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Comparative parameters of the nutritional contribution and functional claims of Brazil nut kernels, oil and defatted cake

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ABSTRACT

This research aims to assess the nutritional contribution and the presence of functional components in the kernels, oil, and flour of the Brazil nut (*Bertholletia excelsa*). The kernels and the cake resulting from lipid extraction were subjected to the analysis of physical characteristics, nutritional composition, and evaluation of thermal behavior. The crude oil obtained by supercritical CO2 extraction was subjected to physical and chemical characterization and fatty acid composition analysis. The results showed an average yield of 67.2% of oil confirming the high fat and calorie content of the fruit. The flour was found to be a significant source of protein, fibers, and minerals; it showed good thermal stability when subjected to gradual temperature increase. The oil obtained showed high nutritional value based on the quantification of the major essential fatty acids, especially unsaturated, 75%, and monounsaturated fatty acids, mainly the oleic and linoleic acids. The data show that Brazil nut is of great nutritional and functional importance not only due to the *in natura* consumption of its kernels but also as a source of essential fatty acids, present in its oil and flour (by-product), and as a of source proteins, fibers, and minerals essential to health confirming the nutritional and functional essentiality of its kernels, oil, and flour.

1. Introduction

Amazonian fruits have attracted great attention; there have been many studies on the main nutritional, functional, and economical components of oil seeds. These aspects are related to their potential to be used in the manufacture of pharmaceuticals, foods, skin care products, and renewable fuels among other industry sectors (Pardauil et al., 2011; Santos, Lopes, Azevedo, & Santos, 2010; Santos et al., 2012).

The kernels of the Brazil nut have great potential in contributing to food research, mainly due to their lipid, protein, and antioxidant composition such as selenium. Based on these aspects, industries have devoted considerable attention to obtaining its oil, mostly frequently by hydraulic press, process in which its waste is rarely used.

The caloric and nutritional richness of Brazil nut is recognized internationally; a fact that has become the focus of numerous studies focusing on isolating its main nutritional and functional components. The lipid fraction of this fruit stands out as one of the food products of great industrial interest in search of more profitable and economic isolation and/or extraction of lipids and future commercial applications that can lead to a good cost and benefit ratio and great development in the experimental field (Neto et al., 2009; Santos et al., 2012; Yang, 2009).

Scientific research has shown the beneficial effects of regular consumption of Brazil nut on health, suggesting that its macro and micronutrients are sources of nutritional and functional compounds, especially selenium, in addition to the high amounts of amino acid rich proteins, which exhibit a bonding affinity with selenium forming an organic complex of great bioavailability (Moodley, Kindness, & Jonnalagadda, 2007; Santos et al., 2012; Yang, 2009).

Selenium can affect physiological and metabolic changes and has an important role in the delay and prevention of natural processes of organic oxidation. It is an essential trace mineral, and when combined with Vitamin E is one of the most important organic antioxidants. Selenium participates in antioxidant enzymes, the selenodeiodinases, such as glutathione peroxidase, selenoprotein P, and tyrosine reductase.

It should also be considered that functionality related to the consumption of this oilseed is focused on its essential fatty acid composition, mainly ω-3, ω-6, and ω-9. Its levels of tocopherol, phytosterols, and phenolic compounds, among other factors, have been reported as potentially beneficial to maintaining health (FDA, 2009; Pardauil et al., 2011; Santos et al., 2012; Yang, 2009).

Therefore, due to nutritional and functional relevance of the Brazil nut and its by-products, it has been the focus of research in the field of food science and technology. Studies on its nutrient profile have identified the presence of components with different functions from those of most fruits and sometimes in amounts greater that those recommended. Moreover, this kernel is considered as a functional food since it falls into

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this category according to Decree No. 398, April 30, 1999 of the National Health Surveillance Agency (Brasil, 1999; Santos, 2012).

Additionally, due to the functional and nutrient profiles of this kernel, its by-products are potential research objects. One of the major focuses of this study is the stability of Brazil nut flour in the face of temperature changes, the main agent of degradation in food processing. Analyses that simulate changes imposed by this process are essential to study the stability of these oilseed by-products. The progressive increases in temperature are aimed at investigating its use in food products.

Since Brazil nut flour can be used as nutritional enrichment, the knowledge of its internal structure via scanning electron microscopy (SEM) can make it applicable in the food industry, because the presence of certain morphologic features may confirm its technology and functional potential such as its high water-holding capacity, emulsifying capacity, viscosity, and film forming among others.

Given the above and based on potential nutritional, functional, and technological application and focusing on adding high commercial value and wide range of industrial application, the objective of this study is to assess the nutritional contribution and the presence of functional components in the kernels, oil, and flour of the Brazil nut (*Bertholletia excelsa*).

2. Materials and methods

2.1. Material

Brazil nut kernels (5.0 kg) from Brazil nut trees that grow along the tributaries of Trombetas and Curuá rivers (2012 harvest), medium size type, and packed in polyethylene bags were purchased in the city of Belém do Pará. The samples were transported in cardboard boxes and stored at 7 °C in the Laboratory of Operations and Separations (LAOS), Federal University of Pará (UFPA).

