XXV Congresso Brasileiro de Ciência e Tecnologia de Alimentos
Alimentação: a árvore que sustenta a vida
X CIGR Section IV International Technical Symposium
Food: the tree that sustains life
24 a 27 de outubro de 2016 • FAURGS • GRAMADO/RS

Oils and fats of 12 Amazonian plants: A determination of fatty acids, tocols and total carotenes reveals new sources for industrial use

Josilene Lima Serra[1]; Antonio Manoel da Cruz Rodrigues[2]; Luiza Helena Meller da Silva[2], Antonio José de Almeida Meirelles[3], Sylvain Darnet[4]

[1]Departamento de Tecnologia em Alimentos, Instituto Federal do Maranhão - CEP: 65365-000 - Zé Doca-MA-Brazil - e-mail: (josilene.serra@ifma.edu.br)
[2] Instituto de Tecnologia , Universidade Federal do Pará, CEP: 66.075-900, Belém-PA, Brazil.
[3] Faculdade de Engenharia de Alimentos, Universidade Estadual de Campinas, CEP: 13083-862, Campinas – SP, Brazil – e-mail: (lhmeller@ufpa.br).
[4]Instituto de Ciências Biológicas, Universidade Federal do Pará, CEP: 66.075-900, Belém-PA-Brazil - e-mail: (sylvain@ufpa.br)

ABSTRACT – The present study aimed to identify the content of fatty acids, tocopherol, tocotrienol and total carotenes present in twelve oils and fats of plant species from Amazonian region. The fatty acids profile could have classified the studied oleaginous in three groups, firstly as saturated fats rich in lauric acid (babassu oil), miristic acid (ucuuba fat) and palmitic acid (bacuri fat). Second group, as monounsaturated oils with high oleic acid content, as buriti, pracaxi and patawa oils. The third group is composed to polyunsaturated oils rich in linoleic acid as passion seed oil and Brazil nut. For tocopherol, tocotrienol and total carotenes were used a simultaneous determination method and reveal a higher level these vitamins in buriti oil and pracaxi fat. Among studied oleaginous plant, the buriti oil is a highlight to be a very rich source of vitamin E and carotenoids containing about 1500 ppm and 1700 ppm, respectively.

KEYWORDS: oleaginous, fatty acids, vitamin, physico-chemical composition

1. INTRODUCTION

The present demand for oils and fats destined for human consumption with empathize for health food and uses industrial has increased the interest for new sources vegetable oils. Several studies have been done in oleaginous plants species in order to find new sources of oils with high nutritional, industrial and pharmaceutical importance (Nehdi, 2011; Franke et al., 2010).

The Amazon region is rich in genetic resources of fruits and oleaginous plants, and their economic exploitation is potentially of great importance for the region. More of 60 to 80% of unsaponifiable fraction of amazon fruits are composed of bioactive compounds, especially unsaturated fatty acids, sterol, vitamin E, carotenoids. The profile of fatty acids of major Amazon oleaginous exhibits a high unsaturation level, which is particularly high in the palm species. Oleic (C18:1) and linoleic (C18:2) acids are the most abundant fatty acids in some palm species, which could be higher than other vegetable oils, such as olive and palm oil (Santo et al. 2010; Bereau et al. 2003; Costa et al., 2010; Rufino et al., 2010).

Amazon fruits were also rich in fat-soluble vitamins, mainly carotenoids and vitamin E, which are present in the unsaponifiable lipid fraction of foods. The vitamin E is a class of lipid soluble antioxidants that is synthesized only by plant tissues and other photosynthetic organisms at various levels and in different combinations. This term is used for fat-soluble 6-hydroxychroman compounds of related structure: α-, β-, γ- and δ- tocopherols and four corresponding tocotrienols (Hunter, Cahoon, 2007). Carotenoids are lipid-soluble plant pigments found in photosynthetic plants and animal tissues. The main features of chemical structure of carotenoids is system of conjugated double bonds, which corresponds to the chromophore, and allows these compounds absorb light in the visible region, also is responsible for their antioxidant activity (Mínguez-Mosquera et al., 2002).

One of the main physiological functions of vitamin E and carotenoids is antioxidant activity, being considered as natural antioxidants in both, vegetal and animal tissues. These vitamins protect the polyunsaturated fatty acids against lipid peroxidation (Sies and Stahl, 1995; Smirnoff, 2010). Amazonian fruits have a good nutritional value and nutraceutical due presented bioactive compounds, which play an important role in human health in prevention diseases (Rosso and Mercadante, 2010; Rufino et al., 2010). However, the potencies of fat and oils of Amazonian plant species have been few explored. In the present paper were to evaluate physico-chemical composition and identify the fatty acids profile, tocols composition and total carotenes of twelve fats and oils of native species plant from Amazonian region.

