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

Lívia de Lacerda de Oliveira Pineli [a], [*], Mariana Veras de Carvalho [b], Lorena Andrade de Aguiar [a], Guilherme Theodoro de Oliveira [a], Sônia Maria Costa Celestino [c], Raquel Braz Assunção Botelho [a], Marileusa D. Chiarello [d]

[a] Department of Nutrition, Faculty of Health Sciences, Campus Universitário Darcy Ribeiro, Universidade de Brasília, Brasília, DF, 70910900, Brazil
[b] Human Nutrition Postgraduation Program, College of Health Sciences, Campus Universitário Darcy Ribeiro, Universidade de Brasília, Brasília, DF, 70910900, Brazil
[c] Embrapa Cerrados, BR 020, Km18, Laboratory of Food Science, Planaltina, Federal District, 73310970, Brazil
[d] Laboratory of Food Science and Technology, Catholic University of Brasilia, 71966700, Brasilia, DF, Brazil

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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.

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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[*] Corresponding author. Tel.: +55 61 3107 1805; fax: +55 61 3107 1741.
E-mail addresses: liviapineli@unb.br, liviapineli@gmail.com (L.L.O. Pineli).

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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

Cluster Analysis, generating two groups of consumers with different preferences for samples. Data were analyzed by ANOVA with Fisher test ($p < 0.05$) within each cluster and t test ($p < 0.05$) for each treatment between clusters. This project was approved by the Research Ethics Committee of the University of Brasilia, case number 01988112.1.3001.0029.

3. Results and discussion

3.1. Composition of PDBF

As shown in Table 1, moisture was lower in PDBF in comparison with wheat flour (WF) and close to that of almond flour (AF) (De Pilli et al., 2008). PDBF presented about three times more protein than WF and was 32.5% higher than the protein content in AF. During cooking, proteins coagulate and supplement gluten structure (McGee, 2004, chap. 10). Therefore, it is believed that the high protein content of PDBF can contribute to the structure of the dough when replacing the wheat flour.

The content of lipids (about 12 g/100 g) was much higher than those found in WF (1.4 g/100 g), but much lower than that of AF (58.7 g/100 g). It should be considered that the remaining content of lipids in PDBF is consistent with physical oil extraction. The almond flour used by De Pilli et al. (2008) was not resulted of oil extraction, but obtained by the complete crushing of the almonds, which explains the higher concentration of lipids. According to Takemoto et al. (2001), baru oil has a high content of α-tocopherol (5 mg/100 g) and it is similar in fatty acids composition to peanut oil, especially concerning to oleic and (50.4 g/100 g) linoleic (28 g/100 g) acids. Pyler (1988) stated that liquid oil is dispersed in the dough forming small droplets, which are less effective with respect to shortening and aeration properties than are the semi-solid fats.

On the other hand, carbohydrate content of PDBF (11.5 g/100 g) was lower than the levels observed in WF (67–75 g/100 g), but close to that of AF. According to USDA (2011), almonds (*Prunus dulci*) present 3.89 g/100 g of total sugars and only 0.74 g/100 g of starch. Unlike cereals, almonds are not starchy, so their flours do not present functional properties of those polysaccharides in dough. Starch in grain flours fills gluten network, absorbs water during cooking, and as main effect on structure we can observe tenderization of dough and setting of structure during baking. Together with water, starch makes up more than half the volume of dough. The hydrolysis of starch, also contributes to the availability of fermentable sugars, influencing the production of gas and aeration of dough (McGee, 2004, chap. 10). However, the reduction of carbohydrates caused by the use of PDBF can contribute to the reduction of Glycemic loads, which are currently high in bakery products (Foster-Powell, Holt, & Brand-Miller, 2002). Moreover, the high fiber content also contributes to this reduction.

Table 1
Nutritional composition of PDBF and comparison with almond flour (AF) and wheat flour (WF).

Constituents (g/100 g)	PDBF[a]	AF[b]	WF[c]
Moisture	3.63 ± 0.37	4.67	13
Ash	4.70 ± 0.02	3.32	0.8
Proteins	29.46 ± 1.04	22.24	9.8
Lipids	11.84 ± 0.69	58.7	1.4
Carbohydrates	11.57	11.07	75.1
Insoluble fibers	33.73 ± 2.43	–	
Soluble fibers	5.07 ± 1.31	–	
Total dietary fibers	38.80 ± 3.74	–	2.3
Calories	271	661.54	360
Ca (mg/100 g)	200.91 ± 14.1	–	18.00
Fe (mg/100 g)	13.29 ± 1.12	–	1.00
Na (mg/100 g)	9.55 ± 0.69	–	1.00
K (mg/100 g)	1217.6 ± 42.3	–	151.00
Zn (mg/100 g)	7.62 ± 7.75	–	0.80
Cu (mg/100 g)	2.04 ± 0.17	–	0.15

[a] Means ± standard deviations. Analyses of three packs (500 g) of PDBF in triplicate, each.
[b] De Pilli et al. (2008).
[c] NEPA (2011).

