

Physico-Chemical Characterization and Fatty Acid Profile of the *Acrocomia emensis* (Arecaceae) Seed Oil

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Abstract

In Brazil there are several oleaginous plants, with the potential to supply oil as raw material for various types of industries (cosmetic, pharmaceutical, energy, among others), among them we have the *Acrocomia emensis* (Arecaceae) known as tucum rasteiro. The objective of this work was to realize: extraction of the oil of the almonds using two types of cold mechanical press (walrus type and manual hydraulic type of 15 tons), physical-chemical analyzes (acidity index, peroxides, refraction, moisture and volatile material, ash, viscosity and density at 25 °C) and fatty acid profile of the oil extracted from almonds of *A. emensis* from three localities in the northern state of Minas Gerais, Brazil (Bonito de Minas, Brasília de Minas and Montes Claros). The values of the physical-chemical indexes varied among the samples from the different locations. Extraction using walrus type press provided higher yield. The fatty acids of the oils of the three origins were: caprylic, capric, lauric, myristic, palmitic, stearic, oleic and linoleic. The majority in the three samples were the lauric acid.

Keywords: almonds, lauric acid, oleaginous, tucum

1. Introduction

Acrocomia emensis (Arecaceae), popularly known as tucum rasteiro, is a sub-shrubpalm characteristic of Cerrado lato sensu, found in the states of Mato Grosso do Sul, Goiás, Minas Gerais, Paraná and São Paulo, Brazil. It has globose fruits, with leathery epicarp of yellowish-green color, mesocarpo fleshy and immersed in short fibers strongly adhered to the endocarp. This one presents black coloration, 2 mm thick and contains a single seed. Regional fauna such as armadillos, possums and small rodents consume the fruits (Lorenzi, 2010).

The potentialities of the *A. emensis* fruits are still unclear. However, in Brazil palm trees, in general, stand out for the use of products and by-products. Being these used in the food, cosmetics and energy industries. There are studies of physico-chemical parameters of oils of some species of the family Arecaceae that demonstrate the possibility of the use in the production of biodiesel. Some examples are Buriti (*Mauritia flexuosa*), Palma (*Elaeis guineensis*), Tucumã (*Astrocaryum aculeatum*), Macaúba (*Acrocomia aculeata*) and Jerivá (*Syagrus romanzoffiana*) (Barbosa et al., 2009; Cesar et al., 2015; Esteban et al., 2012; Coimbra & Jorge, 2012)

Due to the few existing works on this species, studies on the oil potential of the fruits of this palm are necessary. Because it is important to look for new species that produce good quality oil for the production of biotechnological products such as biodiesel, since currently the production of this fuel occurs using as input mainly the soybean oil that is also used in food (No, 2011).

From the analysis of physicochemical parameters of the oil is possible to identify if it presents suitable characteristics to be used in the production of biodiesel. The verification of different extractive methods to obtain

the oil is important as a way to select the best procedures, promoting better use of the raw material (No, 2011; Manfio et al., 2011).

Thus, the objectives of the present work were to evaluate two types of press: walrus and hydraulic press, physical-chemical characteristics and to identify the fatty acids, of the *A. emensis* fruits of three localities in the North of Minas Gerais, Brazil.

2. Method

2.1 Plant Material

The fruits were collected in three locations in the North of Minas Gerais: Coordinates (UTM): Bonito de Minas (23 K 508650 8315987), Brasília de Minas (23 K 569414 8206247) and Montes Claros (23 K 600899 8169206) (Figure 1). In each locality, 50 individuals were studied, from which a bunch of fruits were collected. Collection took place in February 2015, a sample was deposited on the form of exsicata in the Herbarium of the State University of Montes Claros Voucher 4.362. In total, 2,083 fruits were collected, Bonito de Minas (614), Brasília de Minas (726) and Montes Claros (743). After collection, the fruits were taken to the Laboratory of Bioprospecting and Genetic Resources at the State University of Montes Claros. It was made fruits asepsis and storage in plastic trays at 17 °C (± 2 °C) until the beginning of the analysis.

