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Thermoanalytical Study of Coconut Oil (*Cocosnucifera L.)*

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Abstract:
Background*: Coconut oil (Cocosnucifera L.) has required analytical methods capable of evaluating processing and storage conditions. Foods containing oils and fats deteriorate during storage in an oxygen atmosphere due to auto-oxidation. But when they are heated to high temperatures, the oxidation process is accelerated, with oxypolymerization and thermal oxidative decomposition reactions taking place.*
Materials and Methods*In this work, the thermal and oxidative stability properties of the extra virgin coconut oil produced by the Brazilian industry and the coconut oil obtained in a handmade way were compared.*
Results*: The results confirm the high content of saturated fatty acids in coconut oil, mainly due to the high content of lauric acid, responsible for increasing the oxidation stability, besides changing the oil melting profile, contributing to the increase of the use of the fat of this oil in specific products. Extra virgin oil has greater thermal stability compared to handcraft oil.*
Conclusion:*The higher content of saturated acids in relation to the handcraft oil is responsible for the better thermal stability of the extra virgin oil, while the artisan oil presents greater oxidative stability.*
Key Word*: Coconut oi; Handcraft production; chemical composition; food.*

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I. Introduction

Vegetable oils have several applications in industrial processes and because of these potentialities, have constantly increased their demand for production[1-5]. Vegetable oils are extracted from different oil plants and used mainly as a source of food and in the production of cosmetics, lubricants, paints, pharmaceuticals, biodiesel, among others[6]. Oils and fats are recognized as an essential nutrient for the animal diet, constituting the most concentrated source of energy of the food[7]. Lipids, biomolecules that have high solubility in organic solvents and low solubility in water, are essential supplements of fatty acids, precursors of important hormones such as prostaglandins. Fatty acids are considered the building blocks of lipids and constitute about 90% of fats in foods[8].

The coconut tree (*CocosNucifera L.*), originating in Southeast Asia, was introduced in Brazil in 1553, where it is naturalized in long areas of the northeastern coast, providing abundant raw material for both regional agroindustry's and food use. Coconut oil, obtained from the pulp of mature fresh coconut (*Cocosnucifera L.* species), is composed of saturated fatty acids and unsaturated fatty acids. The saturated fatty acids present in coconut oil are: caproic, caprylic, capric, lauric, myristic, palmitic and stearic; and the unsaturated ones are: oleic and linoleic. Coconut oil is rich in lauric acid, with concentration above 40%. The lauric fats, in the case of coconut oil, are resistant to non-enzymatic oxidation and, unlike other oils and fats have a low and well defined melting temperature. Lauric fats are widely used in the cosmetic and food industry. Due to their physical properties and resistance to oxidation, they are widely used in the preparation of special fats for confectionery, ice cream, margarine and cocoa butter substitutes[9, 10].

In recent years, some studies have shown that coconut fat is able to generate heat and burn calories, favoring weight loss. Coconut oil has also been indicated to lower triglycerides and bad cholesterol, increase good cholesterol and have anti-inflammatory action[11]. In addition, fat from coconut oil leads to normalization of lipids, protects the liver from the effects of alcohol and increases the immune response against various microorganisms, and is also beneficial in combating risk factors for cardiovascular diseases[12]. When subjected to high temperatures, the virgin coconut oil does not lose its nutritional characteristics, being considered stable oil. It is also considered the healthiest to cook, not presenting trans-fat generated by the hydrogenation process, which is present in all other oils of vegetable origin, such as soy, canola, corn and even olive oil, which is considered the oil more saturated fats[13].

Coconut oil has been indicated for the treatment of obesity, whether in its fresh form, in capsules or in food preparation, being recommended as a safe food for consumption, including for use in immersion frying processes [14, 15]. However, the literature is scarce regarding the changes that coconut oil presents after being subjected to a heating process. Oils and fats, when heated, have their physical and chemical composition altered, especially if heating occurs for long periods and at high temperatures[16].

