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Mini cakes prepared with press-cake flour obtained from the oil extraction from araticum seeds (*Annona crassiflora* mart.)

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Abstract

This study aimed to reuse the residue of oil extraction from araticum seeds (AS) (press-cake) applied in mini-cake formulation, partially replacing wheat flour. AS and formulations with different proportions of press-cake flour from araticum seeds (PCFAS) were investigated. The proportions were 0, 5, 10, 15, and 20% of PCFAS in partial replacement of wheat flour. AS, PCFAS, and mini cakes were evaluated for chemical composition, total phenolics, and antioxidant capacity using the FRAP, DPPH, and ABTS methods. The partial wheat flour substitution effects were evaluated by texture, shear, and color parameters. The PCFAS incorporation significantly influenced the mini cakes, providing greater firmness, shear strength, browning of the core, and increased antioxidant capacity. According to the results, AS and PCFAS have high antioxidant capacity and phenolic concentration. The mini cake with 20% PCFAS was considered the best formulation due to an increase in protein, lipid, and antioxidant capacity.

Keywords: agro-industrial waste; baked goods; cerrado fruits; nutritional enrichment.

Practical Application: Press-cake flour from araticum seeds significantly influences the texture of the mini cake.

1 INTRODUCTION

Annona crassiflora Mart., popularly known as araticum, marolo, or pinha do cerrado, is a species native to the Brazilian Cerrado (Carvalho et al., 2022; Pereira & Santos, 2015). Flowering generally occurs between November and January (Melo et al., 2015). The araticum has high nutritional value, with significant levels of lipids, calory, fiber, phenolic compounds, linolenic acid, and carotenoid (Damiani et al., 2011; Menezes et al., 2019; Schiassi et al., 2018).

The same compounds found in other parts of the plant are present in the chemical composition of seeds. The seeds are considered an excellent source of fiber, mineral, and phenolic compounds, and they have a high concentration of proteins and lipids (Coelho & Salas-Mellado, 2014). Seeds contain several bioactive substances that are wasted, many of them being rich in phenolic compounds (Menezes et al., 2019; Storck et al., 2013). Seed and leaves of araticum have been used to prepare infusions with antidiarrheal, antitumor, and menstruation-inducing properties and to treat Chagas disease (Formagio et al., 2015). Also, the seed has high free radical scavenging capacity and high antioxidant activity (Prado et al., 2020).

According to Sousa et al. (2020), the residues (i.e., leaves, bark, roots, and seeds) contain various highly nutritious substances. There are already several studies aiming at sustainably applying these residues, adding value to other products, or even developing new ones. These initiatives collaborate with food quality improvement of people and create employment and income opportunities (Gomes et al., 2016; Ueda et al., 2022). Thus, this material can be converted into commercial products or raw materials for secondary processes if appropriate technology is used.

In this context, this study aimed to characterize the araticum seed (AS) and the press-cake flour from araticum seeds (PCFAS) and evaluate the effect of different proportions of PCFAS in the chemical and physical properties of mini cakes.

2 MATERIALS AND METHODS

2.1 Materials

2.1.1 Obtaining the araticum press-cake flour

AS (*Annona crassiflora* Mart.) were supplied by a pulp producer from Minas Gerais, MG, and transported in plastic boxes to the Food Engineering sector at the Agronomy School, the Universidade Federal de Goiás. The AS were cleaned with running water and centrifuged to remove dirt, and part of the seeds were stored for further analysis. Another part of the seeds were dried in a air-forced oven at 60°C for 24 h, crushed in a Vitalex®

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low-speed blender OP 30791, and pressed with a hydraulic press of 15 tons for 20 min to extract oil from the AS. After the oil was extracted, the residue (press-cake) was dried in an air-forced oven at 60°C for 24 h, crushed in a low-speed blender Vitalex® OP 30791, sieved with a 120-mesh sieve, and roasted at 120°C for 12 h in an oven. Then, the flour from the araticum press-cake (PCFSA) was obtained. Shortly after its preparation, it was used in the mini-cake preparation and packed in opaque plastic at 5°C until the analyses were carried out.

