Food Research International 108 (2018) 27–34

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Sapucaia nut (Lecythis pisonis Cambess) and its by-products: A promising and underutilized source of bioactive compounds. Part I: Nutritional composition and lipid profile

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ARTICLE INFO

Keywords:
Minerals
Selenium
Fatty acids
Triacylglycerol
Tocopherols
Phytosterols

ABSTRACT

The nutritional composition of the sapucaia nut, cake and shell, the nut and cake minerals content and the lipid profile of the nut oil (fatty acids, tocopherols, phytosterols and triacylglycerols) were determined. The nuts and cake exhibited a high content of lipid (47.9 to 60.8 mg 100 g^{-1}), protein (15.8 to 19.5 mg 100 g^{-1}), dietary fiber (16.5 to 22.6 mg 100 g^{-1}) and provided an excellent source of selenium (26.4 to 46.94 μg g^{-1}). The oil contained a high amount of unsaturated fatty acids (39.7 to 45.4% of oleic and 32.2 to 46.6% of linoleic acids) and presented a high Oxidative Stability Index (8.57–12.95 h) indicating the presence of antioxidant compounds in the oil. The major triacylglycerols in the sapucaia oil were LLO, PLO, LOO, POO, OOO, PLL and LLL. The main bioactive lipids identified in the oil were γ-tocopherol (19.2 to 28.5 mg 100 g^{-1}) and β-sitosterol (92.8 to 194 mg 100 g^{-1}). The results showed that the sapucaia nut and its by-products are a promising natural source of bioactive and nutritional compounds and when present in the diet can contribute to the maintenance of human health. In addition, the nut and by-product represents a promising raw material for the food industry.

1. Introduction

Nuts such as almonds, cashew nuts, walnuts, pistachios, hazelnuts, pecans, macadamia and Brazil nuts have received special attention from researchers due to their unique combination of nutrients. Studies have confirmed that a daily intake of nuts associated to a healthy diet contributes to the prevention of cardiovascular disease, type II diabetes and cancer (Aune et al., 2016; Nishi et al., 2014; Yang, 2009). The beneficial effects on health probably are due to the synergistic interaction of the bioactive constituents present in the nuts. Nuts provide large amounts of healthy monounsaturated and polyunsaturated fats which help to regulate blood cholesterol and prevent cardiovascular diseases (Nishi et al., 2014). They are also rich in fiber and phytosterols that contribute to the reduction of the cholesterol re-absorption in the intestine (Robbins, Shin, Shewfelt, Eitenmiller, & Pegg, 2011; Salas-Salvadó, Bulló, Pérez-Heras, & Ros, 2006; Shahzad et al., 2017). In addition, nuts contain tocopherols (vitamin E), minerals (calcium, iron, zinc, potassium and magnesium), antioxidant minerals (selenium, manganese and copper) and phenolic compounds that may reduce oxidative stress and inflammation (Cardoso, Duarte, Reis, & Cozzolino, 2017; Colpo et al., 2014; Naozuka, Vieira, Nascimento, & Oliveira, 2011; Robbins et al., 2011). The low content of sodium and high content of potassium contribute to maintain a normal blood pressure (Ndanuko et al., 2017).

Brazil, due to its size and the existence of different biomes, has one of the largest world reserves of native plant species that have not been fully investigated. Such plants may present significant nutritional and economic potential. Sapucaia nut (*Lecythis pisonis* Cambess), from the

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https://doi.org/10.1016/j.foodres.2018.03.028
Received 31 October 2017; Received in revised form 5 March 2018; Accepted 9 March 2018
Available online 11 March 2018

botanical family of *Lecythidaceae*, is a species present in the Amazon region and Atlantic forest, mainly in the states of Amazonas, Pará, Rondonia, Piauí, Pernambuco, Maranhão, Bahia, Espirito Santo, Minas Gerais, and Rio de Janeiro (USDA, 2017; Vallilo, Tavares, Aued-Pimentel, Campos, & Moita Neto, 1999). The fruits present a weight between 1 and 2.5 Kg and the average yield of sapucaia nuts per tree is 75 kg. Each fruit contain between 30 and 50 nuts and each nut weighs between 4 and 14 g (Wickens, 1995). The nuts are rich in proteins, essential fatty acids and minerals (Denadai et al., 2007; Naozuka et al., 2011; Teixeira, Ávila, Ribani, Silveira, & Ribani, 2017; Teixeira, Ghazani, Corazza, Marangoni, & Ribani, 2018; Vallilo et al., 1999). Although sapucaia nuts are consumed by the local population, their nutritional and phytochemical compositions are unclear and the economic and socio-cultural potential of the nuts have not been explored. Only a few studies have investigated the chemical composition of sapucaia nuts and its by-products. In addition, since there is a demand for this raw material but it is not produced on a large scale, there is a high extractive potential for sapucaia nut, being possible increase their exploitation.

In this study, the nutritional and phytochemical composition of sapucaia nuts, cake, oil and shell were determined. This knowledge is fundamental for encouraging its sustainable production and consumption by the population. In addition, the exploitation of this oleaginous fruit may help the preservation of the ecosystem and the socioeconomic development of the local population and it is also a promising raw material for the food industry.

