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Use of baru (Brazilian almond) waste from physical extraction of oil to produce flour and cookies

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ABSTRACT

We characterized the partially defatted baru flour (PDBF), a byproduct of the extraction of baru oil, and evaluated its use to produce cookies. Analyzes of composition, total phenolics (TP), total flavonoids (TF), condensed tannins (CT) and antioxidant activity (AA) were performed. Cookies were prepared with 5 levels of replacement of wheat flour (WF) by PDBF, and compared for antioxidants, texture and acceptance. PDBF presented more proteins (29.46 g/100 g), lipids (11.84 g/100 g), fibers (38.80 g/100 g), but fewer carbohydrates (11.57 g/100 g) than WF. PDBF can be labeled as rich in iron, zinc and cooper. TP (121.34 mg/100 g) were intermediate to levels found in baru almonds and other nuts. TF (85.41 mg/100 g) was higher than in nuts. CT (64.39 mg/100 g) were close to values known for wines and walnuts but lower than in other nuts. AA was comparable to many tropical fruits. Hardness and fracturability of cookies increased starting from 75 g/100 g PDBF. Acceptance of cookies with 25 g/100 g PDBF was comparable to WF cookies, for some attributes and one group of consumers. Besides the impact on acceptance, the replacement of WF for PDBF influenced positively on nutritional and antioxidant characteristics of cookies.

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1. Introduction

Brazilian savannah concentrates 5% of the world's flora and represents one-third of national biodiversity, being the second largest vegetation type in Brazil (Faleiro & Farias Neto, 2008). Studies for the recovery of fruits from Brazilian Savannah are aligned to projects such as Biodiversity for Food and Nutrition – BFN, internationally coordinated by Bioversity International and implemented by the United Nations Program for the Environment – UNEP and the United Nations Food and Agriculture Organization – FAO, approved by the Global Environment Fund – GEF (Brazilian Ministry of Environment, 2012).

Baru (*Dipteryx alata*) is a fruit from Brazilian savannah, regionally used for human consumption. It is a drupoide fruit, fibrous, monospermic, ovoid, of brownish hue and smooth texture of the Fabaceae family, with an almond-like seed in its center (Ferreira, Botelho, David, & Malavasi, 1998).

The pulp and the almond are the baru's edible parts. According to Takemoto, Okada, Garbelotti, Tavares, and Aued-pimentel (2001), baru almonds present 38.2 g/100 g of fat, 23.9 g/100 g of protein, 15.8 g/100 g of total carbohydrate, 13.4 g/100 g of total dietary fiber (2.5 g/100 g soluble and 10.9 g/100 g insoluble) and significant levels of calcium (140 mg/100 g), phosphorus (358 mg/100 g) and potassium carbonate (827 mg/100 g). Moreover, baru almond shows higher contents of total phenolic compounds than several other almonds consumed in Brazil such as pine nuts, macadamia nuts, Brazil nuts, cashew nuts, hazelnuts and peanuts (Lemos, Siqueira, Arruda, & Zambiazi, 2012).

Due to their high lipid content, baru almonds have been used to obtain edible oil. However, the pressing process generates a partially defatted cake, which is typically wasted. This product probably retains nutrients and bioactive compounds present in

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almonds. Evaluating the use of this waste in the production of partially defatted baru flour (PDBF), and its use in bakery products is fundamental to the sustainability of the baru productive chain.

The replacement of wheat flour (WF) by other flours in bakery foods causes changes in taste, texture, appearance and moisture (Cauvain & Young, 2009, chap. 7). In this context, the objectives of this study were physical and chemical characterization of partially defatted baru flour (PDBF) and its use in cookie production with high amount of fibers and phenolic compounds. Additionally we compared the texture and sensory acceptability of cookies developed with different proportions of PDBF.

2. Material and methods

2.1. Processing of PDBF

Oil extraction, from which cake was obtained, was performed at the Laboratory of Agro-Energy Unit Embrapa Savannah. Previously crushed raw almonds (49 kg) were pressed on a continuous screw MPE-40R (Ecirtec, São Paulo, Brazil) with extraction capacity 40 L/h. The first 10 kg were mixed with rice bran (13 g/100 g) due to its higher percentage of fibers to prevent baru almonds from clogging the press. The remaining 39 kg were passed with the resulting cake from the first pressing, because it served as "fiber", allowing the mass to flow through the equipment. The final yield of the process was 24.5 g of crude oil/100 g of almonds and 53.7 g of cake/100 g of almonds.

The process losses can be attributed mainly to the amount of baru used in the experiment, compared to the higher capacity of the screw press of the Laboratory of Agro-Energy, besides the problem of clogging during the pressing of baru almonds. Although the mix with rice bran decreased this problem and made the pressing of baru almonds feasible, the loss by clogging in the equipment has yet occurred. According to our observations, the processing of higher amounts of almonds may decrease significantly the proportion of losses.