2.2 Methods

2.2.1 Preparation of the mini cakes

The mini-cake preparation started by weighing the ingredients (Table 1), namely, sugar, margarine, milk, eggs, and vanilla essence and then mixing them with an Arno® mixer. After 2 min, wheat flour and PCFAS were added until a homogeneous mass was obtained, and, finally, the chemical yeast was added. The ingredients for making the mini cakes were acquired locally in Goiânia, Goiás, except the PCFSA described above. The dough was baked in 50 g portions in a paper mold no. 0 for 20 min in a Layr® Luxo electric oven, which was previously heated to 180°C. Five replicates of each formulation were made. The mini cakes were cooled to room temperature and frozen at -8°C until physical and chemical analyses were carried out.

2.2.2 Chemical analysis

The Guignard test (Essers et al., 1993) was used for cyanogenic compound analysis. The tannin content was estimated by the Folin-Denis method, according to the AOAC method (2012), and the results are expressed in milligrams of tannic acid/mL.

The AOAC method (2012) was used to determine moisture, protein, and ash. The total lipid determination was carried out according to the method developed by Bligh and Dyer (1959). The total carbohydrate amount was determined by the difference between 100 and the sum of moisture, proteins, lipids, and ashes.

The energy value was calculated by the relationship between the carbohydrate, protein, and lipid proportions, as described by Merril and Watt (1973). Titratable acidity was determined according to the AOAC method (2012). Water activity was determined using an Aqualab device (Aqualab CX-2).

Extracts were prepared with solvents of different polarities to determine the reducing and antioxidant capacities by the FRAP, DPPH, and ABTS methods. In the absence of light, 2.5 g of sample was homogenized with 50 mL of ethyl ether. The solution was filtered until dripping ceased, and the volume of ethyl ether retained in the sample was completed, thus obtaining the ether extract. The residue was recovered and dried in a oven at 40°C, weighed, and homogenized at 20 times the weight of the residue (mg) in mL of ethyl alcohol. The volume of ethyl alcohol retained in the filtration was completed, obtaining the alcoholic extract. The residue was recovered and dried in a oven at 40°C, weighed, and homogenized at 20 times the weight of the residue (mg) in mL of distilled water. The volume retained in the filtration was completed, obtaining the aqueous extract. The residue was recovered, dried in an oven at 105°C, and weighed to determine the concentration.

The content of total phenolic compounds was determined by the Folin-Ciocalteou method (Zieliński & Kozłowska, 2000). The antioxidant activity was carried out using the free radical scavenging of DPPH by capturing the $ABTS^{+\circ}$ free radicals (Rufino et al., 2007) and by the iron-reduction method, FRAP (Rufino et al., 2006). All analyses were performed in triplicate.

2.2.3 Physical analysis of FTSA and mini cakes

The instrumental color parameters were determined using a colorimeter (Colo Quest, XE, USA), according to the CIELab system. The results were expressed in L^*, a^*, and b^*. The parameters C^* and h^o were calculated using Equations 1 and 2, respectively. Instrumental color analyses were performed in five replicates with five repetitions:

$$C* = \sqrt{a*^2 + b*^2} \quad (1)$$

$$h^o = \frac{1}{tan}\left(\frac{b*}{a*}\right) \quad (2)$$

The texture profile parameters (TPA) and shear strength (SF) of the mini cakes were determined in a texture meter (Stable Micro Systems, TA. XT. Plus, Godalming, England), using TPA probe P/36 with 1 mm s^{-1} speed at the pre-test, test, and post-test, and the deformation rate of 40%. For the SF cutting board, the pre-test and test speeds were 1 and the post-test speed was 10 mm s^{-1}, with a deformation rate of 150%. The analyses were made in quintuplicate.