PDBF had a high total dietary fiber content (38.8 g/100 g). This value is also much higher than that found for WF (3.2 g/100 g), corn flour (5.5 g/100 g) and soya flour (20.2 g/100 g) (NEPA, 2011) and about 3.5 times higher than fiber in whole wheat flour (USDA, 2011), indicating high potential for application of PDBF in formulations of healthy bakery products, regarding the high contents of dietary fibers. Takemoto et al. (2001) found 2.5 g/100 g of soluble fiber and 10.9 g/100 g of insoluble fiber in baru almonds. The content in comparison with almonds is raised by the removal of baru oil and the adding of rice bran during pressing, which corresponds to about 5% of the total weight of the cake. In breads, the addition of fibers causes the reduction of loaf volume, the increase of crumb firmness, the dark crumb appearance, and also in some cases a modified bread taste is obtained (Knuckles, Hudson, Chiu, & Sayre, 1997; Lai, Hoseney, & Davis, 1989; Pomeranz, Shogren, Finney, & Bechtel, 1977). Moreover, the resultant fiber-rich doughs have high water absorption, become shorter and have a reduced fermentation tolerance (Gan, Galliard, Ellis, Angold, & Vaughan, 1992; Laurikainen, Harkonen, Autio, & Poutanen, 1998; Park, Seib, & Chung, 1997). Also, fiber surface has a high capacity to hold oil in doughs (Sharma & Gujral, 2014).

The energy value calculated for PDBF was 271 kcal/100 g, lower than that of WF (NEPA, 2011). Despite the increase in lipid content as compared with WF, the significant reduction of carbohydrates affected more the calories of PDBF, which can contribute to lowering energy value in bakery formulations. On the other hand, the higher content of lipids is the cause of about 2.4-fold more calories in AF. We believe the lower content of lipids and lower calories are the main advantages of using PDBF in the place of AF and even of whole baru flours, due to the technological and nutritional impacts that the excess of lipids exert in bakery products.

The amount of calcium found in PDBF (Table 1) is much higher than that found in wheat (18 mg/100 g), corn (34 mg/100 g) and rye (24 mg/100 g) flours, respectively, and close to soybean flour (206 mg/100 g) (NEPA, 2011). The amount of iron is also close to that of soybean flour (13.1 mg/100 g) and higher than wheat (1 mg/100 g), corn (2.3 mg/100 g) and rye (4.3 mg/100 g) flours (NEPA, 2011). According to the Brazilian legislation (Brazilian National Health Surveillance Agency, 2012), one serving or 50 g of PDBF (Brazilian National Health Surveillance Agency, 2003), can be considered rich in iron, zinc and copper. It provides 81.5% of the EAR of iron for women, 40.6% of the EAR of zinc for men and 145% of the EAR of copper for men and women (IOM, 2006), whereas not contributing significantly to sodium intake.

3.2. Antioxidants of PDBF and cookies

The concentrations of TP in PDBF (Table 2) were within the range of TP of baru almonds studied by Lemos et al. (2012). The authors evaluated phenolics of roasted and raw, peeled and unpeeled baru almonds and reported that the levels of TP ranged from 111.3 mg of gallic acid (GAE)/100 g to 568.9 mg GAE/100 g acid for roasted unpeeled and raw peeled almonds, respectively. This may indicate that the unit operations involved in oil extraction and PDBF processing can influence the values of TP. The heating in the screw pressing and the distribution of the compounds between oil and cake may be the main causes of phenolic compounds losses in PDBF.

Table 2
Phenolic content and antioxidant activity of PDBF.

Constituents	Mean ± standard deviation
Total phenolics (mg GAE[a]/100 g)	121.34 ± 2.61
Total flavonoids (mg QE[b]/100 g)	85.41 ± 2.90
Antioxidant activity (μmol trolox/g)	10.36 ± 0.65
Condensed tannins (mg CE[c]/100 g)	64.39 ± 2.97

Analyses of three packs (500 g) of PDBF in triplicate, each.

[a] Gallic acid equivalent.

[b] Quercetin equivalent.

[c] Catechin equivalent.