During the oil heating process, chemical reactions occur that involve hydrolysis, oxidation and polymerization of the triacylglycerol molecule, forming toxic products, such as peroxides. Physical and chemical changes result in the production of free radicals, transfatty acids, aldehydes and ketones which, when incorporated into food, can cause various diseases. Oxidative stability is an important parameter to assess the quality of oils and fats, and the antioxidant compounds present in vegetable oils are, in part, responsible for this property[17]. Coconut oil has phenolic compounds that are able to prevent or inhibit the oxidative chain and, consequently, lipid peroxidation. In this sense, understanding the changes that oils and fats undergo during heating is essential. This work aims to evaluate the thermal and oxidative stability of samples of industrial and craft coconut oil, in a comparative way.

II. Material and Methods

Materials

Samples of 200 g of coconut oils were analyzed in duplicate, being an extra-virgin sample, contained in appropriate containers, produced by Brazilian industry and available on the market, and another sample purchased at the fair-free of the city of Cuité, Brazil, produced by means of handcraft, to compare the effects of the production processes on the composition in fatty acids, physical and chemical characteristics, and thermal and oxidative stability of the oils. Analyzes were done in laboratory environment and at room temperature.

Fatty Acids Composition

Analysis of fatty acid composition was performed by gas chromatography of the methyl esters, according to the method Ce 1-91 of AOCS[18]. Determination of fatty acid composition by gas chromatography was performed under the following conditions: Chromatograph: HP 5890 series II, with flame ionization detector; FFAP fused silica capillary column: 25 mx 0.2 mm x 0.33 μmi.d; Drag gas: Analytical hydrogen 5.0; Drag gas flow: 1.00 mL / min; Column temperature: 120°C to 210°C, with programming of 2°C/min; Injector temperature: 250ºC; Detector temperature: 280ºC; Start time: 1 min; End time: 32 min; Head pressure: 65 KPa; Split rate: 1/100.

The identification of the fatty acids was performed by comparing the retention times of the test samples with the retention time of methyl ester chromatographic standards. The quantification was done by converting the percentages of areas of the peaks in percentage of mass.

Physical-Chemical Characterization

The physicochemical properties were determined using specific methods mentioned in the literature[4, 8], being analyzed the pH, solubility, acidity index, saponification index, iodine index, Peroxide content, moisture content, ash content and free fatty acid content.

The pH of the coconut oil samples was measured at room temperature in a HANNA pH-meter pH / mv.

The solubility of the coconut oil samples was analyzed in aqueous medium, alcohol (ethanol) and ethyl ether at 25^{o}C. The samples were placed in 50 mL beaker, where the respective reagents were added to allow the dissolution of the samples to be observed.

The determination of moisture was performed by gravimetric method. The experimental procedure is described below: About 25g of coarse sand were weighed and placed in a flat bottom porcelain capsule containing a glass rod. This set of materials was oven dried at 105°C for 1 hour and then cooled in a desiccator until it reached room temperature and could be weighed. Immediately after weighing, 10 ml of the coconut oil of each sample to be analyzed was placed on the dry sand and weighed again to obtain the mass of the capsule containing the moist sample. With the help of the glass rod, the oil sample was mixed with the sand. This material was oven dried at 105°C for 2 hours and then cooled in a desiccator until it reached room temperature and could be weighed to obtain the mass of the capsule containing the dried sample. Calculation of moisture was performed using the appropriate equation[19].

In the procedure for determining the acid number, in a previously 250 ml erlenmeyer, 2.01 g of coconut oil was added. Then 16.6 ml of ethyl ether and 8.3 ml of ethyl alcohol (2 + 1) were added to the mixture and stirred until complete dissolution of the sample. Then 2 drops of phenolphthalein and 1 drop of potassium hydroxide were added and titrated with pre-standard solution 0.1 mol/L KOH until a slightly pinkish coloration appeared. To calculate the acid value, expressing the result in mg KOH / g coconut oil, the specific equation was used[19].