2.2.4 Statistical analysis

The randomized experimental design with five treatments was used. Mini cakes without and with wheat flour replaced by AS flour in the proportions of 5, 10, 15, and 20% were evaluated. The Tukey's test compared the means at a 5% significance level for mini cakes and the t-test for PCFAS and AS, using the SISVAR software, version 5.0.

Table 1. Composition of mini cakes with different replacement levels of wheat flour (WF) by the press-cake flour from the oil extraction from araticum seeds (PCFAS).

Ingredient	C	C5	C10	C15	C20
WF (g)	322	306	290	274	258
PCFAS (g)	0	16	32	48	64
Sugar (g)	222	222	222	222	222
Margarine (g)	153	153	153	153	153
Milk (mL)	110	110	110	110	110
Egg (un.)	3	3	3	3	3
Vanilla (mL)	4	4	4	4	4
Yeast (g)	5	5	5	5	5

*C: mini-cake control; C5: mini cake with 5% replacement of WF by PCFAS; C10: mini cake with 10% replacement of WF by PCFAS; C15: mini cake with 15% replacement of WF by PCFAS; C20: mini cake with 20% replacement of WF by PCFAS.

3 RESULTS AND DISCUSSION

3.1 Physical-chemical analysis of AS and PCFAS

It is known that the ingestion of some raw almonds or seeds of unconventional fruits, which contain antinutritional factors, can cause digestive problems (Damiani et al., 2013). AS and PCFAS were evaluated for antinutritional components, and cyanogenic compounds were not detected.

About tannins, in AS and PCFAS, the content of 8.26 ± 0.18 and 6.33 ± 0.15 mg tannic acid/mL was found, respectively. Therefore, the flour processing decreased the tannin content, which are phenolic compounds responsible for the astringency of many plant-origin products due to salivary glycoprotein precipitation causing lubricating power loss (Bruneton, 2009).

Tannins can be considered nutritionally undesirable because they precipitate proteins, inhibit digestive enzymes, and affect the use of vitamins and minerals. Other studies describe the beneficial actions of tannins, in which they can act as free radical scavengers, which intercept active oxygen forming stable radicals (Benevides et al., 2015; Hassan et al., 2020).

Table 2 shows the proximal composition, titratable acidity, and water activity (Aw) of AS and PCFAS. It is observed that the PCFAS had lower levels of ash, lipids, and energy than AS ($p < 0.05$), possibly due to the partial removal of the lipid portion. Also, higher protein and carbohydrate levels were found in PCFAS than in AS due to water removal in the drying process. As for proteins, AS (13.93 ± 0.29%) and PCFAS (15.36 ± 0.55%) had high protein content. According to Brazil (2012), a food that is considered to have a high protein content must have a minimum of 12% protein.

Moisture and Aw are fundamental indexes related to chemical stability, microbiological deterioration, physiological changes, and general food quality, impacting perishability. The water content of the PCFAS is within the limit recommended by Brazilian legislation, which determines that the flour, cereal starch, and bran obtained can reach the maximum content of 15.0% (Brasil, 2005). Foods with Aw less than 0.6 are considered sanitary safe. Thus, the PCFAS can be considered a safe product, with less probability of microbial growth.

Acidity is related to flour conservation status, involving microbiological and chemical aspects (Oliveira et al., 2020). Besides affecting the taste and odor of foods, it is related to the amount of the existing organic acids (Araújo et al., 2015). It is observed that the average value of the acidity of the PCFAS is 3.38% higher than the limit of 2.5% established by the legislation (Decree n 12.486 of 1978) for the corn starch (São Paulo, 1978).