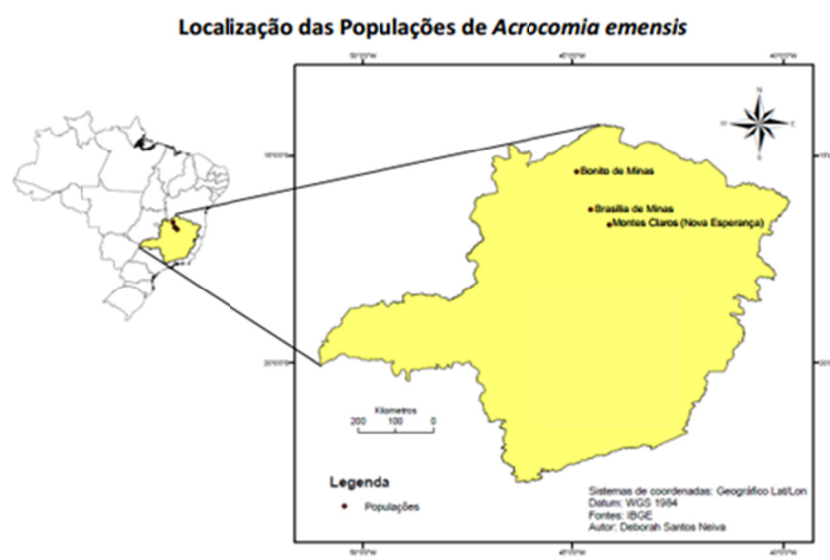


Figure 1. Geographical location of the natural populations of *A. emensis*

2.2 Oil Extraction

The almonds of *A. emensis* were crushed before pressing, which occurred in two types of cold mechanical presses, to verify which method provided the highest yield. The almonds of *A. emensis* from the population of Bonito de Minas were selected for extraction with walrus type press/bench vise. The almonds of Brasília de Minas and Montes Claros were processed in a 15 ton manual hydraulic press (Skay).

2.3 Gas Chromatography

The analysis were performed on an HP7820A Gas Chromatograph (Agilent) equipped with a flame ionization detector. Data Acquisition Program EZChrom Elite Compact (Agilent). An HP-INNOWax (HP) 15 m \times 0.25 mm \times 0.20 μ m column with temperature gradient: 70 °C, 0 min, 7 °C/min to 240 °C was used; Injector (split of 1/50) at 250 °C and detector at 260 °C. Hydrogen as entrainment gas (3 mL/min) and injection volume of 1 μ L. Identification of peaks was done by comparison to FAME C14-C22 methylated fatty acid standards (Supelco cat no 18917).

2.3 Physico-Chemical Analysis

The analyses were carried out with oil from the three origins, following the methodologies of the American Oil Chemists Society (AOCS, 2012) for the analyses of acidity index, peroxides, refraction, ashes and relative

density. To evaluation, the moisture and volatile material and viscosity were used methodologies of the Adolfo Lutz Institute (IAL, 2008).

The exception was the iodine index that was calculated based on the composition of fatty acids with unsaturated bonds and in the percentages in the composition of the oil, obtained by gas chromatography analysis, using equation 1 (Knothe, 2002).

$$II_{oil} = \Sigma 100 \frac{-Af \times 253.81 \times db}{MWF} \quad (1)$$

Where, II = iodine index; db = number of unsaturated bonds of the fatty acid; MWF = molecular weight of the fatty acid; 253.81 = weight of two iodine atoms which are theoretically added to a double bond and Af = percentage of the fatty acid in the composition.

3. Results and Discussions

3.1 Extraction of the Oil

The almonds used to extract the crude oil of *A. emensis* had a dry mass weight ranging from 0.82 g (± 4.03) to 1.68 g (± 4.42), being these values for the populations of Brasília de Minas and Bonito de Minas, respectively. The almond of the *A. emensis* is small and difficult to remove from the endocarp, which makes that the removal without damage be a difficult task. This was also observed in the almond of Jerivá, which has an average weight of 0.23 g, which is lower than the weight measured for the almonds of *A. emensis* (Goudel et al., 2013).

