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Amazonian Buriti oil: chemical characterization and antioxidant potential

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SUMMARY: Buriti oil is an example of an Amazonian palm oil of economic importance. The local population uses this oil for the prevention and treatment of different diseases; however, there are few studies in the literature that evaluate its properties. In this study, detailed chemical and antioxidant properties of Buriti oil were determined. The predominant fatty acid was oleic acid (65.6%) and the main triacylglycerol classes were tri-unsaturated (50.0%) and di-unsaturated-mono-saturated (39.3%) triacylglycerols. The positional distribution of the classes of fatty acids on the triacylglycerol backbone indicated a saturated and unsaturated fatty acid relationship similar in the three-triacylglycerol positions. All tocopherol isomers were present, with a total content of 2364.1 mg·kg^{-1}. α-tocopherol constitutes 48% of the total tocopherol content, followed by γ- tocopherol (45%). Total phenolic (107.0 mg gallic acid equivalent·g^{-1} oil) and β-carotene (781.6 mg·kg^{-1}) were particularly high in this oil. The highest antioxidant activity against the free radical 1,1-diphenyl-2-picrylhydrazyl (DPPH) was obtained at an oil concentration of 50 mg·mL^{-1} (73.15%). The antioxidant activity evaluated by the Oxygen Radical Absorbance Capacity (ORAC) was 95.3 μmol Trolox equivalent·g^{-1} oil. These results serve to present Buriti oil as an Amazonian resource for cosmetic, food and pharmaceuticals purposes.

KEYWORDS: *Fatty acid; Minor compound; Radical scavenging activity; Regio-specific distribution; Triacylglycerol*

RESUMEN: ***Aceite de buriti de la Amazonia: Caracterización química y potencial antioxidante***. El aceite de Buriti es un ejemplo de aceite de palma amazónica de gran importancia económica. La población local utiliza este aceite para la prevención y el tratamiento de diferentes enfermedades; sin embargo, hay pocos estudios científicos que evalúen sus propiedades. En este estudio, se determinaron las propiedades antioxidantes del aceite de Buriti. El ácido graso predominante fue el oleico (65,6 %) y las principales clases de triglicéridos fueron tri-insaturadas (50,0 %) y Di-insaturados-mono-saturada (39,3 %). La distribución posicional de las clases de ácidos grasos en el esqueleto de triacilglicerol indicó una relación de ácidos grasos saturados e insaturados similar en las tres posiciones del triacilglicerol. Todas las isoformas de tocoferol estaban presentes, con un contenido total de 2364.1 mg·kg^{-1}. El α-tocoferol constituye el 48 % del contenido total de tocoferol, seguido de γ-tocoferol (45 %). El contenido fenólico total (107,0 mg equivalente ácido gálico·g^{-1} de aceite) y β-caroteno (781,6 mg·kg^{-1}) fueron particularmente altos en este aceite. La mayor actividad antioxidante contra el radical 1,1-difenil-2-picrilhidrazil libre (DPPH) se obtuvo a una concentración de aceite de 50 mg·mL^{-1} (73,15 %). La actividad antioxidante evaluadas por la capacidad de absorción de radicales de oxígeno (ORAC) fue 95,3 mmol Trolox equivalente·g^{-1} de aceite. Estos resultados presentan al aceite de Buriti amazónico como buen recurso con fines cosmético, alimenticio y farmacéutico.

***PALABRAS CLAVE*:** *Ácido graso; Actividad de captación de radicales; Componentes menores; Distribución regioespecífica; Triglicéridos*

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1. INTRODUCTION

Non-conventional vegetable oils have gained a pronounced importance because their constituents have unique chemical properties. Some of these vegetable oils may augment the supply of nutritional and functional products; others have importance in cosmetic and pharmaceutical applications (Ramandan *et al*., 2009).

