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Composição dos ácidos graxos e química da semente e óleo obtido da semente de marolo (Annona crassiflora Mart.)

Fatty acid and chemical composition of the seed and the oil obtained from marolo fruit (Annona crassiflora Mart.)

Composición grasa y química de la semilla y el aceite obtenido de la fruta de marolo (Annona crassiflora Mart.)

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Resumo

A agregação de valores às frutas nativas por meio de estudos que possibilitem as diversas formas de aproveitá-las torna-se uma estratégia importante no processo de preservação. Nesse sentido, o objetivo deste estudo foi a caracterização física e química da amêndoa (casca, sementes e polpa), bem como seu óleo extraído da amêndoa do marolo (*Annona crassiflora* Mart.). As análises de composição proximal, pH, acidez titulável, foram estudados atividade antioxidante, concentração de vitamina C, carotenóides totais, β – carotenos, índice de iodo, índice de peróxido, refração, saponificação, matéria saponificável, perfil de ácidos graxos, atividade da água, cor e reologia. A casca da amêndoa de marolo mostrou-se rica em carboidratos, substâncias antioxidantes e vitamina C. As amêndoas, por sua vez, apresentaram alto teor de lipídios, proteínas e vitamina C. O óleo extraído da semente de marolo apresentou baixo índice de refração, índice de peróxidos, e matéria insaponificável, além de alto teor de vitamina C e ácidos graxos insaturados em comparação ao óleo de soja, além da presença de compostos antioxidantes. Por meio deste estudo, conclui-se a viabilidade de utilização de subprodutos oriundos do processamento da semente do marolo como fonte de óleos com alto teor nutricional.

Palavras-chave: Óleo de frutos; Bioprodutos; Sementes; Valor nutricional.

Abstract

The addition of values to native fruits through studies that enable the various ways of harnessing them becomes an important strategy in the preservation process. In this sense the objective of this study was the physical and chemical characterization of the seed (peel, seeds, and pulp) as well as its oil derived from marolo fruit (*Annona crassiflora* Mart.) The analyses proximate composition, pH, titratable acidity, antioxidant activity, vitamin C concentration, total carotenoids, β–carotenes, iodine index, peroxide index, refraction, saponification, saponifiable matter, fatty acid profile, water activity, color, and rheology were studied. The peel of marolo seed was proved to be rich in carbohydrates, antioxidant substances and vitamin C. The seeds, in turn, presented high content of lipid, proteins and vitamin C. The oil extracted from marolo seed presented low refraction index, peroxides index, and unsaponifiable matter, besides a high content of vitamin C and unsaturated fatty acid compared with soybean oil, in addition to the presence of antioxidant compounds. Through the study, the feasibility of using by-products from processing of marolo seeds as a source of oils with high nutritional content was concluded.

Keywords: Oil derived fruits; By-products exploitation; Seed; Nutritional value.

Resumen

La adición de valores a las frutas nativas a través de estudios que permiten las diferentes formas de aprovecharlas se convierte en una estrategia importante en el proceso de conservación. En este sentido, el objetivo de este estudio fue la caracterización física y química de la semilla (cáscara, semillas y pulpa), así como su aceite extraído de la semilla del marolo (*Annona crassiflora* Mart.). Los análisis de composición proximal, pH, acidez titulable, actividad antioxidante, concentración de vitamina C, carotenoides totales, β-carotenos, índice de yodo, índice de peróxido, refracción, saponificación, materia saponificable, perfil de ácidos grasos, agua, color y reología. La cáscara de la semilla de marolo era rica en carbohidratos, antioxidantes y vitamina C. Las almendras, a su vez, tenían un alto contenido de lípidos, proteínas y vitamina C. El aceite extraído de la semilla de marolo mostró un bajo índice de refracción, índice de peróxido y materia insaponificable, además del alto contenido de vitamina C y ácidos grasos insaturados en comparación con el aceite de soja, además de la presencia de compuestos antioxidantes. A través del estudio, se concluyó la factibilidad de utilizar subproductos del procesamiento de las semillas del marolo como fuente de aceites con alto contenido nutricional.