Phenolic compounds are classified as primary antioxidants acting mainly as scavengers of free radicals slowing or inhibiting lipid oxidation, thereby decreasing the formation of decomposition products that cause rancidity. In Table 3, it was observed that the contents of total phenolic compounds from AS and PCFAS had a significant difference in ethereal, alcoholic, and aqueous extracts ($p > 0.05$), in which PCFAS presented a higher value in ethereal extract and lower values in alcoholic and aqueous extracts. The highest phenolic compound concentration in AS is due to the maximum total phenolics found in the outer layers of seeds and grains (bark and pericarp) (Shahidi & Ambigaipalan, 2015).

Studies evaluating the most consumed fruits and vegetables in Brazil (pineapple, banana, orange, papaya, mandarin, broccoli, potato, tomato, onion, and carrot) determined the total reducing capacity ranging from 15.3 to 215.7 mg GAE/100 g in fresh weight (Faller & Fialho, 2009). Thus, PCFAS has much higher values than the main phenolic sources of Brazilians, offering an alternative for people who seek healthy feeding practices.

The EC_{50} values found for the aqueous extract and alcoholic extract of the AS are above those found in the literature, 0.03 and 0.42 mg/mL, respectively (Roesler et al., 2007). The difference can be attributed to the distinct methodology applied for extracting the compounds or the tested species. In the FRAP assay, more significant activity was found in the alcoholic extract of PCFAS regarding the AS ($p < 0.05$), and there was no significant difference ($p < 0.05$) in the ethereal and aqueous extracts.

It is observed that PCFAS has considerable macronutrient content and appreciable antioxidant capacity, which can be used to promote human food improvement and agro-industrial residue reduction.

Table 2. Proximal composition, titratable acidity, and Aw of AS and PCFAS.

Composition (%)	AS	PCFAS
Moisture	6.05 ± 0.12[a]	3.13 ± 0.49[b]
Ashes	2.68 ± 0.10[a]	2.02 ± 0.06[b]
Proteins	13.93 ± 0.29[b]	15.36 ± 0.55[a]
Lipids	38.23 ± 1.74[a]	27.39 ± 0.59[b]
Carbohydrates	39.11 ± 2.40[b]	52.10 ± 1.69[b]
Energy value (kcal)	556.23 ± 21.81[b]	516.35 ± 16.03[a]
Titratable acidity	12.00 ± 1.09[a]	3.38 ± 0.17[b]
Aw	0.45 ± 0.01[a]	0.34 ± 0.01[b]

AS: araticum seeds; PCFAS: press-cake flour from araticum seeds. Data are expressed as mean ± standard deviation. Different letters on the same line indicate a significant difference ($p < 0.05$) by the t-test.

Table 3. Antioxidant activity (DPPH, ABTS, and FRAP) and phenolic compounds from araticum seed and PCFAS.

	Extract	AS	PCFAS
Phenolic compounds (mg GAE/100 g)	Ethereal	186.70 ± 5.10[b]	238.24 ± 5.37[a]
	Alcoholic	4393.52 ± 7.13[a]	4231.69 ± 10.90[b]
	Aqueous	606.55 ± 1.77[a]	521.85 ± 1.22[b]
EC_{50} (mg/mL)	Ethereal	0.25 ± 0.03[a]	0.32 ± 0.01[a]
	Alcoholic	0.83 ± 0.03[b]	1.34 ± 0.22[a]
	Aqueous	0.58 ± 0.01[a]	0.61 ± 0.08[a]
ABTS (μM Trolox/g)	Ethereal	15.79 ± 2.72[a]	13.53 ± 0.69[a]
	Alcoholic	165.45 ± 1.05[a]	160.88 ± 0.66[a]
	Aqueous	40.28 ± 2.17[b]	25.70 ± 0.39[a]
FRAP (μM ferrous sulfate/g)	Ethereal	96.38 ± 8.04[a]	76.99 ± 8.27[a]
	Alcoholic	139.42 ± 7.85[b]	286.16 ± 2.29[a]
	Aqueous	83.71 ± 7.25[a]	80.63 ± 8.10[a]

AS: araticum seeds; PCFAS: press-cake flour from araticum seeds. Data are expressed as mean ± standard deviation. Different letters on the same line indicate a significant difference ($p < 0.05$) measured by the t-test.