In Brazil, and specifically in its Amazonian area, a great variety of non-conventional plant oils, with many physicochemical and biological properties can be found (Bataglion *et al*., 2014; Pesce *et al*., 2009). A variety of seed oils, from different species, is commercialized in local markets with a variety of alleged proprieties (Saraiva *et al*., 2009). Buriti (*Mauritia flexuosa* Mart) mesocarp oil is an example of an Amazonian palm oil of economic importance. This oil is used by the local population as healing, sunscreen, for the treatment of burns, for the prevention of skin aging, and acts as anti-inflammatory and antibiotic (Hernández *et al*., 2009; Silva *et al*., 2009; Rodrigues *et al*., 2010). The Buriti oil has some features similar to palm oil such as its reddish-yellow color and its flavor (Pesce *et al*., 2009).

However, while this oil presents a great potential for application either alone or in combination with other oils, most studies only present data on the fatty acid composition, oxidative stability and minor components such as carotenes and tocols (Pardauil *et al*., 2011; Silva *et al*., 2011; Silva *et al*., 2009; Albuquerque *et al*., 2005; Santos *et al*., 2013a). The specialized literature does not present a more detailed assessment of its physical and chemical characteristics, and parameters such as regiospecific distribution are not reported.

In addition, biological studies with Buriti oil are scarce, basically relating to assessments of sunscreen and cytotoxic potential studies (Zanatta *et al*., 2010; Zanatta *et al*., 2008). Studies on the antioxidant activity with this oil are also scarce, with results restricted to a single radical (Ferreira *et al*., 2011; Bataglion *et al*., 2015). Furthermore, these studies generally evaluate the antioxidant activity of the oil after fractionation by difference in polarity and not the intact oil, which may adversely affect the results obtained (Espín *et al*., 2000). Research on antioxidant activity has shown that products with antioxidant features are related to reducing risk of many diseases in which oxidative stress may play a role, especially chronic illnesses such as cancer, cardiovascular, inflammatory and neuro-degenerative diseases (Pandey and Rizvi, 2009).

Therefore, the objective of this investigation is to obtain an information profile about the chemical nature and antioxidant potential against radicals 1,1-diphenyl-2-picrylhydrazyl (DPPH) and the Oxygen Radical Absorbance Capacity (ORAC) of Buriti mesocarp oil. The results are important to verify the cosmetic and nutraceutical potential of the Buriti oil. No previous studies in the literature have analyzed Buriti oil to this extent.

2. MATERIALS AND METHODS

Crude Buriti oil was bought in a local market in the city of Belém, State of Pará, in the Brazilian Amazon. All other reagents and solvents were of analytical grade.

2.1. Fatty acid composition

Fatty acid methyl esters were prepared according to the Hartman and Lago's method (Hartman and Lago, 1973). The fatty acid composition was determined as previously reported (Basso *et al*., 2012).

2.2. Regio-specific distribution

Proton-decoupled ^{13}C NMR (Nuclear Magnetic Resonance) was used to analyze the positional distribution of the classes of fatty acids on the triacylglycerol (TAG) backbone. The determination of ^{13}C was performed at a frequency of 75.8 MHz, with a 5 mm multinuclear probe operating at 30 °C (Vlahov, 1998).

2.3. Triacylglycerol composition

The fatty acid composition was used to predict the groups of TAGs in the non-interesterified blend with PrOleos software (Antoniosi Filho *et al*., 1995). The composition of TAGs present in interesterified lipids was analyzed according to the 1,3-random, 2-random theory (non-random redistribution), and 1,2,3-random theory (random redistribution), based on the analysis of the regio-specific distribution described in item 3.4 (D'Agostini and Gioielli, 2002; Guedes *et al*., 2014).

2.4. Minor compounds

Tocopherols

The α, β, γ, and δ- tocopherol contents were determined by High Performance Liquid Chromatography (HPLC), according to the Ce8–89 AOCS method (AOCS, 2009). Peaks were identified by comparison of their retention times with authentic standards of tocopherols and where quantified based on the peak areas relative to standard calibration plots by the external standard method.

