Research article

http://www.revistas.unal.edu.co/index.php/refame

Revista Facultad Nacional de Agronomía

UNIVERSIDAD NACIONAL DE COLOMBIA

Characterization of oil extracted from the kernel of the fruit of cumare's palm (*Astrocaryum chambira* Barret)

Caracterización del aceite extraído del kernel del fruto de la palma de cumare (*Astrocaryum chambira* Barret)

doi: 10.15446/rfna.v71n1.69589

Miguel Ángel Ramirez-Niño[1]*, Javier Jiménez-Forero[2], Jessica Paola Bernal-Salazar[2] and María Daniela Osorio-Dueñas[2]

ABSTRACT

The objective of this research was the physicochemical characterization, fatty acid composition and Vitamin E content of oil extracted from the kernel of the fruit of cumare´s palm (*Astrocaryum chambira*). The plant material used in this research was collected in Caney-Restrepo, km 12 in the department of Meta-Colombia. The oil extraction process was performed by the soxhlet method using n-hexane as solvent, applying a unifactorial three-level experimental design to determine the most appropriate mass: solvent ratio. The percentage of lipids in dry basis of the kernel samples was 46.88% ± 0.73, which corresponds to the ratio 5 g of dry sample: 150 mL of solvent. The results of the physicochemical parameters were: density at 25 °C 0.9171 ± 0.003 g mL^{-1}, refractive index at 40 °C 1.4518 ± 0.0004, iodine index 8.28 ± 0.60 g I_2 100 g^{-1} oil, saponification index 246.66 ± 0.69 mg KOH g^{-1} oil, the percentage of acidity 0.248% ± 0.002 and the acid index 0.694 ± 0.006 mg KOH g^{-1} oil. The fatty acid profile presented a higher proportion of saturated (91.6%) than unsaturated (8.3%), likewise the analysis showed that lauric acid is the most abundant (48.6%) followed by myristic (29.8%), palmitic (6.7%), oleic (5.7%) and linoleic (2.5%). Based on the results obtained in the present study, data reported in the literature and regulations related to the use of oils of vegetable origin, this oil shows a great potential to be used as raw material in the food, pharmaceutical and oleochemical industry is feasible. However, it is recommended to perform additional tests in order to reaffirm their use in them.

Keywords:
Astrocaryum chambira
Cumare´s oil
Physicochemical parameters

RESUMEN

El objetivo de esta investigación fue la caracterización fisicoquímica, composición de ácidos grasos y el contenido de Vitamina E del aceite extraído de la almendra del fruto de la palma de cumare (*Astrocaryum chambira*). El material vegetal utilizado en esta investigación fue recolectado en la vereda Caney- Restrepo, km 12 en el departamento del Meta – Colombia. El proceso de extracción del aceite se realizó mediante el método soxhlet utilizando n-hexano como solvente aplicando un diseño experimental unifactorial de tres niveles para determinar la relación masa:solvente más apropiada. El porcentaje de lípidos en base seca de las muestras de las almendras fue de 46,88% ± 0,73, el cual corresponde a la relación 5 g de muestra seca: 150 mL de solvente. Los resultados de los parámetros fisicoquímicos fueron: densidad a 25 °C 0,9171 ± 0,003 g mL^{-1}, el índice de refracción a 40 °C 1,4518 ± 0,0004, índice de yodo 8,28 ± 0,60 g I_2 100 g^{-1} aceite, índice de saponificación 246,66 ± 0,69 mg KOH g^{-1} aceite, el porcentaje de acidez 0,248% ± 0,002 y el índice de acidez 0,694 ± 0,006 mg KOH g^{-1} aceite. El perfil de ácidos grasos presentó mayor proporción de saturados (91,6%) que de insaturados (8,3%), así mismo el análisis mostró que el ácido láurico es el más abundante (48,6%), seguido del mirístico (29,8%), palmítico (6,7%), oleico (5,7%) y linoléico (2,5%). Con base en los resultados obtenidos en el presente estudio, lo reportado en la literatura y en la normativa relacionada con el uso de aceites de origen vegetal, se evidencia un gran potencial de uso como materia prima en la industria alimentaria, farmacéutica y oleoquímica. Sin embargo, se recomienda realizar pruebas adicionales con el fin de reafirmar su uso en las mismas.