PDBF was obtained by grinding the cake in industrial blender for 5 min and sieving in 500 μm stainless steel.

Five hundred grams flour was packed in each polyethylene bag. Three packs were analyzed immediately for characterization of PDBF. The remainder was used for preparation of bakery products.

2.2. Characterization of PDBF

2.2.1. Centesimal composition

PDBF was evaluated for moisture, ashes, lipids and proteins by the AOAC (2005) methods. The determination of soluble and insoluble fibers was performed by the enzymatic-gravimetric method, according to AOAC (2005). Samples were subjected to enzymatic digestion, to hydrolyze starch, proteins and amylose using α-amylase, protease and amyloglucosidase, respectively. Soluble fiber was precipitated with 95 mL/100 mL ethanol. The total residue was filtered and washed successively with 78 mL/100 mL ethanol, followed by 95 mL/100 mL ethanol and acetone. After drying, the residue was weighed. A replicate was used for the determination of protein (AACC-1995), modified method 46-13 (catalyst sodium sulfate, copper sulfate and selenium; titrant 0.05 mol/L H_2SO_4) and another for the determination of ashes. Available carbohydrates were calculated by difference. Calories were calculated by Atwater (1887) method (Hargrove, 2006). Lipids, proteins, carbohydrates, total fiber and calories of PDBF, wheat flour (NEPA, 2011) and almond flour (De Pilli et al., 2008) were compared.

2.2.2. Minerals

One gram of PDBF was digested in 5 mL of concentrated nitric acid and swelled to 50 mL in a volumetric flask. After filtration, calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), zinc (Zn) and sodium (Na) were determined by Inductively Coupled Plasma-Atomic Emission Spectrometry, using Spectroflame FVM03 (Spectro Analytical Instruments), equipped with a vacuum polychromator and in air with network holographic monochromator with 2400 grooves/mm, using a Meinhard nebulizer. Standard curves were expressed in mg/100 g.

2.2.3. Antioxidants

PDBF and cookies with 0, 50 and 100 g/100 g of PDBF were analyzed in triplicate from three extracts of each treatment.

2.2.3.1. Total phenolics (TP). TP were quantified using a modified Folin–Ciocalteau colorimetric method (Singleton, Orthofer, & Lamuela-Raventos, 1999), adapted by Pineli et al. (2011).

2.2.3.2. Condensed tannins. Tannins were quantified using vanillin method (Broadhurst & Jones, 1978). Results were expressed as mg of catechin equivalent (CE)/100 g.

2.2.3.3. Total flavonoids (TF). TF was analyzed according to the method proposed by Francis (1982). Results were expressed as mg of quercetin equivalent (QE)/100 g.

2.2.4. Antioxidant activity by ABTS

Antioxidant activity was analyzed according to Re et al. (1999), in triplicate protected from light. We used the same extract prepared for TP analysis, diluted in 4 different concentrations (20 g/L, 50 g/L, 100 g/L and 200 g/L). Trolox standard curve was performed to analyze the results, which were expressed as μmol of trolox/g.

2.3. Preparation of cookies

Cookies were prepared with five levels (0, 25, 50, 75 or 100 g/100 g) of replacement of WF by PDBF using the following ingredients – flour (225 g) salt free butter (120 g), sugar (100 g), egg (50 g) and baking powder (5.0 g).

Cookies were analyzed for antioxidants as described previously (Section 2.2.3) and for texture and sensory acceptance.

2.3.1. Texture analyses

The texture profile analyzes (TPA) were performed using Brookfield CT3 Texture Analyzer coupled to TexturePro CT V1.4 software. Nine grams of cookies (diameter of approximately 3.7 cm, thickness of approximately 2 cm) were used for a compression test using 2 mm diameter cylindrical probe, 5 g stainless steel, 20 mm length; load of 10 g trigger; test speed 1.0 mm/s. Texture variables used for the first compression cycle were hardness and fracturability. Experimental design was completely randomized with 5 treatments, consisting of 5 levels of substitution of wheat flour by PDBF (0, 25, 50, 75 and 100 g/100 g), each with 3 replications. The experimental unit was a tray (batch) with 30 units of cookies of approximately 9 g. All analyzes were performed in triplicate. Data were analyzed by ANOVA ($p < 0.05$) with mean comparison by Fisher's test.

2.3.2. Sensory analysis

Acceptance test with 9 cm unstructured hedonic scale for overall acceptance and the attributes appearance, flavor and texture was conducted with 114 untrained panelists, ages between 17 and 45 years, 78 females and 36 males, all cookies' consumers at least once a month. Sensory data were submitted to Hierarchical

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