3.2 Physical-chemical analysis of mini cakes

Figure 1 shows the cross-sectional image of the mini cakes with partial replacement of wheat flour by PCFAS.

Table 4 presents the data from the color analysis of the PCFAS and the "crumb" of the mini cakes with partial wheat flour replacement by PCFAS, as well as its texture and shear strength parameters.

The color components were analyzed for color parameters, namely, L^*, a^*, b^*, chroma, and hue. The value L^* refers to the luminosity and C^* refers to the chroma. Decreases in these parameters represent the darkening and intensity, respectively. Therefore, with the wheat flour substitution for PCFAS, there is a darkening and opacity increase inside the mini cakes, with a possible cause of non-enzymatic browning during baking. In the parameters a^* and b^*, a significant difference ($p < 0.05$) was observed with an increase in a^* and a decrease in b^*, that is, the mini cakes changing from a yellowish color in the formulation without PCFAS tending to brown in the formulation with a higher content of PCFAS. This color change can also be observed in the parameter h^o, which refers to the hue. When close to 90º presents a yellow color, and its decrease tends to red, associated with parameter L^*, the coloration tends to brown.

As described by Teotônio et al. (2021), the specific texture and volume of bakery products are the most important parameters from the point of view of consumers. The PCFAS addition caused a progressive increase ($p < 0.05$) in the parameters related to the firmness, hardness, chewability, and shear of the mini cakes in which the C20 formulation presented the highest values, probably influenced by the decrease in wheat flour, offering a product that requires greater strength for chewing. The softness of cakes is one of the determining criteria for their acceptability and consumption. Therefore, values higher than usual can create strangeness in the consumer (Golmakani et al., 2015).

Table 5 presents the results obtained from the proximal composition, titratable acidity, and water activity of the mini cakes with the wheat flour replacement by PCFAS and shows the values of total phenolic compounds and antioxidant activity by the DPPH, ABTS, and FRAP methods in the mini cakes. It is observed that, with the partial wheat flour replacement by PCFAS, there was an increase in ash ($p < 0.05$) and protein contents, from the replacement of 15% of wheat flour by PCFAS ($p < 0.05$). The C20 mini cake was the one with the highest protein value. It should also be noted that the mini-cake formulations differed regarding the lipid content, as there was a wheat flour replacement by PCFAS. There was an increase ($p < 0.05$) in lipid content, which must be taken into account as lipids present in the AS have 67.76% unsaturated fatty acids (Luzia & Jorge, 2013).

The total titratable acidity content is related to the fermentation process or processing type that the product underwent (Chisté & Cohen, 2011), having an effect on the taste and odor of the food and relating to the amount of organic acid in the food (Araújo et al., 2015). It is observed that the titratable acidity content increased with the concentration of PCFAS in the mini cakes, which can be a differential in terms of flavor and stability during storage.

Based on the values of total phenolic compounds and antioxidant activity by the DPPH, ABTS, and FRAP methods in the mini cakes, it is noted that there was a significant difference in the formulations tested ($p < 0.05$). The higher the concentration of PCFAS, the higher the concentration of phenolic compounds and antioxidant activity. Thus, it is clear that processing did not affect the PCFAS antioxidant activity. Therefore, the consumption of the C20 mini cake can provide a good protein and lipid supply and antioxidant capacity, obtaining the benefit of reducing free radical production.

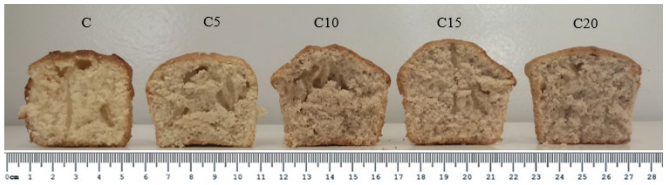

Figure 1. Cross sections of the mini cakes with partial replacement of the wheat flour by press-cake flour from araticum seeds.