Palabras clave:
Astrocaryum chambira
Aceite de cumare
Parámetros fisicoquímicos

[1] Facultad de Ciencias Básicas e Ingeniería. Universidad de Los Llanos. Km 12 vía Puerto López, vereda Barcelona, Villavicencio, Colombia.
[2] Facultad de Ciencias Agropecuarias y Recursos Naturales. Universidad de Los Llanos. Km 12 vía Puerto López, vereda Barcelona, Villavicencio, Colombia.
* Corresponding author: <miguelramirez@unillanos.edu.co>

Received: April 6, 2017; Accepted: July 18, 2017
Rev. Fac. Nac. Agron. Medellín 71(1): 8415-8422. 2018 ISSN 0304-2847 / e-ISSN 2248-7026

The Amazon region presents a great variety of fruits and oilseeds with great potential for commercial exploitation due to its richness in micronutrients (De Rosso and Mercadante, 2007), as well as oils and fats that are extracted from the grains of some species such as Brazil nut (*Bertholletia excelsa*), andiroba (*Carapa guianensis*), babaçu (*Orbignya spp.*), Cupuaçu (*Theobroma grandflorum*), murumuru (*Astrocaryum murumuru*), buriti (*Mauritia flexosa*), passion fruit (*Passiflora spp.*). These plant species are of great economic importance, since its oils and fats have great application in the cosmetics, food and chemical oil industry (Saraiva *et al*., 2009).

Some studies carried out on oils extracted from palm fruits native to South America show great potential for agroindustrialization: the macauba palm (*Acrocomia aculeata*) native to the American tropics is widely distributed in Brazil; the oil extracted from the fruit and from the kernel were characterized and was determined that they have great application in the food industry, cosmetics as well as in the biodiesel industry (Del Rio *et al*., 2016).

The oil extracted from buriti´s palm (*Mauritia flexuosa*), is considered of economic interest due to its great antioxidant potential due to the high tocopherol content, in addition its physicochemical properties and composition in fatty acids make it an oil with great possibilities of use in foods, cosmetic and pharmaceutical industries (Speranza *et al*., 2016).

Other species of palms such as bacaba (*Oenocarpus bacaba*), inajá (*Maximiliana maripa*), pupuna (*Bactris gasipaes*) and tucuma (*Astrocaryum vulgare*) have been studied as to the composition of the oil of the fruit and have been found to have great potential as oils vegetables, due to their composition in fatty acids and the presence of bioactive compounds like tocopherols and sterols (Santos *et al*., 2013b).

In addition to palms, it has been found that there are other products native to this region that are rich in oils with industrial applications. Vieira *et al*. (2017), presented in their study a series of technological applications when oils and fats obtained from products originating in the Amazon (pracaxi and passion fruit oils, palm stearin, and cupuassu fat) are mixed, which are dependent of the physicochemical properties, composition in fatty acids and nutritional properties. These new blends have a great application in the production of vegetable shortenings and products for bakery and confectionery.

Nowadays, there is a great interest in the search for new vegetable species with a high content of oils, in order to evaluate its possible use in the food, cosmetics, pharmaceutical industry as well as in the production of biofuels. Globally, there are reports of oils extracted from palms or fruits of trees originating in certain regions with great agroindustrial potential. The tree of *Oecopetalum mexicanum*, native to southeastern Mexico and known by the name of cacaté, jamacuquiaca and cachichin, produces a fruit that is rich in lipids and which is used by communities as a source of oils. Hernández *et al*. (2013), studied the oil extracted from the fruit of this tree and found that it has 60% unsaturated fatty acids, it also has physicochemical properties that make it an oil with high potential in the food industry, as well as for others industrial purposes.

The palm *Phoenix canariensis* is native to the Canary Islands, commonly used as an ornamentation plant in parks, avenues, campus, among others. The oil extracted from the fruit of this palm was studied by Nehdi *et al*. (2010), which was found to have a 69.33% of unsaturated fatty acids, as well as the presence of tocopherols as a source of vitamin E, as well as physicochemical properties that demonstrate that it is an oil with potential to be used in the food, cosmetics and pharmaceutical industries.

Vermaak *et al*. (2011) proposes six plants native to the African continent, as species with great potential in obtaining oils that can be used in the cosmetic industry thanks to the physicochemical properties, the fatty acid composition and the biological activity obtained. These studies demonstrate the great interest that exists in the search for new alternative plants that can be used to obtain oils, being careful to conserve biodiversity with a bio-sustainable development.

The palm of Cumare (*Astrocaryum chambira*) is widely distributed in the Orinoquía and in the Colombian, Venezuelan, Peruvian and Brazilian Amazonia (Bernal *et al*., 2015). It is a monoecious palm, of solitary stem, with a height of up to 20 m height and 40 cm in diameter approximately, covered with black flat spines up to 20 cm in length in the internodes. The fruits are ovoid 5-7 cm long and 4-5 cm in diameter, greenish-yellow with tiny spines. It produces flowers from August to October and the fruits ripen from March to May. Each palm has a large number of fruits that can be found in a single plant (up to 800 fruits per racime) (García *et al.,* 2016; López *et al*., 2006). The use of this palm to obtain products for commercialization in the Northwest of South America have presented a great demand of the fiber for the development of a variety of handicraft made by indigenous communities (Brokamp *et al*., 2011; García *et al*., 2015). These studies demonstrate the economic potential of this palm that can be extended by obtaining oil to be used as a source of natural origin for the production of products with certain applications such as cosmetics, personal hygiene or food.