2. MATERIALS AND METHODS

2.1 Oils and fats Amazonian fruits samples

This study was carried out using twelve oils and fats of fruits were obtained from Amazon region, Benevides city, Para State, North of Brazil. The oils and fats were extracted from fruits cultivated in 2011 crop. Extraction process applied was by cold extraction and samples were packed plastic vessels. After receipt, the samples transported in isothermal boxes under refrigeration (4ºC) to laboratory of the Campinas State University and maintained this temperature, protected from light until analysis.

2.2 Fatty acids composition

Fatty acid profiles were obtained by gas chromatography of the fatty acid methyl ester derivatives (FAMES) by according method Ce 1-62 (AOCS, 2005). Derivatives were isolated via saponification and esterification with potassium hydroxide in methanol (0.1 mol L-1) and hydrogen chloride in methanol (0.12 mol L-1). The FAMES were extracted with hexane and put through a GC CP3380 VARIAN gas chromatograph (Varian, USA). The chromatograph was equipped with a CP-Sil 88 (60 m x 0.25 mm) capillary column and a flame ionization detector (FID). Helium was used as the carrier gas and the temperature program was as follows: 3 min at 130 ºC; gradual heating to 220 ºC for 9 min and 35 min at 220 ºC. The injector and detector temperature were 245 ºC and 280 ºC, respectively. The chromatograph is controlled through the Galaxie Chromatography Data System (Varian, USA). The Galaxie system was used to the data acquisition and processing.

2.3 Tocols and carotenoid analysis

The tocols and carotenes quantification was performed according to the methodology previously optimized by Silva et al. (2011). In order to obtain the fat-soluble vitamin, the samples were saponified and then performed the liquid-liquid extraction, according method described by Ye, Landen, Eitenmiller (2001) and Darnet et al. (2011). The separation and quantification of compounds was made using a Shimadzu HPLC, series LC-20AT (Japan) at 30°C. The HPLC system was equipped with a quaternary pump, an autosampler (SIL-20A), a degasser, and an SPD-M20A spectrophotometric detector (Photo Diode Array detector – PDA) and a RF-10AXL fluorescence detector. The column was normal-phase Lichrospher column (Merck, 250 x 4.6 mm id; 5 µm particle size) with a guard column (10 x 4.6 mm) purchased from Merck (Germany) in following experimental conditions: the mobile phase was a mixture of hexane and isopropanol (99.5:0.5 v/v), flow rate was 1 mL/min, column temperature was 20ºC. The tocopherols and carotene quantification was performed by fluorescence detection (excitation 290 nm, emission 330 nm) and PDA detection wavelength was set at 292 and 455 nm, respectively.

3. RESULTS AND DISCUSSION

3.1 Fatty acids profile of oils and fats Amazonian fruits

The fatty acids compositions (%) of the studied oleaginous are summarized in Table 1. The samples of muru-muru fat, ucuuba fat, bacuri fat, copaiba oil and babassu oil are composed essentially of saturated fat based on its composition by high saturated fatty acids (SFA) content, ranging of 64.57 to 99.23%. In SFA class the babassu oil and muru-muru fat could be categorized as fat rich in lauric acid (C12:0) containing both about 49% dry mass, the ucuuba fat in miristic acid (C14:0) with 77% dry mass and bacuri fat in palmitic acid (C16:0) with 63% dry mass.

Table 1. Fatty acids composition (%) of studied oils and fats.