Palabras clave: Aceite obtenidos de los frutos; Explotación de subproductos; Semilla; Valoración nutricional.

1. Introduction

The Cerrado is the second largest Brazilian biome corresponding to approximately 22% of the Brazilian territory (Proença et al. 2000). This region is rich in native fruit species and offers a great amount of edible fruits. The habitat still requires further scientific investigation to explore its species and benefit conservation measures. The marolo or araticum (Annona crassiflora Mart.) is among the fruits of Brazilian Cerrado with great exploration potential, being consumed “in nature” or as juice, liquor, ice cream, jam, and diverse sweets (Almeida 1998; Silva et al. 2017);

The fruits of the marolo tree belong to the family Annonaceae and are found in the months of February and March, presenting a mass of approximately 1.0 kg, a large amount of seeds (104 in average) and density of 1.09 g.cm-3. However, the fruits are highly uneven with great variation in mass, form, and volume. The brownish-grey seeds are obovoid-flattened, measuring from 10 to 13 mm by 20 to 27 mm and have testa coriaceous aspect and

consistency (Silva et al. 2013). The oil is extracted from the seeds, whose residue provides the pulp and peels rich in biocompounds, which, with proper exploitation, can contribute to prevent degenerative chronic diseases and premature aging caused by free radicals.

The vegetable oils extracted from seeds represent an important product for the food industry as edible oil (Reda and Carneiro 2007), as well as its use in the development of pharmaceuticals, varnish industry, among others (Roy et al. 1996). Their extraction can be carried out through different processes, such as artisanal (boiling), mechanic hydraulic press (hydraulic and continuous), solvents, and so forth.

Knowing the oil is extremely important to know if it can be applied as a functional food. The study of the fatty profile of little-known oils helps in targeting their application and commercialization since there has been an increase in the search for oils and foods with a higher percentage of unsaturated fatty acids, considered to be healthier (de Lucena et al. 2018). Therefore, several studies have shown this profile, as well as ways to increase the fatty acids of interest (Bahadior Kodca and Argun Uzunmehmetodglu 2018; Zoidis et al. 2018; de Albuquerque et al. 2019).

In order to know and disclose the potential of fruits in Brazilian Cerrado, as well as to provide new forms of seed exploitation following fruits industrialization, the objective of this study is to assess the physical and chemical characteristics of peel, seeds, and pulp of marolo fruit (Annona crassiflora Mart.) along with its oil derived from the seeds, since these data are still scarce in the literature.

2. Methodology

The research is explanatory and experimental, with part conducted in the field where the fruits were collected and in the Chemical Food Analysis Laboratory, of the Federal University of Goiás (Pereira et al., 2018).

2.1. Obtaining raw material and installation of the experiment.

The marolo seeds used in this work were obtained (donated) from Agro-industrial Company of the city of Goiânia – GO, which processes ice cream from typical fruits of Brazilian Cerrado. Followed to the Vegetable Laboratory of the Department of Food Engineering, at Goiás Federal University, for sanitization, where it was used sodium hypochlorite (150 ppm/15 min) and divided into peels and seeds. Subsequently, part of these

seeds (200 g) was stored in low-density polythene bags aluminum-coated in freezer (-18 ºC) for further physical and chemical analyses at the Food Chemistry and Biochemistry Laboratory of Pharmacy School in the abovementioned university. The remaining seeds were followed to oil extraction.

2.2. Seed and Oil Extraction

Around 4.5 kg of the seeds were subjected to oil extraction. For better efficiency extraction, we carried a 30 min waterlogging of the seeds in water at 70-75 ºC followed by 20 min drainage and cooling in water at room temperature. We drained the almonds with the seeds, which were grinded in a blender (Vitalex) and kiln-dried out at 40 ºC for 4 h. Subsequently, we carried out the using Soxhlet extraction (TECNAL TE-044) with a light petroleum solvent at 50°C for 5 h. The residual pulp was stored in a sealed low-density polyethylene bag aluminum-coated under refrigeration (5°C). The resulting oil-solvent mixture was subjected to evaporation under reduced pressure until complete solvent applying a rotary evaporator (digital IKA RV 10). The obtained oil was stored in an amber flask of 60 mL with lid and bung covered with aluminum foil and kept under refrigeration (5°C) until the physical and chemical analyses, which were done in triplicate for the seed (seeds and peel), pulp and for marolo oil and soybean oil (control).