The objective of this study is to characterize the oil extracted from the kernel of the cumare palm, widely distributed in Colombian Orinoquia and Amazonia, in order to obtain the information regarding its physicochemical properties, vitamin E content and composition of fatty acids. This information is indispensable to determine its possible use in the food, cosmetic or pharmaceutical industry.

MATERIALS AND METHODS

Materials and reagents

The reagents n-hexane, potassium hydroxide 99.9%, absolute ethanol, 37% hydrochloric acid, 99.9% sodium hydroxide, potassium iodide 99.9%, chloroform, sodium thiosulfate pentahydrate 99.9%, wijs reagent, starch and phenolphthalein 99.9% were of the brand Merck grade ACS (Darmstadt, Germany). The extraction thimbles used were cellulose 603 33 mm x 80 mm from the Whatman® brand.

Vegetal material samples

The fruits (20 kg) with the same maturity index and with no physical and biological damage were collected manually in Caney - Restrepo, km 12 in the department of Meta – Colombia from 5 palms of cumare (*Astrocaryum chambira*) located at the following geographical coordinates: 4°16'2.7" North and 73°32'21.4" West, this area has an altitude of 452 m, with an annual average temperature of 25.8 °C and an annual precipitation between 4000-6000 mm. These fruits were identified by professionals in biology and agronomy in the area of botany systematics of the Universidad de Los Llanos.

Preparation of vegetal material

The seeds (kernel) of the fruit were separated, cleaned and their size were reduced manually by a chopping process. Subsequently the chopped seeds were taken to a convection oven (JEIOTECH model OF11E), for a drying process at a temperature of 60 °C for 24 hours. After this procedure, the dry sample of the seeds was reduced in size by means of an impact mill (IKA® A11 basic, Germany) to pass a 0.5 mm mesh, in order to obtain a sample of a finer size to facilitate the extraction process.

Experimental design and statistical analysis

An experimental design was carried out in the oil extraction phase to determine the optimum raw material - solvent ratio. The design was based on a unifactorial model with three levels defined for the sample: solvent ratio (1:10, 1:20 and 1:30). The oil performance data were processed using the statistical software InfoStat / Estudiantil® version 2012e, for which a variance analysis (ANOVA) was performed, in order to determine significant differences at a 95% confidence level ($P \leq 0.05$) using the Duncan test. The physicochemical properties evaluated were presented as the average of the six measurements with their respective standard deviation.

Oil extraction process

The extraction of dry and ground kernel oil was carried out by a Solid-Liquid extraction process (soxhlet) using n-hexane as the solvent (Luque de Castro *et al*., 2013). Samples m1 (15 g), m2 (7.5 g) and m3 (5 g) were weighed in triplicate, deposited on cellulose thimbles and a fixed amount of solvent of 150 mL of n-hexane was added. The extraction process was eight hours at boiling point of the solvent. After this time the remaining solvent was removed, the balloon with the oil was brought to a convection oven at 70 °C for 30 min, then left to stand in a glass desiccator and finally weighed the glass balloon (Nielsen, 2010). This same procedure was repeated 15 times to the ratio with higher yield according to the statistical analysis in order to obtain a considerable volume of oil for the later analyzes. Once the oil was extracted from the seeds of the cumare palm, it was stored in an amber glass jar and stored in a refrigerator at 10 °C for storage and subsequent physicochemical analysis, fatty acid profile and vitamin E content.

Physicochemical characterization of extracted oil

Physicochemical analysis of density, refractive index, saponification and iodine were performed by sixfold. The density of the oil was determined using the conventional mass-by-volume method using a Gay-Lussac pycnometer, following the NTC 336 (ICONTEC, 2002a). The refractive index of the oil sample was determined by means of an Abbe refractometer (Brixco), previously calibrated, following the NTC 289 (ICONTEC, 2002b). The saponification index of the oil sample was determined following the NTC 335 (ICONTEC, 1998a). The iodine index of the oil sample was determined following the NTC 283 (ICONTEC, 1998b). The acidity and the acidity index were determined following the methodology proposed by Nielsen (2010). All the glass material used was class A.

Determination of fatty acid profile

The analysis of the fatty acids in the oil sample was carried out by obtaining and quantifying their methyl esters by gas chromatography with flame ionization detector (GC-FID), according to ISO standards 5509-2000 (E) and 5508 - 1990 (E). The 37 component FAME mix (AccuStandar, Inc., 125 Market Street, New Haven CT 06513) was used as the certified reference standard.