Table 4. Color parameters of the PCFAS and the "crumb" of the mini cakes with partial replacement of wheat flour by PCFAS and its texture and shear strength parameter values.

Parameters	FTSA	C	C5	C10	C15	C20
L^*	52.20 ± 1.60	70.88 ± 1.84^a	64.01 ± 3.17^b	59.87 ± 2.59^c	58.23 ± 2.49^c	53.94 ± 2.43^d
a^*	6.81 ± 0.12	6.32 ± 0.34^d	6.90 ± 0.42^c	7.62 ± 0.25^b	7.65 ± 0.47^b	7.94 ± 0.23^a
b^*	19.03 ± 0.28	32.99 ± 0.64^a	27.95 ± 0.43^b	27.96 ± 0.46^b	27.43 ± 0.71^c	25.77 ± 0.46^d
C^*	20.21 ± 0.24	33.59 ± 0.68^a	29.10 ± 0.44^b	28.69 ± 0.49^c	28.48 ± 0.69^c	26.96 ± 0.49^d
h^o	70.32 ± 0.51	79.16 ± 0.46^a	76.16 ± 0.79^b	74.72 ± 0.38^c	74.41 ± 0.99^c	72.88 ± 0.34^d
Firmness (N)	–	4.98 ± 0.61^b	5.91 ± 92.08^{ab}	6.63 ± 0.89^b	6.92 ± 0.63^b	9.25 ± 1.24^a
Hardness (N)	–	7.72 ± 0.62^c	9.97 ± 0.76^c	11.39 ± 0.57^b	9.78 ± 0.43^{bc}	11.90 ± 1.20^{ab}
Gooeyness (N cm)	–	1.55 ± 0.18^c	2.36 ± 0.52^b	2.29 ± 0.33^b	2.42 ± 0.23^b	3.12 ± 0.36^a
Chewability	–	0.79 ± 0.12^c	1.51 ± 0.48^{ab}	1.16 ± 0.21^{bc}	1.46 ± 0.29^{ab}	1.82 ± 0.41^a
Shear (cN)	–	4.94 ± 0.60^b	5.61 ± 0.80^{ab}	6.29 ± 0.79^a	5.43 ± 0.62^{ab}	6.32 ± 0.46^a

L^*: brightness; a^*: green to red; b^*: blue to yellow; C^*: Chroma; h^o: hue; PCFAS: press-cake flour from araticum seeds; C: control mini cake; C5: mini cake with 5% of PCFAS; C10: mini cake with 10% of PCFAS; C15: mini cake with 15% PCFAS; C20: mini cake with 20% of PCFAS. Data are expressed as mean±standard deviation. Different letters on the same line indicate significant differences ($p < 0.05$) measured by the Tukey's test.

Table 5. Proximal composition, titratable acidity, and water activity of the mini cakes with replacement of WF by PCFAS and antioxidant activity (EC_{50}, ABTS, and FRAP) and phenolic compounds from the mini cakes.