FA (%)	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10	SP11	SP12
C:8	1.4	0.1	0	0.	0	0	28.5	0	0	8.6	0	0
C10:0	1.4	0.5	0.1	0	0	0	26.4	0.1	0	7.4	0	0
C12:0	49.6	15.1	0	0	0	0.14	0	5.3	0.2	50.0	0	0
C13:0	0.1	0.1	0	0	0	0	0	0	0	0	0	0
C14:0	28.2	77.5	0.1	0.2	0.1	0.10	0	3.6	0.1	14.2	0	0.1
C15:0	0	0.4	0	0	0	0	1.1	0	0.3	0	0	0
C16:0	6.5	4.4	7.4	63.1	17.6	2.37	4.8	28.7	13.6	6.6	10.8	14.8
C16:1	0	0.2	0.1	6.6	0.3	0	7.4	0.8	0.4	0	0.2	0.3
C17:0	0	0	0.2	0	0.1	0	3.1	0.1	0.1	0	0.1	0.1
C18:0	2.6	0.9	33.9	1.2	1.5	4.65	8.9	6.2	2.8	2.7	3.0	11.1
C18:1	6.8	0.1	43.2	26.2	78.5	72.16	14.5	44.7	78.5	9.0	16.1	32.0
C18:2	3.1	0.5	3.7	2.6	1.1	18.84	5.1	9.3	3.5	1.5	69.2	41.2
C18:3	0.1	0	11.7	0.1	0.1	1.52	0	1.0	0.1	0	0.2	0.3
C20:0	0	0	0.1	0	0.6	0.22	0	0.3	0.5	0	0.4	0.1
C22:0	0	0	0	0	0	0	0.1	0	0	0	0	0
SFA	89.9	99.2	41.7	64.6	20.0	7.5	73.0	44.2	17.6	89.5	14.7	26.1
MUFA	6.9	0.2	43.2	32.7	78.8	72.2	21.9	45.5	78.9	9.0	16.2	32.3
PUFA	3.3	0.5	15.0	2.7	1.2	20.4	5.1	10.3	3.6	1.5	69.4	41.5

Legend: FA (Fatty acids); SP (Sample); SP 1 (Muru-muru fat); SP 2 (Ucuúba fat); SP3 (Cupuaçu fat); SP4 (Bacuri fat); SP5 (Buriti oil); SP6 (Pracaxi oil); SP7 (Copaiba oil); SP8 (Andiroba oil); SP9 (Pataua oil); SP 10 (Babassu oil); SP11 (Passion seed oil); SP12 (Brazil nut oil).

Regarding to polyunsaturated fatty acids (PUFA), the passion seed oil shown highest content about 69% of dry mass and followed by Brazil nut oil. Both are rich in linoleic acid (C18:2). The monounsaturated fatty acids content for higher in the buriti, pracaxi and patawa oils being the oleic acid (C18:1) the most abundant fatty acid. The oleic acid content of these oils is similar or higher to olive oil and “high oleic” sunflower oil (Azian et al., 2010; Codex Alimentarius, 2009). Results similar to shown in table 1 are in accordance with previous works for fatty acids compositions of studied oils and most authors considered these oils as nutraceutical oils (Hernandez et al., 2009; Montufar et al., 2010, Silva et al., 2009, Rodrigues et al., 2010).

3.2 Tocol composition and total carotenes

The tocols were detected and quantified in only eight oils and fats samples (Table 2). A large variability in total vitamin E content was observed in the studied samples, ranging from 21.42 (Brazil nut oil) to 1511.01 mg.kg^{-1} (buriti oil). Buriti oil, pracaxi oil and muru muru fat are excellent vitamin E sources.

Table 2. The vitamin E and carotenes composition in oil and fat from amazon fruit.

Vitamins	SP1	SP3	SP4	SP5	SP6	SP10	SP11	SP12
α-T	89.9	ND	ND	451.5	ND	42.2	ND	ND
β- T	91.5	4.2	4.3	762.0	ND	ND	ND	ND
γ- T	10.1	8.9	ND	56.7	416.1	11.9	12.2	13.3
δ- T	5.6	ND	ND	139.5	7.8	12.1	8.5	8.1
α-T3	ND	ND	ND	90.8	93.5	ND	ND	ND
β- T3	ND	3.7	1.3	ND	79.9	ND	ND	ND
γ- T3	ND	ND	21.0	ND	ND	ND	12.7	ND
δ- T3	ND	ND	ND	10.6	ND	ND	22.1	ND
α-TE*	137.0	3.2	2.2	56	41.85	43.7	1.5	43.7
Vitamin E	197.2	16.8	26.6	1511.01	597.36	66.	55.5	21.4
Carotenes	0	0	0	1722.87	8.84	0	0	0

Legend: SP (Sample); SP 1 (Muru-muru fat); SP 2 (Ucuúba fat); SP3 (Cupuaçu fat); SP4 (Bacuri fat); SP5 (Buriti oil); SP6 (Pracaxi oil); SP7 (Copaiba oil); SP8 (Andiroba oil); SP9 (Pataua oil); SP 10 (Babassu oil); SP11 (Passion seed oil); SP12 (Brazil nut oil), * α-TE: Tocopherol Equivalent Activity. All results are expressed as mean.