Chromatographic analysis of the sample was performed on an AT 6890 N gas chromatograph (Agilent Technologies, Palo Alto, California, USA) with flame ionization detector (FID). The column used in the analysis was DB-23 (J & W Scientific, Folsom, CA, USA) [50% -cyanopropyl-poly (methyl xylosane), 60 m x 0.25 mm x 0.25 μm]. The injection was performed in split mode (50: 1) (Viny: 2 μL). The programming of the oven temperature was 120 °C for 5 min, then the temperature was increased at a rate of 10 °C min^{-1} to 180 °C and was maintained for 30 min at that temperature. The temperature was again increased at 10 °C min^{-1} to 210 °C and maintained at that temperature for 21 min.

The identification of fatty acid methyl esters present in the samples was carried out by the method of comparing their retention times with those of the certified 37 component FAME mix standard (AccuStandar, Inc., 125 Market Street, New Haven CT 06513), analyzed under the same chromatographic conditions. The content (relative percentage) of the fatty acids in the analyzed samples was determined according to the norm 5508-1990 (E) "Animal and Vegetable Fats and Oils-Analysis by Gas Chromatography of Methyl Ester of Fatty Acids".

Vitamin E content (α, γ, δ-Tocopherol) determination

The extraction of α, γ, δ-Tocopherol from the oil sample was performed using the technique of direct saponification of the material and its subsequent analysis by high performance liquid chromatography with diode array detector (HPLC / DAD). As reference material was used the vitamins α-tocopherol (Part No. 25,802-4, Sigma-Aldrich), γ-tocopherol (Part No. T1782, Sigma-Aldrich) and δ-tocopherol (Part No. T2028, Sigma-Aldrich).

For the quantification of (α, γ, δ) -tocopherol in the oil sample, the external standardization technique was used. For this purpose, the response factor (Rf) established from the analysis of the standard solutions of (α, γ, δ) -tocopherol was used in different concentrations.

Chromatographic analysis was performed on a liquid chromatograph (LC) 1200 Series (Agilent Technologies, Palo Alto, California, USA), with a UV-Vis diode array detector (DAD) at λ = 292 nm. The column used in the analysis was KINETEX (C8) (Phenomenex, Torrance, California, USA), 250 mm x 4.6 mm x 5.0 μm. The injection was performed in automatic mode (Viny: 10 μL), isocratic under a ratio of 95: 5 (methanol: water) for 30 min, at a flow rate of 1 mL min^{-1}. The quantification of (α, γ, δ-Tocopherol) in the oil samples was carried out using the external standardization technique.

RESULTS AND DISCUSSION

Oil extraction process

The results obtained for the experimental design applied to the solid-liquid extraction process of the oil using soxhlet were analyzed using the Duncan test ($P<0.05$), this test evidence significant differences between the three ratios studied 1:10, 1:20 and 1:30. The results obtained showed that the ratio 1:30 (5 g: 150 mL) presented a higher yield in the extraction process, these results demonstrate that the amount of sample mass influences the oil extraction process, according to the results reported by Londoño *et al.* (2012). Table 1 shows the yields obtained in the extraction process. The highest percentage of oil in the kernel corresponds to a value of 46.88 ± 0.73%, which is a high percentage compared to other Amazonian palms.

Mambrim and Barrera-Arellano (1997), reported in their study of oils from fruits of Amazonian palms of Brazil to the Tucumán palm (*Astrocaryum vulgare*) a percentage of oil

Table 1. Extraction yield under different Mass-solvent ratio.

Mass-solvent ratio	Yield (%)
1:10	43.13 ± 0.17
1:20	45.42 ± 0.35
1:30	46.88 ± 0.73

kernel of 29.59% and for Muru-Muru palm (*Astrocaryum murumuru*) a percentage of 27.70% kernel oil using hexane as the solvent. Another palm of great interest in the Brazilian Amazon region is the babassu palm (*Orbignya phalerata*); Santos *et al*. (2013a) report a percentage between 46.79 and 61.16% of oil extracted from the nucleus using n-hexane as solvent. In the scientific literature, there is not much information of studies carried out in the Amazonia and Colombian Orinoquía. Therefore, with this study we have as much information as possible for the oil extracted from the nucleus of the fruit of the cumare palm from this region. The result obtained in terms of oil percentage, shows that the fruit grain of this palm can be used as raw material to obtain an oil with potential to be used in the food industry or as raw material for the production of toilet and cosmetic products.