The physical and chemical analyses carried out in the seed and pulp referred to titratable acidity, antioxidant activity (DPPH), proximate composition, total carotenoids, β-carotene, peroxides index, saponification index, unsaponifiable matter, pH, vitamin C, water activity and color.

In addition to the refraction index, iodine index, and fatty acid profile, the chemical and physical analyses carried out in the oils were the same as those conducted in the seed and pulp, except the proximate composition.

Chemical Analysis

The analyses of moisture, raw protein, carbohydrates and ashes were carried out according to methodologies described by AOAC (2016). For fat matter, we followed the Bligh and Dyer method (1959). The total caloric value was estimated according to the Atwater conversion values.

For pH determination, we used a potentiometer according to AOAC (2016); titratable

acidity, in turn, was established through titration with a 0.01N NaOH solution. To solubilize the samples, it was applied water for the seeds and a mixture 2:1 ethyl ether:ethanol for the oil, according to the AOAC (2016) method.

The antioxidant activity of the extract was established through the stable free radical 2.2-di(4-t-octylphenyl)-1- picrylhydrazyl (DPPH), according to the method described by Brand-Williams, Cuvelier and Berset (1995) with alterations by Borguini and da Silva Torres (2009). In order to obtain the ether extract, the sample was weighed in a flask, where it was added ethyl ether and subjected to one-hour stirring. Subsequently, the extract was filtered with filter paper in a test tube of 50 mL, in which it was completed with ether at the proportion of 1:20. The dry residue of the previous extract was used to prepare the alcohol extraction following the above-mentioned steps, but now with ethyl alcohol. Later, the residue once again dried out was used to obtain the aqueous extract using distilled water always at the proportion of 1:20. To quantify the antioxidant activity of the obtained extracts, the Equation 01 was employed for the calculations using the time of 20 minutes of reaction between extract and free radical.

$$\%\ discoloration\ of\ DPPH = \left[1 - \left(\frac{Abs\ of\ the\ sample - Abs\ of\ the\ white}{Abs\ of\ the\ control}\right)\right] * 100 \qquad (01)$$

where Abs of the sample is the absorbance of the sample; Abs of the white is the absorbance of the white, and Abs of the control is the absorbance of the control (750 µL of methanol + 1.5 mL of DPPH).

Vitamin C determination was carried out through a colorimetric method with 2.4-dinitrophenylhydrazine proposed by Strohecker and Henning (1967). The reading of the samples was carried out in a spectrophotometer (Biospectro SP- 220) at 520 nm.

Total carotenoids determination was carried out using hexane as solvent at 450 nm in a spectrophotometer (Rayleigh UV-1800), according to Higby (1962).

β-carotene determination was conducted according to the methodology applied by Nagata & Yamashita (1992), where the extract of the samples was dissolved in acetone-hexane mixture. The reading was conducted in spectrophotometer (Rayleigh UV-1800) at wavelength of 453, 505, 645 and 663 nm.

Iodine index, peroxides index, saponification index, and unsaponifiable matter were carried out according to the AOCS (2009).

The refraction indices of seed and oil were established using a digital refractometer (Reichert AR-200) and expressed in °Brix for the seed and nD-TC for the oil.

Total lipids were extracted and determined according to Uekane et al (2017). The methodology used for extraction of fatty acids, involving acid hydrolysis, and for esterification of fatty acids (mixed, basic and acid catalysis). The oil fatty acids were transformed to fatty acid methyl esters, which were analyzed with a Shimadzu model gas chromatography (GC) for Mass Spectrometer Gas Chromatograph/GC- 2010 PLUS (Kyoto, Japan) equipped with a flame ionization detector. The compounds were separated on a 30 m RTxR-5 capillary fused silica column, 0.25 mm in internal diameter and with a 0.25 µm film thickness. Operating conditions were as follows: programmed column temperature, 80-220°C (5°C/min); injector temperature, 230°C; detector temperature, 240°C; carrier gas, hydrogen; gas linear velocity, 40 cm/s; ratio of sample division, 1:50. The fatty acids were identified by comparing the retention times of pure methyl ester standards of fatty acids and of the samples. Quantification was performed by area normalization.