The extraction of the oil with the walrus type press (Bonito de Minas population) was more laborious, compared to the hydraulic press, but with the best yield (18%). Extraction in hydraulic press (populations of Brasília de Minas and Montes Claros) was faster, but the extraction yield was lower, being that oil yield of the population of Brasília de Minas was 11.75% and of the population of Montes Claros was 10.60%. With that, it was observed that the extraction using the walrus type press allowed a greater use of the almonds of *A. emensis*.

3.2 Chromatographic Analysis

The oils of *A. emensis* have eight fatty acids (Figure 2), which have between 12 and 18 carbons in their chains, as can be observed in the chromatograms.

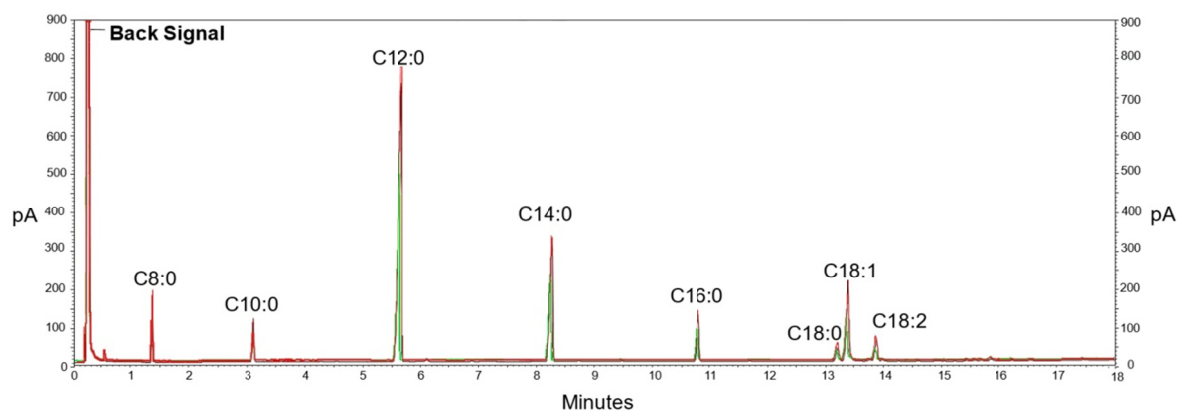


Figure 2. Chromatograms of the oil samples from the three populations of *A. emensis* (black = Bonito de Minas; red = Brasília de Minas and green = Montes Claros)

The amounts of these acids varied little among the three populations, as can be seen in Table 1.

Table 1. Fatty acids of oils of species of the family Areaceae

Oil	Fatty acids (%)								Ref.
	Caprylic (C8:0)	Capric (C10:0)	Lauric (C12:0)	Myristic (C14:0)	Palmitic (C16:0)	Stearic (C18:0)	Oleic (C18:1)	Linoleic (C18:2)	
<i>A. emensis</i>	3.48	3.08	49.82	17.22	6.52	2.15	10.68	2.97	(1)
<i>A. emensis</i>	3.35	3.11	50.57	16.35	6.01	2.42	11.77	3.39	(2)
<i>A. emensis</i>	2.82	2.66	51.04	17.51	6.06	2.02	11.81	3.58	(3)
Babaçu	5.0	6.0	44.0	17.0	8.0	4.5	14.0	2.0	(4)
	4.74	5.17	44.96	16.91	9.7	11.44	7.0	-	(5)
	5.03	9.18	46.89	16.95	7.98	2.38	13.54	1.34	(6)
Buriti	-	-	-	0.5	19.2	1.3	65.6	4.9	(7)
	-	-	0.1	0.1	18.75	1.35	75.5	2.15	(8)
Tucumã	2.03	1.83	51.42	26.09	5.55	2.36	5.97	2.09	(9)
Palma	-	-	0.05	1.14	45.24	4.13	37.23	10.6	(10)
	-	-	-	-	45.6	3.2	38.5	10.5	(11)
Macaúba	3.67	2.79	32.58	9.21	8.25	2.24	36.27	3.82	(12)
Jerivá	6.64	5.69	33.13	9.81	8.24	3.32	27.81	4.19	(12)

Note. (1) Bonito de Minas, (2) Brasília de Minas, (3) Montes Claros. References: (4) Lima et al. (2007); (5) Machado et al. (2006); (6) Santos et al. (2013); (7) Speranza et al. (2016); (8) Rodrigues et al. (2010); (9) Barbosa et al. (2009); (10) Sotero et al. (2008); (11) Esteban et al. (2012); (12) Coimbra and Jorge (2012).