The saponification index was determined by placing 2 g of coconut oil in a pre-tared 250 mL flat bottom flask. Subsequently, 25 mL of potassium hydroxide (KOH) alcoholic solution was added and stirred for complete dissolution of the sample. In another 250 mL flat bottom flask was placed 25 mL of KOH to make the blank. The flasks were then fitted to the reflux condensers and heated in a water bath for 30 min. Every 5 min the solution was stirred so that there was a better dissolution of the sample. When removed from the water bath, it was titrated with 1 mol/L hydrochloric acid (HCl) until phenolphthalein bleaching. To calculate the saponification index, expressing the result in mg of KOH/g of oil, the equation described in the literature[19].

In the determination of the iodine value, in a previously tared 250 mL erlenmeyer, 0.30 mL of the coconut oil was added and weighed. Then, 15 mL of chloroform was added and stirred until complete dissolution of the sample. Then 25 mL of the Rubl Reagent was added. The sample was left in a dark place for 4 hours. Then 15 ml of potassium iodide (10% KI) and 100 ml of distilled water were added. Thereafter, the excess of iodine was titrated with sodium thiosulphate in the presence of starch. The spent volume was recorded and the iodine value of the coconut oil was calculated expressing the result in g iodine/100 g of the oil. He made a blank proof in parallel. To determine the iodine value of coconut oil, the appropriate equation[19].

The appearance of the coconut oils was analyzed visually, in order to observe the presence of impurities.

The ash content was determined by placing a porcelain dish in a QUIMIS muffle at a temperature of 600°C for 20 min and then cooling. When it was reached at room temperature, 2.0 g of coconut oil was added and weighed. Immediately after the assembly was placed in the oven at 600°C for 4 hours. After the sample cooled, it was weighed again. For the determination of ash of the oil of the coconut oils, the appropriate equation was used[19].

To obtain the density, in a pre-weighed 25 ml beaker, 10 ml of oil was placed into the pre-weighed beaker and weighed on a scale DIGMED, model DG-2000, and the weight recorded. For the determination of the densities of the coconut oil samples, the specific equation[19].

The free fatty acid content, expressed as a percentage of lauric acid, was determined by adding 2.01 g of coconut oil in a pre-weighed 250 ml conical flask. Thereafter, the mixture of 16.6 ml of ether and 8.3 ml of alcohol (2 + 1) was added and stirred until the sample was dissolved. Then two drops of phenolphthalein and one drop of KOH were added and titrated with potassium hydroxide (0.1 mol/L KOH, standard) until a clear pinkish color appeared. To calculate the lauric acid index an appropriate equation was used[19].

In the determination of the peroxide index, in a previously tared 250 mL erlenmeyer, 1 g of the coconut oil sample was placed. Thereafter, 20 mL of 3:2 acetic acid-chloroform solution was added, stirring until the sample was completely dissolved. Then, 0.5 ml of KI was added and three shakes were added in 1 min at rest at the end of the procedure, immediately, 10 ml of distilled water was placed. The $Na_2S_2O_3$ solution is then slowly titrated under constant magnetic stirring until the yellow color disappears almost completely, and 2 ml of the starch solution is added to continue the titration with stirring until the blue color disappears, releasing all iodine from the solvent layer. To determine the peroxide index of the coconut oil samples, the equation described[19].

Thermal and Oxidative Stability

Thermogravimetry was used to study the thermal decomposition profile and thermal stability of the thermal degradation process of coconut oil, under non-isothermal conditions. The thermal analyzes used were Thermogravimetry (TG/DTG) and Differential Thermal Analysis (DTA), whose analyzes were performed at the Fuel Laboratory of UFCG. The TG/DTG curves were obtained from a thermobalance model TGA-50 (Shimadzu), using an alumina crucible containing about 35 mg of sample, under a dynamic atmosphere of synthetic air (50 mL/min) and nitrogen (50 mL/min), heating rate of 5 and 10°C/min and temperature range of 25 to 900°C.