Physicochemical properties of kernel oil of cumare palm

Table 2 presents the results for each of the determined physicochemical properties. The result obtained for the density of the oil is very close to other oils like coconut (0.919 a 0.917 g mL^{-1}) (ICONTEC, 1968), palm kernel (0.920 a 0.916 g mL^{-1}) (ICONTEC, 1996) and babassu (0.918 a 0.915 g mL^{-1}) (ICONTEC, 1969). The value obtained for the refractive index corrected at 40 °C was very close to the reported by Mambrim and Barrera-Arellano, 1997 for oils obtained from kernel´s palms *Oenocarpus distichus* (1.4567 g mL^{-1}), *Astrocaryum vulgare* (1.4545 g mL^{-1}) and *Astrocaryum murumuru* (1.4538 g mL^{-1}), these results were reported at that temperature because these oils are solids at room temperature.

The saponification index is a measure that is used to predict the type of triglycerides present in the sample; high values indicate that the triglycerides contain short chain fatty acids (Jelassi *et al*., 2014). The value obtained for the saponification index indicates that cumare palm kernel oil is composed mainly by short chain triglycerides, which makes it suitable for the preparation of liquid soaps, shampoos and cosmetic products (Nehdi, 2011). Bora *et al*. (2001) reported a value of 231.4 ± 4.3 mg of KOH g^{-1} fat for the oil extracted from the tucuma palm kernel (*Astrocaryum vulgare*), which is closely related to the oil rich in saturated fatty acids with short chain (lauric, myristic and palmitic). The saponification index found is very close to some palm oils that are traded on a large scale such as babassu (*Attalea speciosa*) (254-248 mg KOH g^{-1} oil) (ICONTEC, 1969), palm kernel (240-255 mg KOH g^{-1} oil) (ICONTEC, 1996) and coconut (*Cocos nucifera*) (250-264 mg KOH g^{-1} oil) (ICONTEC, 1968).

The iodine index is a measure of the presence of unsaturations in oils or in the fat analyzed (Akbar *et al*., 2009). The value obtained for the kernel oil of the cumare palm was 8.28 ± 0.60 g of I_2 100 g^{-1} of oil, this is a very low value which shows that the percentage of unsaturated and polyunsaturated fatty acids is low. This value is slightly

Table 2. Physicochemical properties of the oil obtained from the cumare kernel.

Physicochemical property	Media ± SD*
Density at 25 °C (g mL^{-1})	0.9171 ± 0.003
Refraction index (40 °C)	1.4518 ± 0.0004
Saponification index (mg KOH g^{-1} oil)	246.66 ± 0.69
Iodine index (g iodine 100 g^{-1} of oil)	8.28 ± 0.60
Free fatty acids (% Lauric acid)	0.248 ± 0.002
Acid index (mg KOH g^{-1} oil)	0.694 ± 0.006

*SD: Standard Deviation

below some oils extracted from the palm kernel of the *Astrocaryum* family. Lognay *et al.* (1995) reported a value of 12 g I_2 100 g^{-1} of oil, which is composed mainly of lauric acid (54.9%) and myristic acid (21.9%), for huicungo oil (*Astrocaryum macrocalyx*). Bora *et al*. (2001) reported for oil extracted from the tucuma palm kernel (*Astrocaryum vulgare*) a value of 12.5 g I_2 100 g^{-1} of oil. Mambrim and Barrera-Arellano (1997), reported a value of 10.3 g I_2 100 g^{-1} for the oil extracted from the Muru-Muru palm kernel (*Astrocaryum murumuru*).

All these oils have a characteristic and is that they are solid at room temperature. The percentage of acidity obtained in the oil was 0.248 ± 0.002%, expressed in terms of lauric acid which is the predominant one (48.6%). The percentage of acidity indicates the amount of free fatty acids present, so a low value indicates that the oil has not carried out lipid deterioration reactions (Nehdi *et al*., 2010). The acid index value indicates the amount of KOH required to neutralize the free fatty acids present in 1 g of sample, the value obtained was 0.694 ± 0.006 mg KOH g^{-1}, indicating a low presence of free fatty acids (Salazar de Marcano *et al*., 2004).

Fatty acids composition

Table 3 presents the results of the chromatographic analysis of the oil sample in terms of the relative amount of the fatty acids present. The oil is composed of two major acids, lauric acid present in 48.6%, followed by myristic acid in 29.8% and others in lesser amount as: palmitic in 6.7%, oleic 5.7%, stearic 3.0% and linoleic in a 2.5%. The percentage of saturated fatty acids according to the results corresponds to 91.6% versus 8.3% of unsaturated fatty acids. These results explain the low iodine index determined in this study. This composition in terms of fatty acids is similar for other oils that have been extracted from other Amazonian palms. García-Pantaleón *et al.* (2006) reported a high content of saturated fatty acids (85.9%) in yagua palm (*Attalea cryptanther)* due to the presence of lauric acid (58%), myristic (16.5%) and palmitic (8.4%), the content found of unsaturated fatty acids was 14.1%.