Physical Analysis

Water activity (Aw) was measured with the equipment AQUA Lab CX-2 at the temperature of 27.5ºC.

In order to establish color, we used a colorimeter (HunterLab ColorQuest XE) with mode CIE L*a*b* determination, where the coordinate L* represents how clearer or darker the sample is, with values varying from 0 (totally black) to 100 (totally white), coordinate a* can have values from -80 to +100, in which the extremes correspond to green and red, respectively and coordinate b*, with intensity from blue to yellow, can vary from -50 (totally blue) to +70 (totally yellow).

The rheological analysis was established using a rheometer (Physica, MCR 101) with variation of temperature from 10 to 95 ºC and deformation rate 100s-1 in cone/plaque with linear scanning.

Statistical Analysis

All analyses were carried out in triplicate and the results represented by the mean value, standard deviation and coefficient of variation. For the comparison, analysis between the marolo seed oil and the soybean oil, consumed worldwide, we adopted the T test, (95% of significance) applying the Sisvar software.

3. Results and Discussion

Table 1 present the results of the chemical analyses and physical for the peel, seeds, and pulp from marolo seed.

Table 1. Chemical compositions of seeds, peel, and pie from the marolo seed, harvested in Goiânia, from 2018/2 to 2019/1.

	Moist(%)	Lip(%)	Ash(%)	Carb(%)	Prot(%)	CV(Kcal)	pH	SS(°Brix)	At(% malic acid)	Ant. Potent(%)			Vit.C
Prod										Ethanolic	Water	Ether	mg/100g
Seeds	43a±1.63	19a±0.04	1.3b±0.05	20c±0.8	17a±3	318b±6	6.4a±0.1	14b±0.1	0.4±0.3	8.2b±0.9	5b±0.6	8.5a±1	26a±3.8
Peel	32b±1.4	3.3b±0.02	0.3c±0.02	62a±1.3	2b±0.9	287c±2	5.9b±0.1	0.9c±0.1	0.15b±0.02	61a±3.6	12.7a±0.7	7.8a±2	29a±2
Pulp	4c±1.4	17a±0.01	2.9a±0.02	59a±1.4	17a±1.8	459a±3	6.3a±0.1	23a±0.2	0.7a±0.05	3.4c2.8	3.4b±2	9.7a±0.4	15b±3

*Numbers with the same letter in the column do not differ at the level of 5% of significance.
Source: Own author (2020).

The content of lipids and vitamin C presented in the seed and pulp are noteworthy since the high lipid content makes it viable as a source of this compound. Regarding the levels of vitamin C, the values presented (Table 1) are higher than those of many commercialized fruits, such as citrus.

Regarding moisture, the high content found both in the seeds and peels suggest that both could be used in the food industry. It would be convenient the application of thermal treatment to decrease this amount of water, extending its useful life. We also observed that the seeds have high lipid content (19%), as expected since the fruits seed oil is concentrated in the seeds corroborating the results found by Roesler et al. (2007), where they observed an oil content of 15%. For protein content, both seeds and pulp had similar values (16.73%) and the fixed mineral residue contents are low in the peel (0.3%). In the seeds, it was observed 1.3%. Roesler et al. (2007) found similar value for ashes (1.14%) for the same seed. Peel and pulp of the marolo seed was proved rich in carbohydrates since each 100 grams consists of 62.24g and 59.26 g, respectively.