It is interesting to notice that the contents of TP in baru and in PDBF are comparable with the values of Folin assay reported by *Phenol-explorer database* (Rothwell et al., 2013) for almonds (126.80–418 mg/100 g) and Brazil nuts (244.0 mg/100 g) and cashew nuts (137.0–274 mg/100 g).

Total flavonoids in PDBF (85.41 mg/100 g) was higher than that of almonds (3.0–22.4 mg/100 g), reported in USDA Database for the Flavonoid Content of Selected Foods (USDA, 2013) and Phenol-explorer database (4.7–13.2 mg/100 g) for the same food (Rothwell et al., 2013). It is important to observe that both database present individual flavonoids data, obtained by chromatography. The higher content of flavonoids in nuts is recorded for pecan nuts (15.6–54.3 mg/100 g) in USDA database (USDA, 2013). Lemos et al. (2012) analyzed some individual phenolics in peeled/unpeeled/raw/roasted baru almonds by HPLC, among which, the flavonoids catechin and epicatechin. Catechin ranged from 3.6 to 45.4 mg/100 g and epicatechin, from 2.1 to 23.9 mg/100 g. Total anthocyanins in baru almonds varied from 0.6 to 1.2 mg/100 g in the same study.

The antioxidant activity of PDBF, in a diet context, is comparable to that of some fruits, e.g. PBDF showed similar results of antioxidant activity by ABTS assay as açaí (15.1 μmol of trolox/g), caja (7.8 μmol of trolox/g), cashew (11.2 μmol of trolox/g), carnauba (10.7 μmol of trolox/g), mangaba (14.6 μmol Trolox/g) and umbu (6.3 μmol Trolox/g), according to the work of Rufino et al. (2010).

The content of condensed tannins found on PDBF (64.39 mg/100 g) was higher than that found in flours of varieties of white sorghum, ranging from 1.39 to 21.79 mg CE/100 g (Afify, El-Beltagi, El-Salam, & Omran, 2012), and intermediate to total tannins found in red wines of ‘Marzemino’ grapes (10.9 mg CE/100 g) and ‘Teroldino’ grapes (71.8 mg CE/100 g) (Mattivi, Vrhovsek, Masuero, & Trainotti, 2009). Comparing with the results reported by Gu et al. (2004) for various nuts analyzed by liquid chromatography, PDBF presented lower contents of condensed tannins than hazelnuts (500.7 mg/100 g), pecans (494.1 mg/100 g), pistachios (237.3 mg/100 g) and almonds (184.0 mg/100 g), but close to that of walnuts (67.3 mg/100 g). Tannins have antioxidant, anticarcinogenic and antimutagenic properties the same time as they precipitate proteins, inhibit digestive enzymes, reduce the use of vitamins, minerals (Amarowicz, 2007).

To evaluate the content of antioxidants in cookies with replacement of WF with PDBF (Table 3), the extreme treatments of PDBF (0–100 g/100 g) and the average treatment (50 g/100 g) were analyzed for TP, TF, anthocyanins and tannins.

Table 3
Antioxidants of cookies with different levels of replacement of WF with PDBF.

Proportion of PDBF (g/100 g)	TP[a] (mg GAE/100 g)	TF[b] (mg QE/100 g)	Condensed tannins (mg CE/100 g)
0	31.21c ± 0.11	1.77c ± 0.09	3.62c ± 0.70
50	46.29b ± 1.31	9.91b ± 0.81	15.77b ± 1.02
100	86.16a ± 0.43	15.42a ± 3.77	37.32a ± 5.78

In columns, means followed by the same letters do not differ by Fisher Test ($p < 0.05$).
Analyses of three batches in triplicate, each.

[a] Total phenolics.

[b] Total flavonoids.

The total (100 g/100 g) and the partial replacement (50 g/100 g) of WF caused, respectively, increases of 176% and 48% in the levels of TP, 8.7 and 5.6-fold the levels of TF, and 10.3 and 4.4-fold the content of tannins. This result indicates the contribution of PDBF and their derived products for the consumption of antioxidants. In a similar study with cookies prepared with different proportions of barley flour, Sharma and Gujral (2014) found higher values of TP (65.6 mg/100 g) and TF (20.7 mg/100 g) for the treatment with 100 g/100 g of wheat flour, which can be attributed to differences in ingredients, formulations, cooking procedures and analytical methods, since the authors' results are expressed as equivalents of ferulic acid for TP and catechin for TF. In that study, total (100 g/100 g) and partial (50 g/100 g) replacement of WF by barley flour resulted, respectively, in increases of 3.28 times and 2.08 times in the levels of TP and increases of 3.86-fold and 2.77 times in the concentrations of TF. Another study also showed that fiber incorporated in biscuits lead to an increase in antioxidant activity (Vitali, Dragojevic, & Sebecic, 2009).