Composition (%)	C	C5	C10	C15	C20
Moisture	22.94 ± 0.15^{ab}	23.7 ± 0.17^{ab}	22.14 ± 0.20^{b}	21.19 ± 0.18^{c}	23.38 ± 0.93^{a}
Ashes	0.89 ± 0.03^{e}	0.98 ± 0.02^{d}	1.11 ± 0.01^{c}	1.34 ± 0.01^{b}	1.66 ± 0.02^{a}
Proteins	7.34 ± 0.16^{c}	7.84 ± 0.12^{bc}	7.56 ± 0.36^{bc}	8.05 ± 0.13^{ab}	8.49 ± 0.20^{a}
Lipids	12.02 ± 0.60^{e}	13.17 ± 0.43^{de}	13.54 ± 0.44^{cd}	14.50 ± 0.39^{bc}	14.76 ± 0.26^{ab}
Carbohydrates	56.82 ± 1.88^{a}	54.31 ± 1.50^{b}	55.66 ± 2.01^{ab}	54.91 ± 1.42^{b}	51.71 ± 2.85^{c}
Energy value (kcal)	364.78 ± 13.54^{a}	367.13 ± 10.38^{a}	374.71 ± 13.41^{a}	382.34 ± 9.74^{a}	373.64 ± 14.58^{a}
Titratable acidity	5.41 ± 0.21^{c}	5.94 ± 0.09^{b}	6.41 ± 0.09^{b}	6.20 ± 0.02^{b}	8.75 ± 0.33^{a}
Water activity	0.85 ± 0.01^{a}	0.86 ± 0.03^{a}	0.84 ± 0.02^{a}	0.83 ± 0.01^{a}	0.86 ± 0.02^{a}
Phenolic compounds (mg GAE/100 g)					
Ethereal	38.18 ± 2.22^{e}	156.16 ± 2.83^{d}	169.34 ± 3.97^{c}	193.60 ± 1.46^{b}	215.14 ± 1.12^{a}
Alcoholic	30.43 ± 3.89^{e}	170.96 ± 5.92^{d}	512.11 ± 10.12^{c}	857.92 ± 12.35^{b}	1041.61 ± 3.05^{a}
Aqueous	190.88 ± 7.97^{e}	473.88 ± 5.09^{d}	961.19 ± 22.04^{c}	609.85 ± 17.41^{b}	1286.63 ± 13.63^{a}
EC_{50} (mg/mL)					
Ethereal	1.28 ± 0.16^{a}	1.13 ± 0.06^{ab}	0.90 ± 0.05^{bc}	0.67 ± 0.01^{cf}	0.51 ± 0.09^{de}
Alcoholic	1.13 ± 0.24^{a}	1.37 ± 0.20^{a}	1.51 ± 0.32^{a}	1.56 ± 0.12^{a}	1.42 ± 0.10^{a}
Aqueous	1.25 ± 0.08^{a}	0.91 ± 0.09^{ab}	1.28 ± 0.18^{ac}	1.01 ± 0.21^{abcd}	0.83 ± 0.05^{bd}
ABTS (μM Trolox/g)					
Ethereal	2.14 ± 1.84^{b}	10.82 ± 1.84^{a}	9.74 ± 1.74^{a}	7.55 ± 1.97^{a}	13.79 ± 0.69^{a}
Alcoholic	N.D.	9.24 ± 6.32^{b}	10.27 ± 3.75^{b}	28.90 ± 1.75^{a}	29.21 ± 4.20^{a}
Aqueous	N.D.	3.57 ± 0.41^{c}	4.87 ± 0.79^{c}	19.67 ± 2.87^{b}	95.16 ± 11.27^{a}
FRAP (μM ferrous sulfate/g)					
Ethereal	N.D.	9.72 ± 1.56^{d}	35.63 ± 0.33^{c}	44.92 ± 0.75^{b}	57.19 ± 1.02^{a}
Alcoholic	17.30 ± 0.54^{e}	65.14 ± 0.37^{d}	72.39 ± 0.26^{cd}	88.42 ± 0.57^{b}	169.50 ± 0.18^{a}
Aqueous	N.D.	10.13 ± 0.53^{c}	17.11 ± 0.81^{ab}	13.16 ± 0.29^{abc}	17.95 ± 1.01^{ab}

C: control mini cake; C5: mini cake with 5% of PCFAS; C10: mini cake with 10% of PCFAS; C15: mini cake with 15% PCFAS; C20: mini cake with 20% of PCFAS. Data are expressed as mean±standard deviation. N.D.: not detected. Different lowercase letters on the same line indicate significant differences ($p < 0.05$) measured by the Tukey's test.