In the results, the energy provided demonstrated that the pulp, even defatted, presented

high contents of lipids, proteins, and carbohydrates, showing the high caloric value (499.66 kcal). The seeds showed a caloric value of 318.50 kcal, much lower than the seeds of the Brazil nut (680.20 kcal) mentioned by Ferreira et al. (2006). Pulp also presented high content of soluble solids, with 23.40 ºBrix, while the peel had only 0.9 °Brix. We found that the pH of both the seeds and the pulp remained close to neutral (6.43 and 6.34). Total titratable acidity presented low contents in the peel (0.15 v/m), followed by seeds (0.43 v/m) and pulp (0.69 v/m). Regarding the antioxidant potential, we found that the peel covering the marolo seed has compounds with antioxidant effects, which after proper processing, is a fraction to be considered in the human diet. We observed that the extraction of the marolo seeds oil led to a loss of vitamin C, as observed in the contents found in the pulp. However, it was an expected result since vitamin C is thermolabile and the extraction was hot. The daily intake dosage of Vitamin C for an adult, according to FAO (2001), is 45 mg. Therefore, a portion of 200 g of seeds is sufficient to fulfill the needs of daily intake.

Table 2 present the results of the chemical analyses and physical for the peel, seeds, and pulp from marolo seed.

Table 2. Physical compositions of seeds, peel, and pie from the marolo seed, harvested in Goiânia, from 2018/2 to 2019/1.

	Aw	Coloration		
Products		**L***	**a***	**b***
Seeds	0.8±0.01	59±0.1	5.7±0.05	17±0.05
Peel	0.4±0.02	49±0.01	7±0.01	17±0.01
Pulp	0.5±0.01	64±0.2	5±0.05	17±0.04

Source: Own author (2020).

Regarding the staining data presented in Table 2, no significant differences were observed between the samples evaluated.

The seeds presented a high content of water activity (0.79). Chisté et al. (2006) mention that a water activity of 0.60 is regarded as the upper limit able to allow the development of microorganisms, suggesting that the moisture must be reduced.

Regarding parameter L*, the pulp presented light color (63.98). Fractions of seeds, peel and pulp are similar regarding parameters a* and b*. The method adopted did not reveal the presence of carotenoids and β-carotenes in all analyzed samples. The moisture content,

acidity index and peroxides, as well as other characteristics such as the smoke point, insoluble impurity, soap, iron and copper content are considered quality attributes by Ministério da Agricultura (2006) and Codex Alimentarius (2001), flavor, taste, and color of vegetable oils.

Table 3, illustrate the quality, identity and physical-chemical characteristics of the marolo oil and commercial soybean oil.

Table 3. Quality characteristics of marolo oil compared to commercial soybean oil, harvested in Goiânia, from 2018/2 to 2019/1.

	Moist (%)	At (% oleic acid)	Peroxide Index (meq peroxide/Kg)
Soybean oil	0.6^{a}±0.49	0.14^{a}±0.01	0.7^{a}±0.05
Marolo oil	6.6^{b}±0.57	0.8^{b}±0.01	0.5^{a}±0.09

*Numbers with the same letter in the column do not differ at the level of 5% of significance.
Source: Own author (2020).

Marolo oil presented high moisture content (6.63%) with significant difference ($p<0.05$) against the moisture content in the soybean oil (0.65%), with a value of 0.1%, established by Brazilian legislation (Brazil 2006) for soybean oil moisture. Consequently, the Aw (Table 2) found in marolo oil was higher (0.82) than that found in soybean oil (0.55). The percentage of water and the water activity content (Aw) found in the oil of marolo seed may reflect directly on its stability, increasing the susceptibility to oxidative processes.

Acid content in the oil (0.78) was higher than that found in soybean oil (0.14), but similar to that found in pequi oil (0.83) (Aquino et al. 2009), another fruit typical of the Brazilian cerrado. Due to the high moisture content of the marolo oil, it is expected that hydrolysis of triacylglycerols will occur, releasing the free fatty acids, as consequence, increasing the acidity.

Peroxide levels should be less than 5.0 meq/kg of oil for Brazilian legislation (Brazil 2006) and for Codex Alimentarius (2001) this value can reach 10 meq/kg of oil. According to Cecchi (2003), the peroxides index is one of the most common methods to measure the state of oxidation of oils and fats. As observed, both the marolo oil (0.55 meq /Kg) and the soybean oil (0.74 meq/Kg) are within the standards established in these legislations with significant difference ($p<0.05$) between each other.

Table 4, illustrate the quality, identity and physical-chemical characteristics of the marolo oil and commercial soybean oil.

Table 4. Identity characteristics of marolo oil compared to soybean oil, harvested in Goiânia, from 2018/2 to 2019/1.