3.3. *Texture of cookies*

The mechanical changes attributed to the replacement of WF by PDBF in cookies are related to the increases of fibers, liquid oil, phenolics (including tannins) and to the reducing of carbohydrates (mainly starch). Moreover, there is an increase in total protein content, but with reduction of gluten in the dough. Cookie and/or biscuit are thought to be composed of a continuous glassy sugar matrix containing embedded ungelatinized starch granules, an undeveloped gluten network, and fat (Kawai, Toh, & Hagura, 2014). There was no difference between the hardness and fracturability of cookies with WF and cookies with up to 50 g/100 g of substitution by PDBF (Table 4). Larger replacements resulted in a gradual increase in these variables. According to Cauvain and Young (2009, chap. 7), cooking process leads to moisture migration from the wet core to the drier surface turning the product drier. The following expansion and contraction cause breakage originating microscopic lines of weakness, influencing its resistance. Starch gelatinization, followed by recrystallization, and protein denaturation have great importance on the development of the structure and texture (Megahey, Mcminn, & Magee, 2005). Pereira, Correia, and Guiné (2013) stated that changes in ingredients and processes cause variations in texture, the fat being one of the main ingredients causing these changes, even more than sugar or flour. Our results indicate that the highest contents of proteins and fibers were probably more important for texture than the lowering of starches or the shortening effect of higher amount of lipids. Previous studies found a positive relation between dietary fibers and hardness and gumminess (Gomez, Ronda, Blanco, Caballero, & Apesteguia, 2003; Kaack, Pedersen, Laerke, & Meyer, 2006).

Table 4
Texture of cookies with different levels of replacement of WF with PDBF.

Treatment	Hardness (gF)	Fracturability (gF)
0 g/100 g PDBF	670.67^{c} ± 17.61	609.75^{c} ± 60.91
25 g/100 g PDBF	773.67^{bc} ± 93.59	773.67^{bc} ± 93.59
50 g/100 g PDBF	688.50^{bc} ± 172.46	697.75^{bc} ± 169.25
75 g/100 g PDBF	887.17^{b} ± 115.93	829.33^{b} ± 22.68
100 g/100 g PDBF	1372.50^{a} ± 113.63	1229.50^{a} ± 101.13

In columns, means followed by the same letters do not differ by Fisher Test ($p < 0.05$). Analyses of three batches in triplicate, each.

Table 5
Acceptance attributes of cookies made with different proportions of PDBF, for each segment of consumers.

Attribute		0 g/100 g PDBF	25 g/100 g PDBF	50 g/100 g PDBF	75 g/100 g PDBF	100 g/100 g PDBF
Overall acceptance	Cluster 1 ($n = 46$)	5.9^{bA} (1.6)	4.7^{bB} (1.7)	4.1^{bBC} (1.8)	3.7^{bC} (2.0)	2.1^{bD} (1.2)
	Cluster 2 ($n = 68$)	6.9^{aA} (1.5)	6.6^{aAB} (1.2)	6.2^{aB} (1.4)	5.5^{aC} (1.9)	6.1^{aB} (1.4)
Appearance	Cluster 1 ($n = 46$)	6.1^{bA} (1.8)	4.5^{bB} (1.9)	3.3^{bC} (1.7)	3.5^{bC} (2.3)	3.2^{bC} (1.9)
	Cluster 2 ($n = 68$)	6.9^{aA} (1.6)	5.9^{aB} (1.9)	5.7^{aBC} (2.1)	5.2^{aC} (1.9)	5.3^{aBC} (2.1)
Flavor	Cluster 1 ($n = 46$)	5.7^{bA} (1.8)	4.8^{bB} (1.9)	4.4^{bB} (2.1)	3.5^{bC} (2.2)	2.4^{bD} (1.3)
	Cluster 2 ($n = 68$)	6.5^{aA} (1.7)	6.2^{aAB} (1.9)	6.1^{aAB} (1.8)	5.7^{aB} (2.0)	6.2^{aAB} (1.7)
Texture	Cluster 1 ($n = 46$)	5.5^{bA} (2.3)	5.0^{bAB} (2.0)	4.3^{bBC} (2.3)	3.6^{bC} (2.5)	2.2^{bD} (1.9)
	Cluster 2 ($n = 68$)	6.9^{aA} (1.7)	6.4^{aAB} (1.7)	6.2^{aBC} (1.7)	5.0^{aD} (2.2)	5.6^{aCD} (2.1)

Within each attribute, clusters with different lowercase letters in the same column differ by t test ($p < 0.05$).
Treatments with different capital letters in the same row differ according to ANOVA and Fisher's test ($p < 0.05$).
Standard deviations in parentheses.