The fatty acid found in greater quantity in the three oils is lauric acid. This acid is also found in large quantity in the Babaçu almond oils (from 44% to 46.89%), Tucumã (51.42%), Macaúba (32.58%) and Jerivá (33.13%) (Table 2). Oils that have a predominance of this acid are interesting for the cosmetics industry and biofuels, due to this acid to confer excellent physico-chemical characteristics to the oil, and in the case of biodiesel production, this fact favors higher yield (González-Perez et al., 2012).

The myristic acid is second most found in *A. emensis* oils (17.51%, 16.35%, and 17.22%), being also the second most found in Babaçu oils (between 16.91% and 17.0%) and Tucumã (26.09%) as can be seen in Table 1. The oleic acid is third most prevalent in *A. emensis* oils (10.68%, 11.77% and 11.81%). This acid is the majority in the oils of Buriti (between 65.6% and 75.5%) and Macaúba (36.27%). It is also present in Babaçu oils (between 7% and 14%), Palma (37.23% and 38.5%) and Jerivá (27.81%) (Table 1). The palmitic acid is fourth most found in *A. emensis* oils (6.01%, 6.06% and 6.52%) and in the palm oil is the most prevalent fatty acid (between 45.24% and 45.6%), as can be seen in Table 1.

3.3 Physico-Chemical Characterization of Oil

There are studies that demonstrate the potential of several species of the Areaceae family for biodiesel production (Table 2).

Table 2. Indices of acidity, peroxides, iodine and moisture of family species oils

Species	Acidity (mg KOH g ⁻¹)	Peroxides (meq Kg ⁻¹)	Iodine (cg I ₂ g ⁻¹)	Moisture (%)
<i>A. emensis</i> ¹	15.88 (±1.08)	14.54 (±0.45)	15.74	0.178 (±0.13)
<i>A. emensis</i> ²	22.36 (±0.43)	15.07 (±1.06)	17.57	0.589 (±0.45)
<i>A. emensis</i> ³	16.04 (±0.54)	12.32 (±1.27)	17.97	0.499 (±0.39)
Babaçu	3.75 ⁽⁴⁾ ; 0.505 ⁽⁵⁾	0.4 ⁽⁴⁾ ; 0 ⁽⁶⁾	17.3 ⁽⁴⁾	0.17 ⁽⁴⁾
Palma	11.6 ⁽⁷⁾	0.6-2.19 ⁽⁸⁾	50.48 ⁽⁹⁾	-
Tucumã	37.5 ⁽¹⁰⁾ ; 1.9 ⁽¹¹⁾	13.9 ⁽¹⁰⁾ ; 6.89 ⁽¹¹⁾	220 ⁽¹⁰⁾	-
Buriti	5.22 ⁽¹²⁾ ; 1.59 ⁽¹¹⁾	4.61 ⁽¹²⁾ ; 7.49 ⁽¹¹⁾	66.6 ⁽¹²⁾	0.1 ⁽¹²⁾
Macaúba	5.61 ⁽¹³⁾	-	-	-

Note. ¹ Bonito de Minas, ² Brasília de Minas, ³ Montes Claros. References: (4) Luz et al. (2011); (5) Lima et al. (2007); (6) Machado et al. (2006); (7) Oliveira et al. (2013); (8) Almeida et al. (2013); (9) Sotero et al. (2008); (10) Barbosa et al. (2009); (11) Santos et al. (2013); (12) Jacobo et al. (2009); (13) Cesar et al. (2015).

The oil of *A. emensis* had an acid index of 15.88 mg KOH g⁻¹, 16.04 mg KOH g⁻¹ and 22.36 mg KOH g⁻¹ for the populations of Bonito de Minas, Montes Claros and Brasília de Minas, respectively (Table 3). These values were higher than those reported for the oils: Babaçu (3.75 mg KOH g⁻¹ and 0.50 mg KOH g⁻¹), Palma (11.6 mg KOH g⁻¹), Buriti (5, 22 mg KOH g⁻¹ and 1.5 mg KOH g⁻¹) and Macaúba (5.61 mg KOH g⁻¹). However, when we compare the *A. emensis* oils with the Tucumã oil (37.5 mg KOH g⁻¹ and 1.9 mg KOH g⁻¹) we noticed that the acid value of *A. emensis* oil is intermediate.