Differential Thermal Analysis (DTA) was used to study the enthalpic transitions related to the thermal decomposition of constituents and primary and secondary compounds, formed in the degradation of coconut oil, in addition to its oxidative stability. To obtain the DTA curves, a DTA-51 cell (Shimadzu) was used, partially closed aluminum capsule containing about 2.0 mg of sample, under a dynamic atmosphere of nitrogen (100 mL/min) and synthetic air (100 mL/min), heating rate of 10°C/min and temperature range of 25 to 550°C.

III. Results and Discussion

Coconut oil is considered an exception when compared to other vegetable oils, because although it is highly saturated, it is liquid due to the predominance of medium chain fatty acids, which correspond to 70-80% of its composition. The fact that coconut oil has a higher amount of medium chain fatty acids, unlike other saturated fats, causes it to have a different metabolic behavior due to its structural characteristics. The fatty acid composition of the analyzed oils is listed in Table 1.

Table 1: Composition in fatty acids (% 100g) of coconut oil.

Fattyacids	Fattyacidcontent (%)	
	Extra virgin coconut oil obtained by industrial means	Coconut oil obtained by handcraft means
Caproicacid	0.38	0.30
Caprylicacid	5.56	6.64
Capricacid	4.99	6.00
Lauricacid	45.78	47.13
Myristicacid	18.56	18.60
Palmiticacid	8.85	8.70
Stearicacid	3.39	2.59
Oleicacid	5.65	7.70
Linoleicacid	0.94	1.34

The results confirm the high content of saturated fatty acids of coconut oil, mainly due to the high content of lauric acid, which together with the hydrogenation can increase the oxidative stability of the product, besides changing the melting point, increasing the range the use of these fats in specific products. Vegetable oils when subjected to hydrogenation to achieve the melting and stability characteristics required to make ice creams are subject to the appearance of new types of compounds, among them the transisomers[20]. The formation of trans isomers during the partial hydrogenation of vegetable oils is proportional to the formation of drastic processing conditions, such as high temperatures. In nutritional terms the trans isomers are digested, absorbed and incorporated by the body in a similar way to cis isomers, but they do not present activity as essential fatty acids. There are some aspects still not fully elucidated regarding the influence of trans isomers on some types of cancer, atherosclerosis and other health problems[21].

In establishing the quality parameters for the acceptability of vegetable oils, it is important that the values for the acid number are the lowest, since high values are indicative of pronounced changes, compromising their ability to use them, whether for food or Fuels. The physicochemical parameters evaluated for the samples of coconut oils analyzed in this work are listed in Table 2.

Table 2: Physical-chemical parameters of coconut oil samples.

Analysis	Extra virgin coconut oil obtained by industrial means	Coconut oil obtained by handcraft means	Standard for coconut oil (Brazil, 1999)
Aspect	Clear, no impurities	Clear, no impurities	Clear, no impurities
Ashes (%)	0.005	0.005	-
Density (g/mL)	0.897	0.896	0.903 - 0.924
Acidity level (mg KOH/g oil)	0.558	0.837	0.3 < (gross); 0.5< (refined)
Lauric acid (%)	1.990	2.985	0.5%<
Iodine Index	15	21	14 - 23
Saponification Index (mg KOH/g oil)	222	233	247 – 255
Moisture (%H_2O)	0.263	0. 382	-
pH	3.33	3.50	-
Peroxide index	0.959	2.158	-

The monitoring of the acidity of vegetable oils is also used as an auxiliary method during the stages of processing, storage and quality control[8]. The acidity index reveals the state of conservation of the oil, expressed as the number of milligrams of potassium hydroxide needed to neutralize the free acids of one gram of the sample. The high acidity index indicates, therefore, that the oil is suffering breaks in its chain, releasing its main constituents, the free fatty acids. The calculation of this index is extremely important in assessing the state of deterioration of the oil that is supplied for consumption. By means of this method, one can determine if the oil underwent hydrolytic or oxidative rancification.