Tocopherols and tocotrienols are valuable antioxidants, which make them particularly important role for human healthy in disease prevention and therapeutic uses. Therefore, the results were also expressed in α-tocopherol activity equivalent (α-TE), unit proportional to antioxidant capacity and absorption level in human of α-tocopherol. Among samples analyzed, the buriti oil (842.30 α-TE/100g), muru-muru fat (136.88 α-TE/100g), babassu oil (43.71 α-TE/100g) and pracaxi oil (41.85 α-TE/100g) presented good antioxidant activity. Buriti oil has the higher α-TE than compared to wheat germ oil and muru muru fat has higher than sunflower oil. The Institute of Medicine recommended daily intake for adult of 15 mg α-TE per day so 2 g buriti oil or 12 g muru muru fat are sufficient to supply the daily needs of an adult (IOM, 2000).

In terms of isoforms of tocols, buriti oil presented all tocopherols and δ-tocotrienol. The isomers most important encountered were β-tocopherol in highest concentration and α-tocopherol, which together compose about 80% of the total tocols. In pracaxi oil was identified four tocol isomers being γ-tocopherol the most predominant composing about 70% of total vitamin E content. Muru muru fat presented all tocopherol isomers, where α- and β-tocopherol together compose about 92% of the total tocols. In others samples, the predominant isomer in babassu oil were α-tocopherol; in Brazil nut oil and cupuacu fat the γ-tocopherol; in bacuri fat the γ-tocotrienol and δ-tocotrienol in passion seed oil.

Regarding the carotenoids content were only detected in buriti and pracaxi oils (Table 2). The buriti oil are rich in carotenoids with 1722.87 mg kg^{-1}, this high value is encountered in a very limited number of edible oils, such palm oil that contain about 1385 mg kg^{-1}(Sampaio et al., 2013). No there is data reported in literature on carotenoids content in pracaxi oil. The total vitamin E content and total carotenes found in literature to buriti oil was lower than results this study (Silva et al., 2009; Silva et al., 2011; Santos et al., 2015).

For Brazil nut oil, our results were lower than reported in literature and β-tocopherol was the isomer predominant (Chunhieng et al., 2008; Kornsteiner et al., 2006). Additionally, the method used was not detected vitamin E in patawa oil. In contrast with works previous in literature that reported this oil is rich in tocopherols, mainly α-tocopherol (Hernandez et al., 2009; Montufar et al., 2010; Rodrigues et al., 2010).

Variations in content of vitamin E and A inside tropical plant species of Amazon region have been related in literature. Among relate factors are highlights the plant variety, the climate during growth and ripening, the content of the polyunsaturated fatty acids, harvest storage and processing (Franke et al., 2010; Silva et al., 2011). There is a larger genetic variation within tropical palm species relates to geographic patterns and ecotypes. Studies genetics can be key to explained these variations and distinguish ecotypes from others.

4. CONCLUSION

Amazonian oils and fats are valuable resources with good potential for use industrial. The studied oleaginous presented a high proportion of saturated acids, as lauric (babassu oil and muru muru fat), myristic (ucuuba fat) and palmitic acids (bacuri fat), monounsaturated as oleic acid (buriti, pracaxi, patawa oils) and polyunsaturated as linoleic acid (passion seed oil). This fatty acids profile allow their improvement to production of foods, cosmetics, biofuels, soap and detergent. Our results showed that buriti, pracaxi, passion seed, patawa and Brazil nut oils presented good nutritional value due high levels of oleic acid, carotenes and vitamin E and has a great potential for use an edible oil. Finally, studies for optimization of processing procedure to oils and fats are needed to obtain a product of uniform quality and to add higher commercial value.

5. REFERENCES

Bereau, D., Benjelloun-Mlayah, B., Banoub, 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

Chunhieng, T., Hafidi, A., Pioch, D., Brochier, J., & Montet, D. (2008). Detailed study of Brazil nut (Bertholletia excelsa) oil micro-compounds: Phospholipids, tocopherols and sterols. Journal of the Brazilian Chemical Society, 19(7), 1374–1380.

D, F. (1994). Official methods and recommended practices of the American Oil Chemists' Society. AOCS Press,Champaign, 4th edn, 2–5.

Darnet, S., Serra, J. L., da Cruz Rodrigues, A. M., & Meller da Silva, L. H. (2011). A high-performance liquid chromatography method to measure tocopherols in assai pulp (Euterpe oleracea). Food Research International, 44(7), 2107–2111.