Table 3. Content of fatty acids in the kernel oil sample of cumare palm

Fatty acid	Fatty acid measured as methylester %
Caproic acid (C6:0)	0.1 ± 0.0
Caprylic (C8:0)	1.6 ± 0.1
Capric acid (C10:0)	1.5 ± 0.0
Lauric acid (C12:0)	48.6 ± 0.1
Myristic acid (C14:0)	29.8 ± 0.1
Palmitic acid (C16:0)	6.7 ± 0.1
Palmitoleic acid (C16:1)	< 0.1
Stearic acid (C18:0)	3.0 ± 0.0
Oleic acid (C18:1)	5.7 ± 0.0
Linoleic acid (C18:2)	2.5 ± 0.0
Linolenic acid (C18:3)	< 0.1
Arachidic acid (C20:0)	0.1 ± 0.0
Eicosenoic acid (C20:1)	< 0.1
Behenic acid (C22:0)	< 0.1

The oil of the coroba palm seed (*Jessenia polycarpa,* synonymy *Oenocarpus bataua*) has a major composition of saturated fatty acids such as lauric (41.7%), myristic (15.7%) and palmitic (9.8%) (Salazar de Marcano *et al*., 2004). Bora *et al*. (2001) reported a high composition of saturated fatty acids (87.37%), which consists mainly of lauric (50.16%), myristic (24.44%), and palmitic (6.21%). The above composition is very similar to other oils that have been extracted from the kernel of fruits of other palms, where predominantly mainly short chain acids, especially lauric acid (Del Rio *et al*., 2016). This fatty acid and its derivatives have many applications both in the food industry and in the chemical industry, which makes it interesting to be used in the production of cosmetics and toiletries. The high percentage of saturated fatty acids of this oil makes it favorable to be used in the manufacture of cocoa butter substitutes, in addition these acids are more resistant to oxidation, so they can be used in the formulation of fatty food systems, because the possibility of the development of oxidative rancidity in the final product can be diminished (Salazar de Marcano *et al*., 2004).

Vitamin E content (α,γ,δ - Tocopherol)

Vitamin E is a natural antioxidant found in some plants as tocopherols (α, β, γ and δ) and their corresponding tocotrienols, all of these have vitamin E activity. However, the most active form corresponds to α-tocopherol (Darnet *et al*., 2011). The action of vitamin E as an antioxidant is quite complex and there are several theories to be able to explain it, however one of the most accepted is the coordination with other molecules and enzymes for the defense of cells against free radicals from the autoxidation of lipids (Sayago *et al*., 2007). The presence of radicals in the body can generate degenerative diseases, cardiovascular and cancer (Valko *et al*., 2016).

The result obtained for the vitamin E content for the extracted oil was 12.0 mg kg^{-1} of oil, which is within what was reported by Bereau *et al*. (2003), in a study of oils extracted from the kernel of fruits of five native palms of the Amazon (*Acrocomia lasiospatha* Wall., *Astrocaryum vulgare C*. Mart., *Bactris gasipaes* H.B.K., *Elaeis oleifera* (Kunth) Cortés, and *Maximiliana maripa* Drude), where the total content of tocopherols is reported between 5–150 mg kg^{-1}.

CONCLUSIONS

The obtained results show that the oil extracted has the potential as raw material in the elaboration of foodstuffs and personal care products or cosmetics such as soaps, shampoo, skin products, make-up, deodorants, among others. This research aims to demonstrate that there are other sources of natural origin with great potential to be used in this type of products, in order to replace raw materials of synthetic origin, however this oil should be tested before use human and animal nutrition. In addition, the production of oil from native species requires further studies to carry out a sustainable production process.

ACKNOWLEDGMENTS

The authors express their appreciation to the staff of the laboratory of chemistry at the Universidaad de Los Llanos for their assistance in the implementation of this work, to the research groups CINQUIBULL and CITIA by the management and coordination of this research and to the general direction research of the Universidad de Los Llanos for funding part of this project.

REFERENCES

Akbar E, Yaakob Z, Kamarudin SK, Ismail M, Salimon M. 2009. Characteristic and Composition of *Jatropha Curcas* Oil Seed from Malaysia and its potential as biodiesel feedstock. European Journal of Scientific Research 29(3): 396-403.

Bereau D, Benjelloun-Mlayaha B, Banoubb J, Bravo R. 2003. FA and unsaponifiable composition of five amazonian palm kernel oils. Journal of the American Oil Chemists' Society 80(1): 49-53.

