat. Therefore, the greater the unsaturation of a fatty acid, the greater its capacity of iodine absorption and, consequently, the higher the index (Moretto and Fett 1998). In order to present quality, the oils should not exceed the value of 10/meq 1000g of sample to guarantee the edible standard (Cecchi 2003). The results found in the mesocarp pequiá oils with 3.83 meq and seed with 1.99 meq are parameters that are related to the quality of the oil, therefore, the values obtained meet the Anvisa/2004 Resolution, which regulates the standard for edible oils and fats.

The refraction index of oils and fats is widely used as a criterion of quality and identity, since when referring to an oil, this index increases with the iodine index and can be used in the control of hydrogenation processes of unsaturated oils (Cecchi 2003).

The presence of one constituent may mask the indicative color of the presence of another, that is, the tests whose results are negative do not reflect the absence of compounds, but rather that the amount of them is not significant, which gives the tests such results (Perez 2004). This occurs in the tests for flavonoids, because this compound is present in the mesocarp, however the result was negative. This fact was registered in histochemical tests (Table 1).

Phenols are widely found in plants and correspond to a very diverse group of phytochemicals derived from phenylalanine and tyrosine. Phenolics in plants are essential in plant growth and reproduction. In addition, they act as antipathogenic agents and contribute to pigmentation. In foods, they are responsible for color, astringency, aroma and oxidative stability. There are about five thousand phenols, among them, flavonoids, phenolic acids, simple phenols, coumarins, tannins, lignins and tocopherols (Naczk and Schahidi 2004).

The main sources of phenolic compounds are citrus fruits, such as camu-camu, acerola, lemon, orange and tangerin, as well as other fruits, being found in larger quantities in the pulp than in fruit juice (Pimentel et al. 2005).

In the test for tannins, a change in the coloration of the solution of the pericarp and the seed was observed, which shifted from the original color (yellow) to a greenish coloration, that is, it is derived from aqueous solutions of catechin (hydrolysable tannins). This result indicates a positive test for the presence of tannins, which makes pequiá a recommended product for dye industry. However, no change was observed for the mesocarp, so its result is negative for this class of substances.
For anthocyanin, anthocyanidin and flavonoids there was no change in the extract when submitted to the tests, being therefore negative for these constituents.

In the pericarp there was no change in coloration, so the result for flavonols, flavanones and xanthones is negative. Nonetheless, in the mesocarp and in the seed the change was noticeable, which indicates positive test signals for this class of compounds.

The presence of phenolic constituents such as tannins, flavonols, xanthones show a wide range of biological effects, including antioxidant, antimicrobial, anti-inflammatory and vasodilator actions. These phenolic compounds have several defense functions for plants, not only against environmental conditions (light, temperature and humidity), but also for internal factors, including genetic differences, nutrients and hormones, contributing to their synthesis. (Burns et al 2001, Kähkönen, Hopia and Heinonen 2001, Seng et al 2001, Zheng and Wang 2001, Aherne and O'Brien 2002, Sellapan, Akoh and Krewer 2002). Loureiro et al. (1979) mentions the use of the pericarp (rind) of pequiá in medicinal treatment as a diuretic and in the relief of high fevers.

As for the verification of the possible presence of alkaloids in the parts of the fruits mentioned above, there was no turbidity or precipitate formation, i.e., for this class of compound the result is negative, which means the absence of this chemical component in the oil.

4 CONCLUSION

Anatomical aspects help phytochemical studies;
The composition of some fatty acids present in the mesocarp/seed oil indicates potential to reduce total cholesterol and LDL cholesterol;
It reveals potential for the manufacture of soaps, moisturizers and perfumes.
It can be helpful in leather, wood and dye industries;
It demonstrates cosmetic potential, as well as for biodiesel production;
The oil yield in extractions depends on the method and type of solvent used.

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ANEXOS

Figure 1. (*) Points of collection of pequiá, all georeferenced. Legend: 12 – Municipality of Tartarugalzinho. Source: DIDOC/IEPA.

Figure 2. Fruits of pequiá after harvest.
Figure 3. Schematic drawing of anatomical regions of pequiá. A – Fruit; B – Seeds; C – Fruit in longitudinal cut; D – Seed cut in cubes. Elaborated by Deusivan de Nazaré Cardoso.

Figure 4. General vision of the fruit (pequiá) highlighting the seeds.
Figure 5. Photomicrographs of the fruit and the seed of pequiá in transversal section: mesocarp (me); endocarp (ed); endocarpic trichomes (te); seed coat (ts); cotyledon (co).

Figure 6. Photomicrographs of the fruit and the seed of pequiá in longitudinal section: mesocarp (me); endocarp (ed); endocarpic trichomes (te); seed coat (ts); cotyledon (co).
Figure 7. Photomicrograph highlighting a transversal cut of the seed with endocarpic trichomes.

Table 1. Histochemical tests of the fruit of pequiá

| Constituents/Tests       | Pericarp | Mesocarp | Seed |
|--------------------------|----------|----------|------|
| - Lipids                 | +        | +        | +    |
| - Tanin                  | +        | -        | +    |
| - Protein                | -        | +        | +    |
| - Phenolic compounds     | -        | +        | +    |
| - Cutin                  | +        | +        | +    |
| - Suberin                | +        | -        | +    |
| - Cellulose              | +        | +        | +    |
| - Lignin                 | +        | +        | +    |
| - Mucilage               | +        | +        | +    |
## Table 3. Oil obtained from pequiá by pressing extraction

| Denomination | Mass weight (g) | Amount of oil (g) | Yield (%) |
|--------------|-----------------|-------------------|-----------|
| - Mesocarp   | 100             | 38.25             | 38.25     |

## Table 4. Oil obtained from pequiá by hexane solvent extraction.

| Denomination | Mass weight (average in g) | Amount of oil (average in g) | Yield (%) |
|--------------|-----------------------------|------------------------------|-----------|
| - Pericarp   | 15.05                       | 0.040                        | 00.27     |
| - Mesocarp   | 10.28                       | 5.404                        | 52.57     |
| - Seed       | 10.13                       | 2.239                        | 44.35     |
### Table 5. Composition of fatty acids.

| Parameters                  | Mesocarp | Seed  |
|-----------------------------|----------|-------|
| - Palmitoleic acid (C 16:1)-9 | 3.84%    | 5.76% |
| - Palmitic acid (C 16:0)     | 44.63%   | 44.84%|
| - Oleic acid (C 18:1)-9      | 43.66%   | 33.62%|
| - Linoleic acid (C 18:2)-9.12| 6.38%    | 8.19% |
| - Stearic acid (C 18:0)      | 0.93%    | 6.69% |
| - Myristic acid (C 14:0)     | 0.56%    | 0.90% |