Total carotenoid

The β-carotene content was obtained using the method described by Davies (1973). The oil was diluted in hexane at a concentration of 0.004 g.mL^{-1} and read at 446 nm using a computerized Shimadzu Spectrophotometer (Kyoto, Japan).

Total polyphenols

Phenolic compounds were extracted with water-methanol 60:40 (v v^{-1}). Folin-Ciocalteu reagent (Sigma Chemicals) was added to suitable aliquots of the methanolic extracts. After 3 minutes, a sodium carbonate solution (35%, w v^{-1}) was added to the reaction mixture, which was finally mixed and diluted with water to a final volume of 1000 µL. The absorbance of the solution was measured after 2 h, against a blank sample produced with distilled water, on a Shimadzu Spectrophotometer (Kyoto, Japan) at a wavelength of 725 nm. Results are given as µg mL^{-1} of gallic acid (Hrncirik and Fritsche, 2004).

2.5. Antioxidant assays

DPPH

The DPPH procedure was done according to Vorarat et al. (2010). The oil is dissolved in ethyl acetate at concentrations of 5, 10, 50 and 100 mg·mL^{-1}. The reaction mixtures were mixed on 96-well plates (BMG Labtech 96) and the reaction was carried out on a NovoStar Microplate reader (BMG LABTECH, Germany) with absorbance filters for an excitation wavelength of 520 nm after 16 minutes. Results are presented as a function of absorbance (Free radical scavenging activity).

ORAC

The ORAC procedure was carried out according to the method of Prior et al. (2003) with some modification. The assay was carried out on a NovoStar Microplate reader with fluorescence filters for an excitation wavelength of 485 nm and an emission wavelength of 520 nm at 37 °C. The oil (40 mg) was diluted to a final volume of 1 mL of a mixture of dimethyl sulfoxide (DMSO): Triton X-20 (9:1) and stirred for 90 seconds on the ultra turrax (IKA-ULTRA-TURRAX®) for 5 min at 4000 rpm. For the analysis, 40 µL of this solution was added to the 96 well dark microplate. 400 µL of fluoresce in solution (70 nM) were added by injectors in the microplate reader, followed by 150 µL of AAPH (17.2 mg·mL^{-1}, 9.4 µmol/well). Results are expressed in terms of trolox equivalents (TE).

2.6. Statistical Analysis

Results were presented as the mean±standard deviation from three replicates of each experiment. A p-value<0.05 was used to denote significant differences among mean values determined by the analysis of variance (ANOVA) with the assistance of Statistica 7.0 (StatSoft, Inc., Tulsa, OK) software.

3. RESULTS AND DISCUSSION

3.1. Fatty acid compositions

The results in Table 1 indicate that Buriti oil is very rich in oleic acid (65.6%). The fatty acid composition also indicates that this oil presents palmitic acid as the major saturated fatty acid (19.2%). Regarding polyunsaturated fatty acids, the concentration in this oil does not exceed 13.3%.

The previous studies which address the fatty acid composition of Buriti oil confirm that oleic acid is the major fatty acid, followed by palmitic acid. Santos *et al*. (2013b), using the same technique to determine the fatty acids employed in this study (GC-FID), obtained similar values for oleic (71.6) and palmitic (20.8) acids; however, the values obtained for the polyunsaturated