The mean values of acidity determined in the samples were below the maximum value established for crude oils (4.0 mg KOH/g oil). These results demonstrate that lipid hydrolysis and oxidation did not occur during the production and storage of the oil and that probably the ambient temperature and the storage conditions in which the samples were present did not affect the constituent fatty acids very much, being evidenced by the acidity of the Conform to the standards of conformity. The acid value of the coconut oil sample, however, was higher in relation to the industrial coconut oil sample, as shown in Table 2. The acidity index can usually reveal incorrect forms of fruit harvest, improper ripening and storage, and unsatisfactory extraction processes. In addition, fat decomposition by the enzyme lipase is accelerated by light and heat, forming free fatty acids that increase acidity and cause unpleasant taste and odor[22]. Therefore, the highest acidity value in a sample may be indicative of early development of hydrolytic reactions. In addition, the storage of the oil, made in plastic packaging without adequate protection against the passage of light, contributes to the

reduction of its stability, since the sample of coconut oil extracted by hand may have remained during the storage period, more exposed to light and, therefore, have undergone greater alteration in the fatty acids content in relation to the other sample. Considering the above, it can be observed that, in general, the acidity indexes of coconut oil presented positive results, indicating a good initial state of conservation, and that, despite the adverse storage conditions; these were not sufficiently aggressive for the Deterioration of the oils according to the limits of acceptability stated in the legislation.

The iodine value is a parameter used to predict the presence of double bonds in a fatty acid ester. The higher the value found for this index, the greater the degree of unsaturation, serving as indicative of tendency to oxidation of vegetable oils. The values described in the literature for the iodine index are generally presented as a value range, rather than a fixed number, because the degree of unsaturation may vary according to aspects related to the seasonality of the oilseed or depending on different types of oil processing.

The determination of the peroxide index in vegetable oils will serve as an estimate of the degree of degradability of the raw material. The presence of peroxides is not desirable in oils and fats, since it presupposes degradation processes. Even so, Brazilian National Health Surveillance Agency Resolution[23] establishes limit values for some edible oils, and those considered to be good for consumption are those with a maximum value of 10 mEq/kg of oil or fat, for example oils peanut, linseed, palm oil, grape seed, among others. Changes in the sensory characteristics of vegetable oils are generally attributed to the presence of peroxides in the grease matter. They can also promote viscosity change, since they participate in the oxidation reactions, which end up forming compounds related to the increase of this parameter, for example the polymers[2].

Saponification index is the amount of base needed to saponify defined amount of oil and/or fat. It is expressed in the number of milligrams of potassium hydroxide needed to saponify one gram of the sample. The saponification index is an indication of the relative amount of high and low molecular weight fatty acids and does not serve to identify the oil, since many oils have very similar indices.

The values of the saponification indices obtained in the analyzed samples were below the limits determined by ANVISA[23] for coconut oil, as presented in Table 2. These results demonstrate the high proportion of low molecular weight fatty acids, but demonstrate the similarity between different oils analyzed in relation to the composition of fatty acids. The results can be explained considering the occurrence of a variation in the nature of its constituent fatty acids or even of possible adulterations with the addition of other types of vegetable oils with different saponification indices. The variations between the results of the saponification index can also be attributed to the particular characteristics of each oil, such as the form of cultivar and the region of cultivation. Another factor that must be taken into account is the difficulty in saponifying some samples, since they require more time for the process.

The ash content in food refers to inorganic residue, or fixed mineral residue (sodium, potassium, magnesium, calcium, iron, phosphorus, copper, chloride, aluminum, zinc, manganese and other mineral compounds) remaining from burning organic matter In high temperature (500-600°C)[1]. However, this is not always the case for the inorganic substance present in the sample, since some salts can be reduced or volatilized when heated at high temperatures[8]. Table 2 shows the ash amount results in these oil samples. It can be concluded that the total insoluble matter obtained in the determinations of insoluble in the ether are of organic origin, since, after burning in muffle at 550ºC, no ash content was obtained in the samples of coconut oil investigated. No values were found in the literature for the minimum limits for the determination of ash content in coconut oil.