2.2. Methods

2.2.1. Physical characterization of Brazil nut

The kernels were randomly selected based on the presence of mechanical injuries or irregularities that could prevent an accurate diameter measurement. Next, the weight was measured using an analytical balance (QUIMIS — FA 2104n Bioprecisa Electronic Balance), and the measures of maximum and minimum diameter were taken using a digital caliper (Vonder).

2.2.2. Brazil nut crude oil extraction and cake production

The samples were preheated to 50 °C in an oven with air circulation (Fabbe) the extraction supercritical CO_2 applied separation-apparatus (Speed 78 SFE, model 7071, Allentown, PA, USA) the extraction was performed in the Supercritical Extraction Unit at Federal University of Pará (UFPA).

The supercritical fluid extractor unit uses carbon dioxide P-4574 (CO_2), 99.9% purity (Indústria White Martins, Belém — PA) from a cylindrical reservoir with a capacity of 30 kg at pressure of 70 bar. After defining the optimum parameters of temperature and pressure that resulted in the best yield, exhaustive extractions were performed in order to obtain material for subsequent analyses.

The cake, resulting compound of lipid extraction, was ground in a mill (TE-650 Willie). Its structure was arranged maintaining uniformity according to granule size based on the average particle size obtained from passing through 12, 14, and 20-mesh Tyler series sieves coupled to a magnetic stirrer (Bertel Ltda, Brazil, model 0701) with the rheostat set to 8 for 10 min for the complete separation of particles, thus obtaining the Brazil nut flour. The flour was packed in low density polyethylene bags and stored under refrigeration for further analyses.

2.2.3. Determination of the composition of macro and micronutrients of the Brazil nut kernels and flour

The analyses related to the Brazil nut kernel and the cake resulting from its oil extraction were based on physicochemical analyses of nutritional composition including the assessment of lipid, protein, fiber, ash, moisture, carbohydrates, and total energy content (Brasil, 2003), which were performed according to the methods of Association of Official Analytical Chemists [AOAC] (2000).

The analysis of mineral composition expressed as macro-and microminerals in this study is related to the content of calcium, magnesium, iron, copper, zinc, manganese, selenium, phosphorus, sodium, and potassium. The samples were prepared (open) in duplicate with triplicate readings by acid digestion (closed system) using a Multiwave 3000 Microwave digestion system (Anton Paar) following the methodology of the chemistry laboratory (IQUSP). The reading of the elements was performed by argon plasma atomic emission spectrometry (ICP-AES) coupled to a Spectro Smart Analyzer Vision Software (Genesis SOP). The solutions were read by generating a curve of intensity [cps] versus concentration [ppm]. Based on prior preparation of standard curves, the generation of values related to this curve and the software automatically allows the calculation of the concentration of the element of interest based on standards.

2.2.4. Amino acid composition of partially defatted Brazil nut flour

The quantification of amino acids in the proteins of partially defatted Brazil nut flour was performed by hydrolysis on 6 N chloric acid for 24 h. The amino acids released during the acid hydrolysis react with phenylisothiocyanate (PITC) and are separated by HPLC (A53000 — Thermo Separation Products) using a reversed phase HPLC C-18 column (Phenomenex) and detected by UV absorptivity at 254 nm. Their quantification was performed using internal multilevel calibration and acid alpha-aminobutyric acid (creatine AAB) as the internal standard. The results obtained were assessed by calculating the chemical score of each amino acid (Eq. (1)) and were compared with the Food and Agriculture Organization of the United Nations/World Health Organization/ United Nations University [FAO/WHO/UNU] standards (WHO, 1985).

$$EQ = \frac{\text{mg of amino acids/g of protein}}{\text{FAO/WHO standard.}} \quad (1)$$

2.2.5. Thermal analysis of defatted Brazil nut flour

For the performance of thermal analysis of the defatted Brazil nut, the samples were subjected to drying an oven with air circulation at 105 °C. Next, thermogravimetric analyses (TG/DTG and DTA) were performed using a DTG-60 Shimadzu thermo balance under the following parameters: air flow: 60 mL/min, temperature: 750 °C, heating ramp rate of 10 °C/min, and sample mass of 5 mg $\pm$ 0.5 in an alumina crucible.

2.2.6. Morphological analysis of partially defatted Brazil nut flour

Morphological analysis of the partially defatted Brazil nut flour granule was performed using scanning electron microscopy (SEM), and the samples were previously dried in an air circulation oven at 105 °C for 48 h. Subsequently, they were coated with a 20-nm thick gold layer for 150 s under a current of 25 mA (Silveira, 1989). The images or electron micrographs were taken in a LEO 1450 VP scanning electron microscope.

2.3. Physicochemical properties of the oil extracted from the Brazil nut kernels

The analyses performed in the extracted oil included: acidity, determined according to the American Oil Chemists' Society [AOCS] official method Cd 3d-63; saponification, AOCS Cd 3–25; density, by direct readings obtained with a digital densitometer (KEM KYOTO