Table 1. Fatty acid composition of Buriti oil

Fatty acids	Buriti (%)
Caprylic acid (C8:0)	–
Capric acid (C10:0)	–
Lauric acid (C12:0)	–
Myristic acid (C14:0)	0.5±0.00
Palmitic acid (C16:0)	19.2±0.03
Stearic acid (C18:0)	1.3±0.00
Oleic acid (C18:1)	65.6±0.0
Linoleic acid (C18:2)	4.9±0.05
Linolenic acid (C18:3)	8.2±0.01
Σ Saturated	**21.0**
Σ Monounsaturated	**65.6**
Σ Polyunsaturated	**13.2**

linoleic and linolenic acids were lower, at 2.5% and 1.4%, respectively. The same difference was observed in the study of Pardauil *et al*. (2011). Amounts of polyunsaturated fatty acids similar to ours were obtained in the study of Silva *et al*. (2009). Their methods of determination based on mass spectrometry (MS) also confirm that oleic (71%) and palmitic acids (20%) are the major fatty acids in Buriti oil, and stearic acid, as well as in our study, was also detected (Bataglion *et al*., 2015). This small variation in results is predictable and may be influenced by many factors, such as season, extraction and refining processes (Aquino *et al*., 2012).

The fatty acid profile of Buriti oil reveals the lipid as a good source of monounsaturated fatty acids. A great interest has been placed in oils that contain these fatty acids. The high oleic and low linoleic fatty acid contents help make them more resistant to oxidation than most liquid oils (Santos *et al*., 2013a; Silva *et al*., 2009; O'Brien, 2009). Olive oil is a very flavor-stable oil because of the high oleic fatty acid content (70–80%) (O'Brien 2009; Criado *et al*., 2008). Moreover, interest in oleic acid as a health-promoting nutrient has expanded in recent years (Capurso *et al*., 2014; Sales-Campos *et al*., 2013). Studies using animal cells have shown that oleic acid enhanced intra-cellular levels of lipid peroxidation, indicating that the acid can promote good adaptive response and increase the tolerance of the cells by increasing antioxidant capacity (Haeiwa *et al*., 2014). Thus, the Buriti oil can represent a new option of oil rich in oleic acid, and thus, an alternative to olive oil.

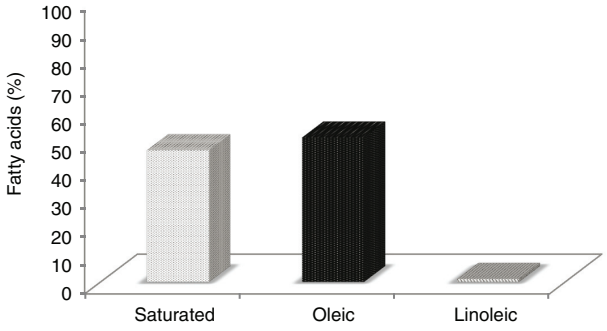

FIGURE 1. Regio-specific distribution of fatty acids at the **sn-1,3 positions** of Buriti oil.

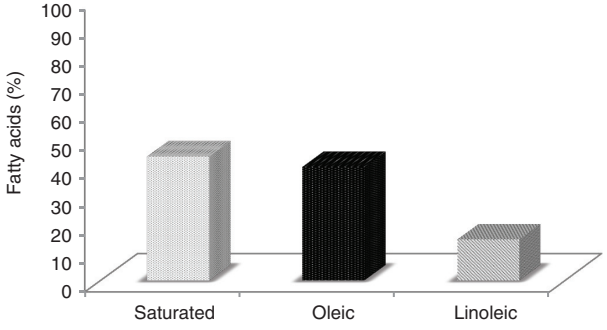

FIGURE 2. Regio-specific distribution of fatty acids at the **sn-2 position** of Buriti oil.

3.2. Regio-specific distribution

The fatty acid distribution in TAG affects the physical properties, lipolytic and oxidative stability, and nutritional availability of lipids (Kolakowska and Sikorski, 2002). Buriti oil is characterized by a random distribution of oleic and saturated fatty acids in all glycerol positions. Polyunsaturated fatty acids are located almost exclusively in the sn-2 position (Figures 1 and 2).