2. Materials and methods

2.1. Samples

Sapucaia nuts (*Lecythis pisonis* Cambess) were collected from native trees in Teresina - Piauí, Brazil (05° 05′ 21″ S; 42° 48′ 07″ W; 72 m of altitude, and average annual temperature and relative humidity of 26.2 °C and 71%, respectively) and provided by the Brazilian Agricultural Research Corporation (EMBRAPA Meio-Norte) (samples A1, A2 e A3). The sample B1 was collected in Viçosa - Minas Gerais, Brazil (20° 45′ 14″ S; 42° 52′ 53″ W; 648 m of altitude, and average annual temperature and relative humidity of 18.5 °C and 66%, respectively) and provided by the Federal University of Viçosa (UFV). All samples (about 600 g each) were harvested in October 2016.

2.2. Chemical reagents

The standards and Rh, Ca, Mg, Cu, Zn, Mn, Se, Na, Sn, Pb, Cd, Cr, Ni, Al and Mo stock solutions were purchased from Sigma-Aldrich Co. (St. Louis,USA). The fatty acid standards (a mix with 37 components, linolenic acid methyl ester isomer mix, all-cis-7,10,13,16,19-docosapentaenoic acid, linoleic acid and conjugated methyl esters) were purchased from Merck (Darmstadt, Germany). The tocopherols standards, α-, β-, γ- and δ-tocopherol, and the phytosterols standards, β-sitosterol, estigmasterol, campesterol and brassicasterol, were purchased from Merck (Darmstadt, Germany). Nitric acid (65% m/m) was purchased from Merck (Darmstadt, Germany) and purified by quartz double sub-boiling distillation (Kürner Analysentechnik, Rosenheim, Germany). Solvents of analytical grade were used in the chemical analysis and they were purchased from Vetec Fine Chemicals (Xerem, Brazil) and Sigma–Aldrich Co. (St. Louis, USA).

2.3. Sample preparation and lipid extraction

The sapucaia nuts were cracked and the sapucaia oil was obtained using a hydraulic press TE-098 Tecnal® (Sao Paulo, Brazil). The samples were pressed three times and the obtained oil was centrifuged for 10 min at 4.000 rpm. The oil samples were stored in amber vials (flushed with nitrogen) at −24 °C for further use in the analyses. The

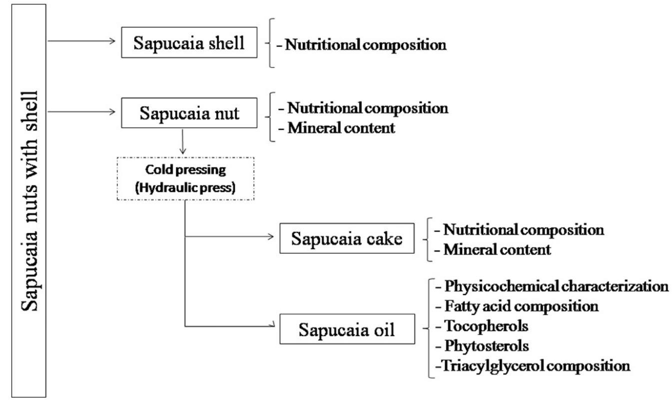

Fig. 1. Analyses carried out on sapucaia nuts, cake, oil and shell.

extraction yield (EY) was calculated according to the equation:

$$\text{EY (\%)} = [(\text{weight of extracted oil})/(\text{weight of crushed almonds})] \times 100 \quad (1)$$

The physicochemical characterization, fatty acid composition, tocopherol, phytosterol and triacylglycerol content of the extracted oil were determined. The nutritional composition and mineral content of the sapucaia nuts and of the resulting cake generated after pressing of the nuts were determined. Fig. 1 show a schematic diagram of the analyses carried out on sapucaia nuts, cake, oil and shell.

2.4. Nutritional composition

The nutritional composition of the sapucaia nut, cake, and shell was performed following the methods recommended by the Association of Official Analytical Chemicals (AOAC, 2005). The moisture content (925.09) was determined by oven-drying the samples at 105 °C until a constant weight was reached. The ash content (923.03) was determined by incineration at 550 ± 15 °C. The crude protein content (N × 6.25) was estimated by the macro-Kjeldahl method (920.87). The total lipids (920.85) were determined by the Soxhlet extraction method. The total dietary fiber, was analyzed by the enzymatic–gravimetric method (991.43). Total carbohydrates were calculated by difference according to the Eq. (2):

$$\text{Total carbohydrates (g 100 g}^{-1}) = 100 - (\text{g fat} + \text{g protein} + \text{g ash} + \text{g fiber}) \quad (2)$$

Total energy was calculated according to the Eq. (3):

$$\text{Energy (kcal 100 g}^{-1}) = 4 \times (\text{g proteins} + \text{g carbohydrates}) + 9 \times (\text{g fat}) \quad (3)$$

2.5. Mineral content

The samples (0.1 g) were digested using a MLS-1200 Milestone microwave oven (Sorisole, Italy), with 6 mL of HNO_3 and 1 mL of H_2O_2, with the applied power varying from 250 to 600 W for 25 min in closed PFA vessels. The digested samples were diluted appropriately with deionized water. Rhodium (10 μg L^{-1}) was used as the internal standard for all determinations. External calibration was carried out using aqueous solutions prepared from a multi-element stock standard solution containing all analytes. The elements selenium, calcium, magnesium, manganese, zinc, copper, chrome, nickel, molybdenum, sodium, aluminum, cadmium, tin and lead were determined by inductively coupled plasma mass spectrometry (ICP-MS) using a Perkin Elmer SCIEX, model NexIon 300D (Shelton, USA). The operating parameters of the ICP-MS equipment were: sampling/skimmer cones: platinum; RFpower: 1100 W; signal measurement: continuous; auto lens: on;