Bernal R, Gradstein SR and Celis M (eds.). 2015. Catálogo de plantas y líquenes de Colombia. Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá. http://catalogoplantasdecolombia.unal.edu.co

Bora PS, Narain N, Rocha RVM, De Oliveira Monteiro AC, De Azevedo Moreira R. 2001. Characterization of the oil and protein fractions of tucuma (*Astrocaryum Vulgare* Mart.) fruit pulp and seed kernel. Ciencia y Tecnología Alimentaria 3(29): 111-116.

Brokamp G, Valderrama N, Mittelbach M, Grandez CA, Barfod AS, Weigend M. 2011. Trade in palm products in North-Western South America. Botanical Review 77(4): 571-606. doi: 10.1007/s12229-011-9087-7

Darnet S, Serra JL, da Cruz Rodrigues AM, Meller da Silva LH. 2011. A high-performance liquid chromatography method to measure tocopherols in assai pulp (*Euterpe oleracea*). Food Research International 44: 2107–2111. doi: 10.1016/j.foodres.2010.12.039

Del Rio JC, Evaristo AB, Marques G, Martín-Ramos P, Martín-Gil J, Gutiérrez A. 2016. Chemical composition and thermal behavior of the pulp and kernel oils from macauba palm (*Acrocomia aculeata*) fruit. Industrial Crops and Products 84: 294–304. doi: 10.1016/j.indcrop.2016.02.018.

De Rosso VV, Mercadante AZ. 2007. Identification and quantification of carotenoids, by HPLC-PDA-MS/MS, from amazonian fruits. Journal of Agricultural and Food Chemistry 55: 5062-5072.

García N, Galeano G, Mesa L, Castaño N, Balslev H, Bernal R. 2015. Management of the palm *Astrocaryum chambira* Burret

(Arecacea) in northwest Amazon. Acta Botanica Brasilica 29(1): 45-57. doi: 10.1590/0102-33062014abb3415.

García N, Zuidema P. A, Galeano G, Bernal R. 2016. Demography and sustainable management of two fiber-producing *Astrocaryum* palms in Colombia. Biotropica 48(5): 598–607. doi: 10.1111/btp.12338

García N, Galeano G, Mesa L, Castaño N, Balslev H, Bernal R. 2015. Management of the palm *Astrocaryum chambira* Burret (Arecacea) in northwest Amazon. Acta Botanica Brasilica 29(1): 45-57. doi: 10.1590/0102-33062014abb3415.

García Pantaleón DM, González J, Moreno-Álvarez MJ, Belén-Camacho DR, Medina-Martínez C, Linares O. 2006. Physicochemical characteristics of yagua palm (*Attalea cryptanther*) endospermus oil. Grasas y Aceites 57(3): 308-312. doi: 10.3989/gya.2006.v57.i3.53

Hernández B, Luna G, García O, Mendoza MR, Azuara E, Beristain CI, Jimenez M. 2013. Extraction and characterization of *Oecopetalum mexicanum* seed oil. Industrial Crops and Products 43: 355-359. doi: 10.1016/j.indcrop.2012.07.022

ICONTEC. 1968. Grasas y aceites comestibles. Aceite de coco. NTC 252. Instituto Colombiano de Normas Técnicas y Certificación, Bogotá.

ICONTEC. 1969. Grasas y aceites comestibles. Aceite de babassu. NTC 263. Instituto Colombiano de Normas Técnicas y Certificación, Bogotá.

ICONTEC. 1996. Grasas y aceites comestibles vegetales y animales. Aceite de palmiste. NTC 260. Instituto Colombiano de Normas Técnicas y Certificación, Bogotá.

ICONTEC. 1998a. Grasas y aceites animales y vegetales. Determinación del índice de saponificación. NTC 335. Instituto Colombiano de Normas Técnicas y Certificación, Bogotá.

ICONTEC. 1998b. Grasas y aceites vegetales y animales. Determinación del índice de yodo. NTC 283. Instituto Colombiano de Normas Técnicas y Certificación, Bogotá.

ICONTEC. 2002a. Grasas y aceites animales y vegetales. Método de la determinación de la densidad (Masa por volumen convencional). NTC 336. Instituto Colombiano de Normas Técnicas y Certificación, Bogotá.

ICONTEC. 2002b. Grasas y aceites animales y vegetales. Determinación del índice de refracción. NTC 289. Instituto Colombiano de Normas Técnicas y Certificación, Bogotá.