Espírito Santo, A. P. do, Silva, R. C., Soares, F. A. S. M., Anjos, D., Gioielli, L. A., & Oliveira, M. N. (2010). Açai pulp addition improves fatty acid profile and probiotic viability in yoghurt. International Dairy Journal, 20(6), 415–422.

Franke, S., Fröhlich, K., Werner, S., Böhm, V., & Schöne, F. (2010). Analysis of carotenoids and vitamin E in selected oilseeds, press cakes and oils. European Journal of Lipid Science and Technology, 112(10), 1122–1129.

Hernández, P. B. N., Fregapane, G., & Moya, M. D. S. (2009). Bioactive compounds, volatiles and antioxidant activity of virgin seje oils (Jessenia bataua) from the Amazonas. Journal of Food Lipids, 16(4), 629–644.
Hunter, S. C., & Cahoon, E. B. (2007). Enhancing vitamin E in oilseeds: Unraveling tocopherol and tocotrienol biosynthesis. Lipids.
IOM. (2000). Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. Washington, DC: National Academy of Sciences, National Academy Press.
Kornsteiner, M., Wagner, K. H., & Elmadfa, I. (2006). Tocopherols and total phenolics in 10 different nut types. Food Chemistry, 98(2), 381–387.
Mínguez-Mosquera, M. ., Hornero-Méndez, D., & Perez-Galvez, A. (2002). Carotenoids and provitamin A in functional foods. In W. . Hurst (Ed.), Methods of analysis for functional foods and nutraceuticals (Washington). London.
Montufar, R., Laffargue, A., Pintaud, J. C., Hamon, S., Avallone, S., & Dussert, S. (2010). Oenocarpus bataua Mart. (arecaceae): Rediscovering a source of high oleic vegetable oil from amazonia. JAOCS, Journal of the American Oil Chemists' Society, 87(2), 167–172.
Nehdi, I. A. (2011). Characteristics and composition of Washingtonia filifera (Linden ex André) H. Wendl. seed and seed oil. Food Chemistry, 126(1), 197–202.
Rodrigues, A. M., Darnet, S., & Da Silva, L. H. M. (2010). Fatty acid profiles and tocopherol contents of buriti (mauritia flexuosa), patawa (oenocarpus bataua), tucuma (astrocaryum vulgare), mari (poraqueiba paraensis) and Inaja (Maximiliana Maripa) fruits. Journal of the Brazilian Chemical Society, 21(10), 2000–2004.
Rosso, V. V., & Mercadante, A. Z. (2007). Identification and quantification of carotenoids, by HPLC-PDA-MS/MS, from Amazonian fruits. Journal of Agricultural and Food Chemistry, 55(13), 5062–5072. http://doi.org/10.1021/jf0705421
Rufino, M. do S. M., Alves, R. E., de Brito, E. S., Pérez-Jiménez, J., Saura-Calixto, F., & Mancini-Filho, J. (2010). Bioactive compounds and antioxidant capacities of 18 non-traditional tropical fruits from Brazil. Food Chemistry, 121(4), 996–1002.
Sampaio, K. A. ., Ayala, J. V. ., Silva, S. M. ., Ceriani, R. ., Verhé, R. ., & Meirelles, A. J. A. . (2013). Thermal degradation kinetics of carotenoids in palm oil. JAOCS, Journal of the American Oil Chemists' Society, 90(2), 191–198.
Santos, A, M. F. G., Alves, R. E., & Roca, M. (2015). Carotenoid composition in oils obtained from palm fruits from the Brazilian Amazon. Grasas Y Aceites, 66.
Silva, S. M., Rocco, S. A., Sampaio, K. A., Taham, T., Da Silva, L. H. M., Ceriani, R., & Meirelles, A. J. A. (2011). Validation of a method for simultaneous quantification of total carotenes and tocols in vegetable oils by HPLC. Food Chemistry, 129(4), 1874–1881.
Silva, S. M., Sampaio, K. A., Taham, T., Rocco, S. A., Ceriani, R., & Meirelles, A. J. A. (2009). Characterization of oil extracted from buriti fruit (Mauritia flexuosa) grown in the Brazilian Amazon Region. JAOCS, Journal of the American Oil Chemists' Society, 86(7), 611–616.
Ye, L., Landen, W. O., & Eitenmiller, R. R. (2001). Simplified extraction procedure and HPLC determination for total vitamin E and β-carotene of reduced-fat mayonnaise. Journal of Food Science, 66(1), 78–82.