During the process of refining edible oils, the concern is to eliminate the moisture acquired in some stages of the process to preserve the characteristics of the final product for a long period of time. The presence of moisture in the oils and the heat favor the activation of enzymes that rapidly hydrolyze the oil, producing a considerable increase in the free acidity generating an odor and unpleasant taste of rancid. Besides these conditions, they also lose valuable food components such as vitamins and antioxidants[8].

The iodine index is the measure of unsaturation in oils and fats and is used as a control for some processing. This index is based on the fact that iodine and other halogens are added in a double bond of the unsaturated fatty acid chain and expressed as the number of grams of iodine absorbed per 100 g of the sample.

The solubility of coconut oil varied in different solvents. In aqueous medium, as expected, coconut oil samples did not mix with water, even with constant stirring, since oils and fats are nonpolar substances and water is polar. In an alcoholic medium coconut oil samples were not mixed with the alcohol. Samples of coconut oil showed total solubility in medium with ethyl ether.

Foods containing oils and fats deteriorate during storage in an oxygen atmosphere due to auto-oxidation. But when they are heated to high temperatures, the oxidation process is accelerated, with oxypolymerization and thermal oxidative decomposition reactions taking place. This can also be observed during the refining phases of vegetable oils[4]. The thermal stability of oils depends on their chemical structure: oils with saturated fatty acids are more stable than unsaturated ones. As these oils are widely used in cooking and in industry, researchers and specialized technicians have been required to have new analytical methods

capable of evaluating the processing and storage conditions. Therefore, knowledge of the thermal stability of vegetable oils is of fundamental importance for a rigorous quality control[24]. Among the factors that influence the changes that appear in the oils during frying, some have greater influence at temperatures above 200°C where the maximum decomposition of the oils begins[25-27].

According to the TG/DTG curves (Figures 1 and 2), it can be observed that for coconut oil obtained by handcraft, the thermal stability is around 234°C and the oxidative stability around 229°C. Under synthetic air atmosphere, the first decomposition event occurred in the range 229–350°C with a weight loss of 78%, attributed to the decomposition of unsaturated fatty acids. The second event (350–545°C) with 21% weight loss probably refers to the decomposition of saturated fatty acids and oxidative compounds formed in the first stage by the action of air. Under nitrogen atmosphere, the first decomposition event occurred in the range 234–383°C with a weight loss of 89%, attributed to the decomposition of unsaturated fatty acids. The second event (383–582°C) with approximately 11% weight loss probably refers to the decomposition of saturated fatty acids.

Figure 1: TG/DTG curves of handcraft coconut oil under synthetic air atmosphere.

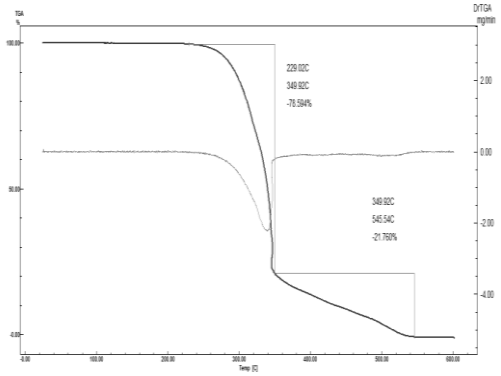
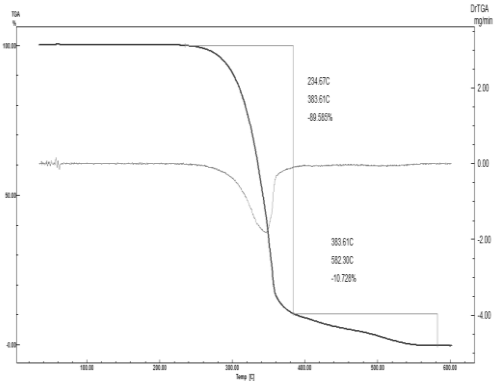


Figure 2: TG/DTG curves of handcraft coconut oil under nitrogen atmosphere.