The oil extracted from the almonds of the population of Brasília de Minas (22.36 mg KOH g⁻¹) had the highest acidity value. This result can be due to possible degradation of the almonds, due to the time elapsed between the collection and the extraction of the oil, this can be applied to the other oils. In this way, the selection of operating conditions (storage and time) reduces changes and is important for obtaining a good quality product.

The values of peroxides for the oils of the populations of Brasília de Minas (15.07 meq kg⁻¹), Bonito de Minas (14.54 meq kg⁻¹) and Montes Claros (12.32 meq kg⁻¹) were higher than the values reported in the literature for other oils of the Areaceae family species: Babaçu (0 and 0.4 meq kg⁻¹), (0 and 0.4 meq kg⁻¹), Palma (0.6 and 2.19 meq kg⁻¹), Buriti (4, 61 and 7.4 meq kg⁻¹) and Tucumã (13.9 and 6.8 meq kg⁻¹) as can be seen in Table 2.

The moisture of the oil of the almonds in the population of Brasília de Minas (0.589%) was higher than the value of samples from Montes Claros (0.499%) and Bonito de Minas (0.178%). These results corroborate with the biometric analyzes, where the population of Brasília de Minas also had a higher percentage of moisture in the epicarp, mesocarp and seed. The moisture in the Bonito de Minas oil sample was similar to the values reported for Babaçu (0.17%) and Buriti (0.1%) as can be seen in Table 2. The moisture value confirms the analysis of acidity and peroxide, because in both, the oil of the population from Brasília de Minas obtained a higher value in relation to the other populations, demonstrating that moisture is one of the factors that influence on this parameter.

The iodine index of *A. emensis* oils varied little among the three populations. In the oil from Montes Claros (17.97 cg I₂ g⁻¹ oil), a value very close to that of Brasília de Minas (17.57 cg I₂ g⁻¹ oil) was observed. On the other hand, the oil from the population of Bonito de Minas (15.74 cg I₂ g⁻¹ oil) had the lowest iodine value. In spite of this variation is possible to verify that these values are similar to the one mentioned for the oil of Babaçu (17.3 cg I₂ g⁻¹ oil), and are inferior to those reported for oils of Palma (50.48 cg I₂ g⁻¹ oil), Buriti (66.6 cg I₂ g⁻¹ oil) and Tucumã (220 cg I₂ g⁻¹ oil) (Table 2).

The degree of oil insaturation is what determines the iodine index. Soon after analyzing the fatty acid composition (Table 1) it is possible to verify that the oil of the population of Montes Claros, which had a higher iodine value, is the one with the highest amount of oleic fatty acids (11.81%) and linoleic acid (3.58%). In the locality Brasília de Minas, where was observed iodine value lower than Montes Claros, it has oleic acid (11.77%) and linoleic acid (3.39%) in intermediate amounts among the three populations. On the other hand, the oil from the locality Bonito de Minas has the lowest amounts of oleic acid (10.68%) and linoleic acid (2.97%), which reflects a lower iodine value.

The oil extracted from the population of Bonito de Minas was the one that obtained the highest viscosity value (67.89 mm² s⁻¹), followed by Brasília de Minas (60.70 mm² s⁻¹) and Montes Claros (54, 60 mm² s⁻¹). These values are higher than those reported for Babaçu oil (34.84 mm² s⁻¹) and Macaúba oil (4.20 mm² s⁻¹), however are lower than the value of palm oil (79.7 mm² s⁻¹) (Table 3).