	Nd refraction index	Iodine Index (g I_2/100g)	Saponification Index (n° mg/g of sample)	Unsaponifiable Matter (%)
Soybean oil	1.47^{b}	117.7^{b}±0.51	195.0^{a}±1.80	0.02^{b}±0.00
Marolo oil	1.46^{a}	89.7^{a}±0.63	176.1^{a}±5.54	0.01^{a}±0.00

*Numbers with the same letter in the column do not differ at the level of 5% of significance.
Source: Own author (2020).

The iodine index indicates the content of unsaturations in oils. Hence, the higher their value, the higher the content of unsaturated fatty acids present. The Codex Alimentarius (2001) establishes values between 124-139 g I2/100g for the iodine index in soybean oil. The showed value in the soybean oil was below to the value indicated in the legislation (117.69 g I2/100 g) and the value for marolo oil (89.70 g I2/100g) resembles that of peanut oil (86-107 g I2/100g), according to Codex Alimentarius (2001). Regarding the refraction index, the Codex Alimentarius (2001) and Brazilian legislation (Brazil 2006) establish values between 1.466-1.470 nD for soybean oil. There was no significant difference ($p<0.05$) between the oils assessed, with the marolo oil presenting 1.46 nD and soybean oil, 1.47 nD. The refraction index is known to be the deviation suffered by the light while passing through a medium. Thus, the higher this value, the less translucent the sample. Similar values for nD were found by Kaki et al. (2016) when studying the oil extracted from Butea parviflora seeds.

Regarding the saponification index, this parameter indicates the amount of base needed to saponify the oil. The marolo oil presented a saponification index of 176.14 mg of KOH/g of oil and soybean oil had 195.04 mg of KOH/g of oil. The Codex Alimentarius (2001) established values for soybean oil between 189-195 mg of KOH/g of oil. This is not a good parameter for the identification of oils since several of them have similar saponification indices.

The unsaponifiable matter is any content present in the oil, which is not saponifiable

by the conventional treatment with the base. The oil of marolo had lower levels of unsaponifiable matter (0.01%) compared to soybean oil (0.02%), with a significant difference ($p<0.05$) between the oils. These values are in accordance with the Codex Alimentarius (2001) and Brazil (2006), which established values lower than 1.5% for this parameter.

Table 5, illustrate the quality, (vitamin C and potential antioxidanty) characteristics of the marolo oil and commercial soybean oil.

Table 5. Bioactive components and coloring of marolo and soybean oils, harvested in Goiânia, from 2018/2 to 2019/1.

	Vit. C (mg/100g ascorbic acid)	Ant. Pot-ethanolic extract (% discoloration)	Ant. Pot. ether extract (% discoloration)	Color L*val	Color a* val	Color b* val
Soybean oil	$8.2^{a}\pm2.21$	$4.9^{a}\pm2.01$	$7.9^{b}\pm1.42$	$22.3^{a}\pm0.05$	$-3.0^{b}\pm0.07$	$8.69^{a}\pm0.15$
Marolo oil	$16.7^{b}\pm1.01$	$6.9^{b}\pm1.12$	$3.1^{a}\pm1.66$	$31.7^{b}\pm0.01$	$-2.2^{a}\pm0.01$	$10.56^{b}\pm0.02$

*Numbers with the same letter in the column do not differ at the level of 5% of significance.
Source: own author (2020).

In the analysis of antioxidants by DPPH, it was observed that the oil of marolo had a higher percentage of discoloration with the ethanolic extract, while for the soybean oil the highest percentage of discoloration occurred with the ether extract. These results are directly related to the vitamin C content presented in the samples, since this compound is a natural antioxidant.

Regarding vitamin C content, it was found a significant difference between the oils of marolo and soybean, where marolo one showed higher content (16.67). No levels of carotenoids and β-carotenes in neither marolo nor soybean oils.