In relation to coconut oil obtained industrially, extra virgin, it can be observed that the thermal stability is around 236°C and the oxidative stability around 226°C, according to the TG/DTG curves (Figures 3 and 4). Under synthetic air atmosphere, the first decomposition event occurred in the range 225–410°C with a weight loss of 94%, attributed to the decomposition of unsaturated and saturated fatty acids. The second event (410–595°C) with 6% weight loss probably refers to the decomposition of the remaining saturated fatty acids and the oxidative compounds formed in the first stage by the action of air. Under nitrogen atmosphere, the first decomposition event occurred in the range 236–447°C with a weight loss of 97%, attributed to the decomposition of unsaturated and saturated fatty acids. The second event (447–595°C) with approximately 3% weight loss probably refers to the decomposition of the remaining saturated fatty acids.

Figure 3: TG/DTG curves of extra virgin coconut oil under synthetic air atmosphere.

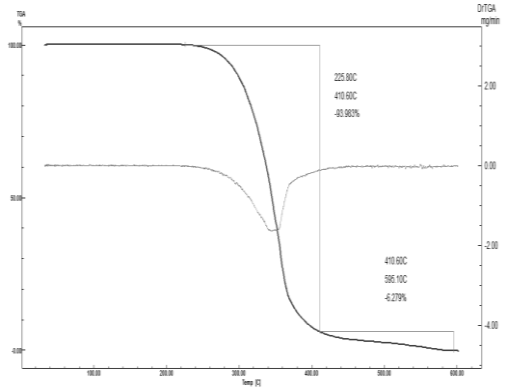
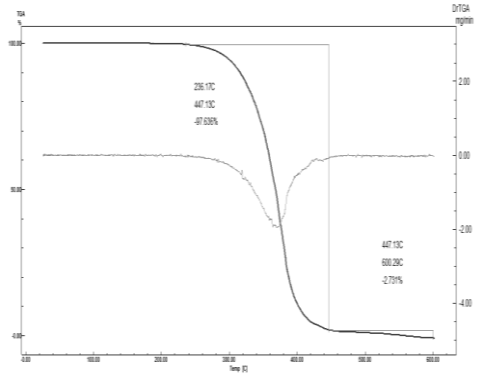


Figure 4: TG/DTG curves of extra virgin coconut oil under nitrogen atmosphere.



Through the thermogravimetric curves (TG/DTG) of coconut oil obtained industrially (extra virgin) and that obtained by handcraft it can be observed, in relation to thermal decomposition, that both with regard to thermal stability (atmosphere of nitrogen) as for the oxidative stability (synthetic air atmosphere) there is little variation in the beginning temperatures of these processes in relation to the two oils. However, extra virgin oil has greater thermal stability compared to handcraft oil. This result suggests that the higher content of saturated acids in relation to the artisanal oil is responsible for the better thermal stability of the extra virgin oil, while the artisan oil presents greater oxidative stability.

The events verified in the TG curves were exothermic transitions, as evidenced in the DTA curves, showed in the Figures 5 to 8. According the Figures, these events are characteristic of decomposition/combustion, in addition to the possible polymerization of the material. In all cases, the first exothermic event occurred with greater energy release with maximum temperature varying according to the atmosphere and the oil analyzed. The maximum peak of oxidative decomposition was 339^{o}C for handcraft coconut oil and 355^{o}C for extra virgin coconut oil. As for thermal decomposition, the maximum peak was 350^{o}C for handcraft coconut oil and 372^{o}C for extra virgin coconut oil.

Figure 5: DTA curve of handcraft coconut oil under synthetic air atmosphere.