The high proportion of oleic acid in all glycerol positions along with the predominance of polyunsaturated fatty acids in the sn-2 position make Buriti oil less susceptible to oxidation. In addition, the high concentration of saturated fatty acids in the sn-2 position of the Buriti oil provides a differentiated regio-specific distribution. In vegetable oils, unsaturated fatty acids tend to be located at the sn-2 position of the glycerol, while the saturated ones tend to be located at the sn-1 and sn-3 positions (Brockerhoff, 1971). In some applications, such as human milk fat substitute production, the aim is to enhance vegetable oils with unsaturated fatty acids at the sn-2 position, using lipases (Pina-Rodrigues and Akoh, 2010). Buriti oil, to present this distribution of fatty acids naturally can be used for producing such fats.

The information about the stereo-specific positional distribution of fatty acids in the Buriti oil can be used for the development of the structural lipids for food, pharmaceutical and medical purposes.

3.3. Triacylglycerol composition

Triacylglycerol (TAG) composition is key to understanding the various physical properties of an oil or fat (Buchgraber *et al*., 2004). Given the high contents in oleic (65.6%) and palmitic (19.2%) acids, which are the two major fatty acids in Buriti oil, TAG species combining both acids (i.e. oleic-oleic-oleic (OOO) and palmitic-oleic-oleic (POO)), were the major species in the oil analyzed. These two species account for over 50% of the TAGs presented in the oil (Table 2). Oleic-oleic-linolenic (OOLn) and palmitic-oleic-palmitic (POP) TAGs were also present in a significant percentage in Buriti oil (11.1 and 7.4, respectively). The results of this study are in agreement with other studies with

Table 2. Classes of TAG in Buriti oil

TAG	%
PPO	7.4
MOO	1.2
PPLn	1.0
POO	25.1
POL	3.9
POLn	6.4
SOO	1.6
OOO	28.8
OOL	6.9
OOLn	11.1
OLLn	1.6
OLnLn	1.4
Others	3.6
Sum	100.0
Total SSS	0.9
Total SUS	9.8
Total SUU	39.3
Total UUU	50.0

L: linoleic acid; Ln: linolenic acid;
M: miristic acid; O: oleic acid;
P: palmitic acid; S: stearic acid.

Buriti oil. Santos *et al*. (2013b) and Saraiva *et al*. (2009) found OOO (39.8% n 35.6%, respectively) and POO (35.9% and 34.5%, respectively), as dominant species, although in the study of Saraiva *et al*. (2009) a higher concentration of palmitic-oleic-stearic was obtained (POS, 7.8%) and oleic-oleic-stearic (OOS, 10.7%) TAGs and in the study of Santos *et al*. (2009) were not detected oleic-oleic-linoleic (OOL) TAG specie. These small differences in the TAG species are related to the variation in the concentration of fatty acids (Table 1).

The tri-unsaturated TAGs (U_3), prevalent in Buriti oil, with melting points from −14 to 1 °C, are important for the softness and lubricity of some products at room temperature, and offer the nutritional benefits of unsaturated fatty acids. The mono-saturated-di-unsaturated (SU_2) TAGs, with melting points from 1 to 23 °C are important for the oral properties and mechanical-performance of some products at room temperature (O'Brien, 2009; Rodrigues and Gioielli 2003; Bessler and Orthoefer 1983).

The TAG composition of Buriti oil is similar to olive oil, which presents the TAG OOO (32.5%), followed by POO (21.82%), as the main species of TAGs (Criado *et al*., 2008). Both oils have TAG SU_2 between 50 and 60%, and TAG U_3 between 38–40% (O'Brien, 2009).

The information about the stereo-specific positional distribution of fatty acids in camellia oil can be used for the development of structured lipids for food, pharmaceutical, and medical purposes.