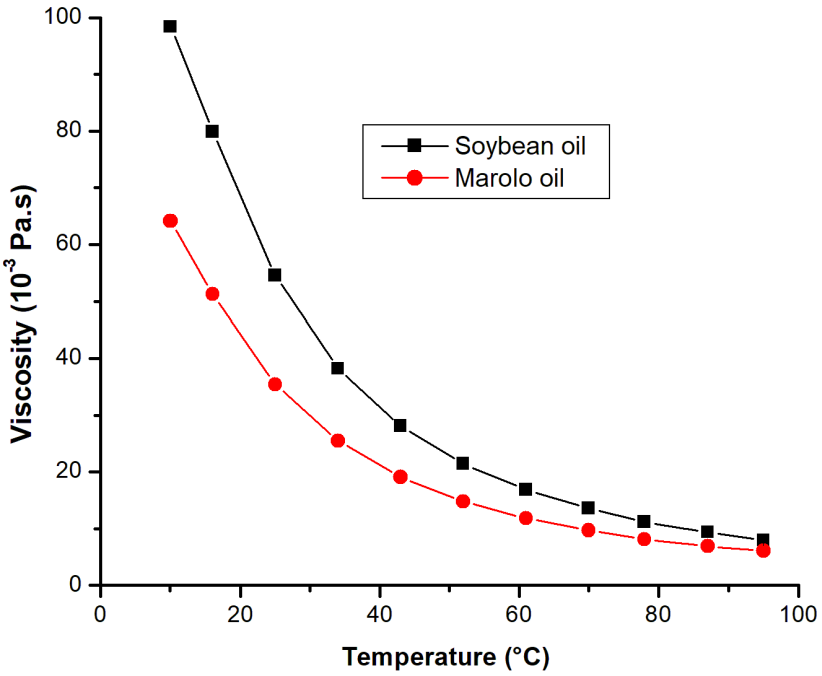
All of the parameters assessed (L*, a*, and b*) had a significant difference for color ($p<0.05$) between the oils. The marolo oil obtained 31.74 for coordinate L* and the soybean oil had 22.31, revealing that the former is lighter than the latter.

It was observed that marolo oil is composed mainly of unsaturated fatty acids (87.34%), among them 51.21% are monounsaturated and 36.13% is polyunsaturated. It causes greater instability in the formation of free radicals since the greater numbers of unsaturation allows the attack of the oxygen molecules. Among the monounsaturated fatty acids, oleic acid represents 50.76%, similar to canola oil (51-70%) and olive oil (55-83%) (Codex Alimentarius, 2001). In a study by Lopez-Huertas (2010), the substitution of dietary saturated fats for oleic acid was able to reduce blood lipids, especially cholesterol, LDL-cholesterol and

triglycerides. The major representative polyunsaturated fatty acid was linoleic acid (35.20%), which is also of great importance since it is an essential fatty acid obtained by feeding and it is not produced by the body human. Other percentages (12.56%) correspond to saturated fatty acids, among them palmitic acid, representing 7.52% of this percentage.

Figure 1 illustrates the viscosity of both oils according to the temperature alteration.

Figure 1. Viscosity (10-³ Pa.s) of both oils at different temperatures.



Source: Own author (2020).

The viscosity is a important characteristics for oils because, is a determining factor the fluidity of the compound at a given temperature. The more viscous the oil, the thicker it will be. This feature will determine its use.

Fan and Wang (2003) emphasizes the importance of knowing and controlling the viscoelastic properties of fluid for the formulation and preparation of emulsions, creams, gels, solutions, among other products. The viscosity of the oils was analyzed in the temperature range between 10-90°C, decreasing the viscosity with increasing temperature. For each studied range, there was a significant difference ($p < 0.05$) between the oils of marolo and soybean. A study by Brock et al. (2008) for cotton, rice, canola, sunflower, corn, soybean, and olive oil, complement the results found in this work and suggest that the rheological

parameters are related to the concentration of fatty acids.

4. Conclusion

After the analysis of the marolo seed components, we observed that the seeds presented high contents of lipids, proteins, and vitamin C. The peel proved to be rich in carbohydrates, antioxidants and vitamin C.

Marolo oil to be before proved more translucent and with low indices of peroxides and unsaponifiable matter, high vitamin C content and higher amount of unsaturated fatty acid, such as oleic and linoleic, in relation to soybean oil. Future works adding the 'oils are necessary' aiming to show their best use.

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