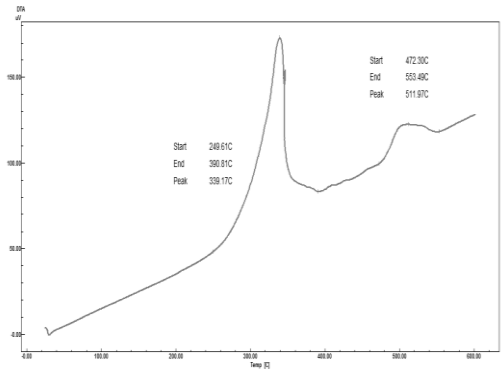


Figure 6: DTA curve of extra virgin coconut oil under synthetic air atmosphere.

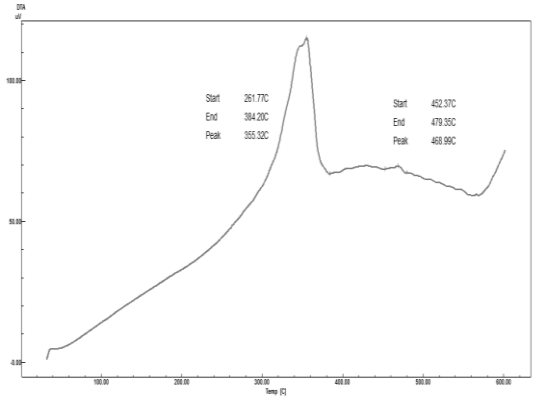


Figure 7: DTA curve of extra virgin coconut oil under nitrogen atmosphere.

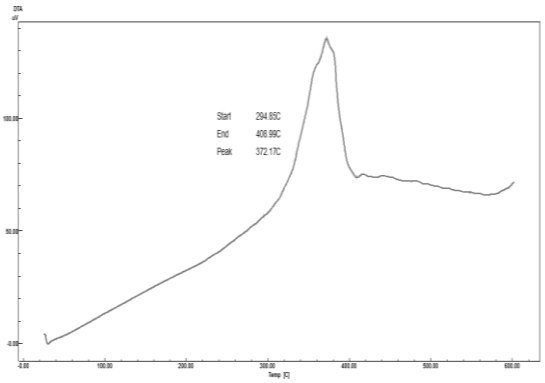
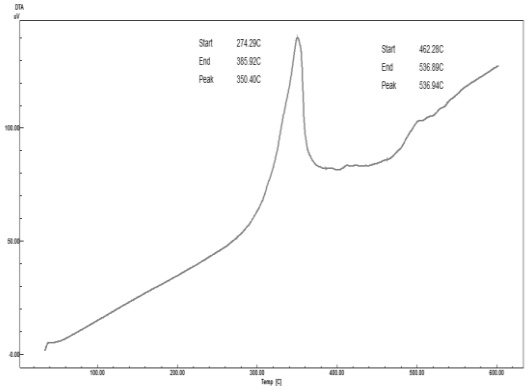


Figure 8: DTA curve of artisanal coconut oil under nitrogen atmosphere.



IV. Conclusion

The handcraft extraction method does not interfere in the physicochemical properties; since independent of the methodology adopted these parameters remain within the limits stipulated by the current legislation for cold pressed and unrefined oils. However, the analyzes made of coconut oil were extremely important to be able to refer to this oil, as its studies are still scarce and controversial in the literature. It is important to note that coconut oil is denominated as extra virgin because it has an acid value less than 0.5%. In addition, the saturated fat content of coconut oil is similar to that of human milk, which means that it is easily digested, generating energy quickly and beneficial effect on the immune system.

In relation the thermal and oxidative stability was observed the extra virgin oil has greater thermal stability compared to handcraft oil. This result suggests that the higher content of saturated acids in relation to the handcraft oil is responsible for the better thermal stability of the extra virgin oil, while the artisan oil presents greater oxidative stability.

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