3.4. Minor compounds

Tocopherols

Tocopherols are natural antioxidants present in fats and oils. The antioxidant activity is due not only to the de-activation of free radicals produced by the decomposition of lipid hydroperoxides, but also to the inhibition of lipid hydroperoxide decomposition (Pokorny and Parkányiová, 2005; Makinen *et al*., 2001). In addition, previous studies have shown that tocopherols have substancial health benefits such as hypocholesteremic, hypolipidemic, anticancer, anti-inflamatory and antioxidant properties and slow down the aging process (Ghaffari *et al*., 2011; Singh and Devaraj 2007; Hau *et al*., 2006).

The data obtained on the qualitative and quantitative composition of tocopherols in Buriti oil are summarized in Table 3. This oil is particularly rich in tocopherols (2364.1 $mg \cdot kg^{-1}$) and such high values are encountered in a very limited number of oils (Tuberoso *et al*., 2007). Vegetable oils normally contain tocopherol concentrations in the range of 200–1000 $mg \cdot kg^{-1}$ (Chen *et al*., 2011).

All tocopherols were present in Buriti oil, wherein α- and γ- constituted 93% of the total tocopherol content. The α-tocopherol shows the highest vitamin E activity and is the most effective antioxidant *in vivo* compared to other isomers (Ghazani and Marangini, 2013). γ-tocopherol has a complementary effect to the α-tocopherol in relation to human health (Wagner *et al*., 2004). These results are similar to those found by Santos *et al*. (2013a) and Rodrigues *et al*. (2010) where Buriti oil presents α-tocopherol as the most important homologue.

Total carotenoid

The search for natural sources of β-carotene is of great interest, since only 2% of all commercial β-carotene is naturally produced worldwide (Dufossé *et al*., 2005; Ribeiro *et al*., 2011). Carotenoids attracted attention because a number of epidemiological studies have revealed that an

Table 3. Minor compounds in Buriti oil

Compounds	$mg \cdot kg^{-1}$
α-tocopherols	1125.0±3.9
β-tocopherols	71.3±0.0
γ-tocopherols	1074.0±3.4
δ-tocopherols	93.8±0.5
Total β-carotene	781.6±67.3
Total phenol (gallic acid equivalent)	107.0±1.2

increased consumption of a diet rich in carotenoids is correlated with a diminished risk for several degenerative disorders, including various types of cancer, cardiovascular or ophthalmological diseases (Stahl and Sies, 2003; Mayne, 1996). The preventive effects have been associated with their antioxidant activity, protecting cells and tissues from oxidative damage (Sies and Stahl, 1995). Carotenoids also influence cellular signaling and may trigger redox-sensitive regulatory pathways (Stahl *et al*., 2002). The bioactivity of these compounds depends on the foods matrix where they are present. β-carotene which is present in oils has a bioactivity six times higher than that found in vegetables (Benadé, 2013).

Data about the carotenoid composition in Buriti oil are presented in Table 3. The results indicate that this oil is one of the richest known sources of biological active β-carotene (781. 6 mg·kg^{-1}), which imparts the characteristic orange-red color and also lends oxidative protection to the oil (Ribeiro *et al*., 2011; Benadé, 2013). In the literature, the total carotenoid content of Buriti oil fluctuates between 600 mg·kg^{-1} to 10,000 mg·kg^{-1}, probably depending on the varietal selection, the degree of ripeness, agronomical factors, and extraction procedure (Santos *et al*., 2015).

In a study that assess the antioxidant activity of carotenoids measured by ferric reducing antioxidant power (FRAP), ABTS bleaching assay (α-TEAC), DPPH assay and peroxyl radical scavenging assay compared to α-tocopherol, BHA and BHT, most of them showed carotenoid as the greatest antioxidant. The carotenoid tested displayed an antioxidant activity more than eight times as high as α-tocopherol (Muller *et al*., 2011). Due to the ability of the carotenoids to quench singlet oxygen, such as the superoxide radical, peroxide radical and hydroxyl radical, which can be generated by exposure to UV radiation, studies using Buriti oil in sunscreen formulations are promising (Zanatta *et al*., 2010). In another study, red palm oil, which is rich in carotenoids such as Buriti oil (between 500 and 700 mg·kg^{-1} total carotenoids), has been used to combat vitamin A deficiency in Africa (Benadé, 2013; Gunstone and Harwood, 2007).