Jelassi A, Cheraief I, Hamza MA, Jannet HB. 2014. Chemical composition and characteristic profiles of seed oils from three Tunisian Acacia species. Journal of Food Composition Analysis 33: 49–54. doi: 1 0.1016/j.jfca.2013.11.001

Lognay G, Desmedt A, Mejia K, Trevejo E, Marlier M. 1995. Caracterización del aceite de la almendra de *Astrocaryum macrocalyx* (Burret). Grasas y Aceites 46(4-5): 308-310. doi: 10.3989/gya.1995.v46.i4-5.944

Londoño P, Mieres-Pitre A, Hernández CE. 2012. Extracción y caracterización del aceite crudo de la almendra de durazno (*Prunus persica*). Avances en Ciencias en Ingenierías 3(4): 37-46.

López C. R, Navarro L. J. A, Montero G. M. I, Amaya V. K, Rodríguez C. M. (2006). Manual de identificación de especies no maderables del corregimiento de Tarapacá, Colombia. https://www.sinchi.org.co/files/publicaciones/publicaciones/pdf/Nomaderables2006.pdf

Luque de Castro MD, Priego-Capote F. 2010. Soxhlet extraction: Past and present panacea. Journal of Chromatography A 1217: 2383–2389. doi: 10.1016/j.chroma.2009.11.027

Mambrim MCT, Barrera-Arellano D. 1997. Caracterización de aceites de frutos de palmeras de la región amazónica del Brasil. Grasas y Aceites 48 (3): 154-158. doi: 10.3989/gya.1997.v48.i3.783

Nehdi I, Omrib S, Khalil MI, Al-Resayesa SI. 2010. Characteristics and chemical composition of date palm (*Phoenix canariensis*) seeds and seed oil. Industrial Crops and Products 32: 360–365. doi: 10.1016/j.indcrop.2010.05.016

Nehdi I. 2011. Characteristics, chemical composition and utilization of *Albizia julibrissin* seed oil. Industrial Crops and Products 33: 30–34. doi: 10.1016/j.indcrop.2010.08.004

Nielsen S. 2007. Análisis de los alimentos – Manual de laboratorio. Acribia, Zaragoza.

Salazar de Marcano E, Belén D, Jiménez N, Pino K. 2004. Características fisicoquímicas del aceite de la semilla de la coroba (*Jessenia polycarpa* karst). Grasas y Aceites 55(4): 423-427. doi: 10.3989/gya.2004.v55.i4.210

Santos DS, Da Silva IG, Araujo BQ, Lopez Junior CA, Monção NBN, Das G.L Citó AM, De Souza MHSL, Do DSB Nascimento M, Pires Costa MC a. 2013a. Extraction and evaluation of fatty acid composition of *Orbignya phalerata* Martius Oils (Arecaceae) from Maranhão State, Brazil. Journal of the Brazilian Chemical Society 24(2): 355-362. doi: 10.5935/0103-5053.20130045.

Santos MFG, Alves RE, Ruiz-Mendez MV b. 2013b. Minor components in oils obtained from Amazonian palm fruits. Grasas y Aceites 64(5): 531-536. doi: 10.3989/gya.048913

Saravia SA, Cabral EC, Eberlin MN, Catharino R. 2009. Amazonian Vegetable Oils and fats: fast typification and quality control via triacylglicerol (TAG) profiles from dry matrix-assisted laser desorption/ionization time-of-flight (maldi-tof) mass spectrometry fingerprinting. Journal of Agriculture and Food Chemistry 57: 4030-4034. doi: 10.1021/jf900043u

Sayago A, Marín MI, Aparicio R, Morales MT. 2007. Vitamina E y aceites vegetales. Grasas y Aceites 58(1): 74-86. doi: 10.3989/gya.2007.v58.i1.11

Speranza P, De Oliveira Falcao A, Alves Macedo J, Da Silva LHM, Da C Rodrigues AM, Alves Macedo G. 2016. Amazonian Buriti oil: chemical characterization and antioxidant potential. Grasas y Aceites 67(2): e135. doi: 10.3989/gya.0622152

Valko M, Jomova K, Rhodes CJ, Kuča K, Musílek K. 2016. Redox- and non-redox-metal-induced formation of free radicals and their role in human disease. Archives of Toxicology, 90(1): 1–37. doi: 10.1007/s00204-015-1579-5

Vermaak I, Kamatou GPP, Komane-Mofokeng B, Viljoen AM, Beckett K. 2011. African seed oils of comercial importance – Cosmetic applications. South African Journal of Botany 77: 920-933. doi: 10.1016/j.sajb.2011.07.003

Vieira Bezerra C, Da Cruz Rodrigues AM, De Oliveira PD, Albuquerque Da Silva D, Meller Da Silva LH. 2017. Technological properties of amazonian oils and fats and their applications in the food industry. Food Chemistry 221: 1463-1473. doi: 10.1016/j.foodchem.2016.11.004