3.4. *Acceptance of cookies*

Sensory data were analyzed by Cluster Analysis, generating two groups, with 46 and 68 consumers each (Table 5).

For all products and attributes, cluster 2 ($n = 68$) gave higher scores of acceptance for samples than cluster 1 ($n = 46$). Regarding global acceptance, cluster 1 preferred the control sample, then 25 g/100 g and 50 g/100 g PDBF, whereas cluster 2 also preferred control and 25 g/100 g PDBF.

For appearance, cluster 1 preferred the sample with 0% PDBF and then the sample with 25 g/100 g PDBF, but with a note already in the rejection region, followed by other treatments. Cluster 2 also preferred the control sample, followed by samples with 25 g/100 g and 50 g/100 g PDBF, with means in the region of acceptance in hedonic scale.

For flavor, while cluster 1 preferred the control sample which scores in the rejection region for the other samples, without differences between cookies with 25 g/100 g and 50 g/100 g PDBF, cluster 2 gave similar acceptance for the control treatments, 25 g/100 g, 50 g/100 g and 100 g/100 g, differing from sample with 75 g/100 g PDBF, although it has also presented mean in acceptance region.

Regarding the texture, while cluster 1 showed no difference in the acceptance of cookies control and 25 g/100 g PDBF, cluster 2 accepted equally treatments with 0 g/100 g, 25 g/100 g and 50 g/100 g PDBF.

It is known that the process of food choice and perception by consumer is multifactorial, associated with several non-sensory aspects such as brand, familiarity with the product, price, among others (Cardello, 2003). Low means of acceptance for some treatments of cookies with PDBF can be related to the usual low willingness to taste novel foods showed by some people (Pliner & Salvy, 2006). In fact, as panelists assigned their informed consent, they were informed about tasting cookies with the exotic baru almond ingredient. Stallberg-White and Pliner (1999) stated that although acceptability is not perfectly correlated with familiarity and there are examples of familiar foods which are not liked, much research on the “mere exposure” phenomenon indicates that acceptance do vary directly with exposure. The authors also found that the use of familiar flavors could enhance acceptability of novel exotic foods. In this context, it is possible that the addition of chocolate drops could improve acceptance of all treatments of cookies, making feasible total replacement of WF with PDBF, from a sensory point of view.

Gupta, Bawa, and Abu-Ghannam (2011), studying the effect of the addition of barley flour in cookies, also concluded that the standard samples (100 g/100 g wheat flour) have higher acceptability compared to the increased barley flour samples, with no significant difference in samples with 10 g/100 g, 20 g/100 g or 30 g/100 g barley flour. In the present study, PDBF cookies with 25 g/100 g and sometimes 50 g/100 g did not differ for the larger group of consumers and some attributes, and were more accepted than the treatments with 75 g/100 g and 100 g/100 g PDBF.

Therefore, acceptance results by cluster analysis suggest that the partial replacement of WF by PDBF in the proportion of 25 g/100 g of PDBF might be feasible in the sensory point of view, only for a group of consumers, since there was no significant difference in the taste and texture when compared to the standard sample, for cluster 2 (Table 5). Some studies have shown that, besides sensory attributes, nutritional and health properties can drive the consumption of healthier products. Some people may be willing to forego certain amount of sensory quality to follow a healthier diet, and therefore, accept some negative sensory changes (Sabbe, Verbek, Deliza, Matta, & Van Damme, 2009; Verbek, 2005).

Further studies can investigate if an increase in the acceptability of baru cookies with PDBF could be achieved by the use of legal health claims such as “source of fiber” or “food with high content of antioxidants” as described by Carrilo, Varela, and Fiszman (2012), in a study with sweet biscuits market in Valencia (Spain).

4. Conclusions

PDBF, produced from the waste of baru oil extraction, showed high total dietary fiber, lipids, calcium and iron, besides low carbohydrates. As for bioactive compounds, PDBF presented an interesting polyphenol content and a level of antioxidant activity comparable with various fruits. In cookie making, partial replacement of WF by PDBF in the proportion of 25 g/100 g was feasible regarding some sensory attributes and only for a group of consumers, but with the advantage of a composition rich in fiber and in bioactive compounds, leading to higher antioxidant activity. Hardness increased only with high proportions of PDBF. Gluten free cookies with PDBF were more breakable than the other cookies. The development of cookies formulated with PDBF values a product from Brazilian savannah, reducing food waste by adding value to a by-product with good nutritional qualities.

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