Table 3. Refraction, viscosity, density and ash of oils of species of the family Areaceae

Species	Refraction (nD)	Viscosity (mm ² s ⁻¹)	Density (g cm ⁻³)	Ash (%)
<i>A. emensis</i> ¹	1.455	67.89 (±2.70)	0.937 (±0.00)	0.622 (±0.13)
<i>A. emensis</i> ²	1.456	60.70 (±0.98)	0.882 (±0.00)	0.909 (±0.46)
<i>A. emensis</i> ³	1.458	54.60 (±3.62)	0.884 (±0.00)	0.498 (±0.18)
Babaçu	1.448 ⁽⁴⁾	34.84 ⁽⁵⁾	0.914 ⁽⁶⁾ ; 0.914 ⁽⁴⁾	0.03 ⁽⁷⁾
Palma	1.460 ⁽⁸⁾	79.7 ⁽⁹⁾	0.9151 ⁽⁸⁾ ; 0.917 ⁽⁹⁾	0.01 ⁽⁷⁾
Tucumã	-	-	0.8889 ⁽¹⁰⁾	-
Buriti	1.466 ⁽¹¹⁾	-	0.9097 ⁽¹¹⁾	-
Macaúba	1.451 ⁽¹²⁾	4.20 ⁽¹²⁾	0.9205 ⁽¹²⁾	-

Note. ¹ Bonito de Minas, ² Brasília de Minas, ³ Montes Claros. References: ⁽⁴⁾ Machado et al. (2006); ⁽⁵⁾ Nascimento et al. (2009); ⁽⁶⁾ Luz et al. (2011); ⁽⁷⁾ Costa Neto et al. (2000); ⁽⁸⁾ Sotero et al. (2008); ⁽⁹⁾ Siddique et al. (2010); ⁽¹⁰⁾ Barbosa et al. (2009); ⁽¹¹⁾ Jacobo et al. (2009); ⁽¹²⁾ Cesar et al. (2015).

The viscosity of oils increases with the length of the chains of the fatty acids that compose it and decreases with the increase of the degree of insaturation. As can be seen in Table 1, fatty acids that have the largest chain size are also the only ones that have insaturations. Thus it can be inferred that the oil of Bonito de Minas has higher viscosity among the oil of the three populations due to the lower amount of oleic (16.68%) and linoleic (2.97%) unsaturated fatty acids. On the other hand, the oil of the Montes Claros population had a lower viscosity value due to the higher amount of oleic acid (11.81%) and linoleic acid (3.58%). Moreover, the oil of the locality Brasília de Minas has intermediate amounts of oleic acids (11.77%) and linoleic acids (3.39%) which legitimates with the viscosity measured for the oil of that locality.

The density values of the oils from the populations of Brasília de Minas (0.882 g mL⁻¹) and Montes Claros (0.884 g mL⁻¹) were similar. However, the oil of the population of Bonito de Minas (0.937 g mL⁻¹) had a higher value than the other populations. When compared to the oils of other species of the family Arecaceae, it is possible to observe that the values are close, as can be seen in Table 3.

The oil ash index of the population of Brasília de Minas (0.909%) was higher than the value measured for the populations of Bonito de Minas (0.622%) and Montes Claros (0.488%). These values are higher than those determined for palm (0.01%) and Babaçu (0.03%) oils (Table 3).

The refractive index increases with the length of the hydrocarbon chain and with the degree of insaturation of the fatty acids constituting the triglycerides. It can still vary with the presence of oxidized compounds and polymers and with heat treatment, so it will be characteristic for each type of oil (Santos & Vieira, 2013). The refractive index was similar for the oils of the populations of Bonito de Minas (1.455 nD), Brasília de Minas (1.456 nD) and Montes Claros (1.458 nD). This value is close to that verified for oils from other palms such as Babaçu (1.448 nD), Palm (1.460 nD), Buriti (1.466 nD) and Macaúba (1.451 nD) as can be seen in Table 3.

4. Conclusions

The physico-chemical characteristics of the oils extracted from the almonds of these fruits of *A. emensis* varied among the analyzed populations. Being that these differences may be due to genetic factors and environmental conditions, since the availability of water, temperature and soil can influence the quality of the oil. It can be concluded that the oil of *A. emensis* has similar characteristics to other oils of species of the family Arecaceae. Therefore, it can be inferred that this oil has potential for industrial use. However, it is important to improve the extraction of the oil to obtain a higher yield and a better use of the raw material. It is also necessary to work the storage of the fruits and almonds to obtain oil with acidity indexes and peroxides lower.

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