Total polyphenol

Phenolic compounds have significant biological potential, especially in preventing oxidative stress, inflammation and bacterial infection (Lesjak *et al*., 2014). In addition these effects on health, such phenolic compounds, due to their antiradical activity, can protect the tocopherols present in the oil and prevent the autoxidation of unsaturated fatty acids, increasing the shelf-life of the oil (Valavanidis *et al*., 2004).

The results in Table 3 show that the Buriti oil is a source of phenolic compounds (107.0 mg gallic acid equivalents·kg^{-1}). Although the concentration of this compound in this oil is not as high as olive oil (170–210 mg gallic acid equivalents·kg^{-1}), it is superior to many other vegetable oils (Tuberoso *et al*., 2007). Non-traditional oils, such as black cumin oil, coriander seed oil and niger seed oil, sources of bioactive compounds with antioxidant potential, present phenolic compound concentrations of 24, 11 and 5 mg·kg^{-1}, respectively, which are lower than the one found in Buriti oil, which reinforces the great nutritional and health potential of this oil (Ramadan *et al*., 2003).

3.5 Antioxidant assay

DPPH

The assays which determine the antioxidant potency of oils can be categorized into two groups: tests for radical scavenging ability and tests that examine the ability to inhibit lipid oxidation. However, the model for scavenging stable free radicals is widely used to estimate the antioxidant properties in a relatively short time and with reliability (Reische *et al*., 2002; Ramadan and Moersel 2006).

Table 4 shows the antioxidant capacity of Buriti oil expressed as percentage of decrease in the absorbance (Free radical scavenging activity). As a result of a color change from purple to yellow the absorbance decreased when the DPPH radical was scavenged by an antioxidant through donation of hydrogen to form a stable DPPH-H molecule (Matthaus, 2002). Thus, a higher percentage of absorbance decrease indicates a greater free radical scavenger.

The oil was dissolved in ethyl acetate in different concentrations (5–100 mg·mL^{-1}) against the free radical DPPH. The results demonstrate that a dose-dependent effect, in general, was noted; the higher the oil dose, the stronger the radical scavenging ability obtained. However, at the concentration of 50 mg·mL^{-1} of oil, free radical scavenging activity begins to be stabilized; doubling the oil concentration increases the free radical scavenging by only 6%.

The choice of ethyl acetate as solvent was due to its ability to dissolve the oil without the need to fractionate it. A previous study suggests that the

TABLE 4. Antioxidant capacity of Buriti oil by DPPH assay.

Oil concentration (mg·mL^{-1})	Free radical scavenging activity
5	36.53±1.35^{a}
10	39.74±1.58^{ab}
50	73.15±1.4^{a}
100	78.07±2.13^{ab}

$^{a, ab}$ - Means with the same letter in the column are not significantly different at the 5% significance level.

assessment of antioxidant potential without the polar and non-polar fractions of the oil demonstrate a higher antioxidant potential. This could be due to the synergistic effect of the different antioxidants present in both the non-polar and polar fractions (Espín *et al*., 2000).

Comparison of the results obtained in this study with other studies is inaccurate, since experimental conditions differ. Different solvents may cause differences in the antioxidant pattern between the groups' assays, since it has been shown that the solvent may affect the hydrogen-donating ability of the antioxidant (Ramadan and Moersel, 2006). However, the results of this study, compared to other oils with antioxidant activity, suggest that the Buriti oil proved to be efficient in DPPH radical scavenging. In a study with olive oil, which has a fatty acid and TAG composition similar to Buriti oil, it is observed that olive oil reduced the free radical DPPH by 8.8% after 60 minutes of reaction (Ramadan and Moersel, 2006). In this same study, coriander seed oil was able to quench the free radical in 26.7% after 60 minutes of reaction. Coriander seed oil is rich in oleic acid (67%) and presents a carotenoid concentration of 892 $mg \cdot kg^{-1}$; physicochemical characteristics which are similar to Buriti oil.

Some studies evaluate the results of DPPH in EC_{50}, defined as the concentration in $mg \cdot mL^{-1}$ required to scavenge 50% of the DPPH free radical. In a study with Buriti oil, using chloroform as a solvent, it was found that the oil's antioxidant capacity is similar to other oils from the Amazonian area, with EC_{50} 7.7 $mg \cdot mL^{-1}$ (Ferreira *et al*., 2011). The results, although impossible to compare with those obtained in this study, confirm the antioxidant potential of Buriti oil against the DPPH radical.

ORAC

The ORAC assay measures the oxidative degradation of the fluorescent molecule, namely fluorescein. In the presence of antioxidants, loss in fluorescence in the fluorescein is inhibited and this inhibition is directly related to antioxidant activity (Miraliakbari and Shahidi, 2008).

The ORAC value found for Buriti oil was 95.3 μmol $TE \cdot g^{-1}$ oil, a value similar to other oils rich in minor compounds and known for positive health effects (Zullo and Ciafardini, 2008; Dhavamani *et al*., 2014). Although, as with the DPPH analysis, comparison of the results of this study with other studies it is inaccurate, and serves only as a reference. No other study assessing the antioxidant activity of Buriti oil without its fractionation was found, but a study that evaluated the ORAC value of the lipophilic and hydrophilic fractions of this oil indicated that the hydrophilic fraction (8.3 μmol $TE \cdot g^{-1}$ oil), due to synergistic effects of the pool of antioxidants, presents a value almost 5 times higher than the lipophilic fraction (1.8 μmol $TE \cdot g^{-1}$ oil) (Bataglion *et al*., 2015). When comparing these results with those obtained in our study, the big difference in the total ORAC (95.3 and 10.1 μmol $TE \cdot g^{-1}$ oil, respectively) is, as mentioned above, due to the synergistic effect of the different antioxidants present in both non- polar and polar fractions, type of solvent used or even oil characteristics. When comparing the results with various integral olive oils from Italy, known for high antioxidant potential, the total ORAC value found was between 146–280 μmol $TE \cdot g^{-1}$ oil, relatively close to those obtained in our study (Zullo and Ciafardini, 2008). In another study that evaluated the antioxidant activity of various oils rich in minor compounds, rice bran oil presented an ORAC content of 130.0 μg $TE \cdot mg^{-1}$, sesame oil 122 μg $TE \cdot mg^{-1}$, olive oil 111 μg $TE \cdot mg^{-1}$ and palm oil 79 μg $TE.mg^{-1}$ (Dhavamani *et al*., 2014). These results indicate that Buriti oil, as well as with the DPPH assay, is a good antioxidant in the ORAC assay.

The antioxidant activity of bioactive compounds is related to the preservation of chain initiation by binding oxygen or catalytic metal ions to delay the oxidation, decomposition of peroxides, prevention of continued hydrogen abstraction and radical scavenging protecting against oxidative damage to DNA, proteins and lipids (Marineli *et al*., 2014; Halliwell, 1994). The use of Buriti oil in cosmetic formulations, food and pharmaceuticals could be interesting for health improvement. This result reinforces the importance to comprehensively evaluate the chemical composition and antioxidant properties of unexplored Amazonian oils.

5. CONCLUSIONS

Amazonian vegetable oils have attracted attention because of their often-remarkable biological properties. Many oils are known to possess biological properties and have been used by the local population to treat many diseases. Enlarging the scientific data on the chemical, technological and biological properties of the Amazon Buriti oil can facilitate the development of industrial applications for this non-conventional oilseed.

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