4 CONCLUSION

AS and PCFAS demonstrated considerable macronutrient values, in addition to a high concentration of phenolic compounds and antioxidant capacity. The PCFAS significantly altered the mini cakes. As PCFAS was added, there was an increase in the hardness, firmness, and darkening. Protein, lipid, and phenolic compound contents along with antioxidant capacity significantly increased. Therefore, the PCFAS as a 20% replacement proved a viable alternative for using this byproduct.

REFERENCES

Araújo, C. S. P., de Andrade, F. H. A., Galdino, P. O., & de Caldas Pinto, M. D. S. (2015). Desidratação de batata-doce para fabricação de farinha. *Agropecuária* científica *no* semiárido, *11*(4), 33-41.

Association of Official Analytical Chemists (AOAC) (2012). *Official Methods of Analysis of AOAC International* (19th ed.). AOAC.

Benevides, C. M. de J., Souza, M. V., Souza, R. D. B., & Lopes, M. V. (2015). Fatores antinutricionais em alimentos: revisão. *Segurança Alimentar e Nutricional*, *18*(2), 67-79. https://doi.org/10.20396/san.v18i2.8634679

Bligh, E. G., & Dyer, W. J. (1959). A rapid method of total lipid extraction and purification. *Canadian Journal of Biochemistry and Physiology*, *37*(8), 911-917. https://doi.org/10.1139/o59-099

Brasil (2012). Resolução RDC nº 54, de 12 de novembro de 2012. Dispõe sobre o Regulamento Técnico sobre Informação Nutricional Complementar. *Diário Oficial Da União*. Retrieved from http://portal.anvisa.gov.br/documents/33880/2568070/rdc0054_12_11_2012.pdf/c5ac23fd-974e-4f2c-9fbc-48f7e0a31864

Brasil (2005). Agência Nacional de Vigilância Sanitária. Resolução RDC nº 263, de 22 de setembro de 2005. Regulamento técnico para produtos de cereais, amidos, farinhas e farelos. *Diário Oficial da União*.

Bruneton, J. (2009). *Pharmacognosie, phytochimie, plantes médicinales* (2nd ed.). Lavoisier Tec & Doc. Retrieved from https://books.google.fr/books/about/Pharmacognosie_phytochimie_plantes_médi.html?id=jDVXngEACAAJ&redir_esc=y

Carvalho, N. C. C., Monteiro, O. S., da Rocha, C. Q., Longato, G. B., Smith, R. E., da Silva, J. K. R., & Maia, J. G. S. (2022). Phytochemical Analysis of the Fruit Pulp Extracts from Annona crassiflora Mart. and Evaluation of Their Antioxidant and Antiproliferative Activities. *Foods*, *11*(14), 2079. https://doi.org/10.3390/foods11142079

Chisté, R. C., & Cohen, K. D. O. (2011). Teor de cianeto total e livre nas etapas de processamento do tucupi. *Revista do Instituto Adolfo Lutz*, *70*(1), 41-46.

Coelho, M. S., & Salas-Mellado, M. de las M. (2014). Revisão: Composição química, propriedades funcionais e aplicações tecnológicas da semente de chia (Salvia hispanica L) em alimentos Review : Chemical composition, functional properties and technological applications. *Brazilian Journal of Food Technology*, *17*(4), 259-268. https://doi.org/10.1590/1981-6723.1814

Damiani, C., Almeida, T. L., Costa, N. V., Medeiros, N. X., Silva, A. G. M., Silva, F. A., Lage, M. E., & Becker, F. S. (2013). Perfil de ácidos graxos e fatores antinutricionais de amêndoas de pequi crua e torrada. *Pesquisa Agropecuária Tropical*, *43*(1), 71-78. https://doi.org/10.1590/S1983-40632013000100004

Damiani, C., Vilas Boas, E. V. de B., Asquieri, E. R., Lage, M. E., Oliveira, R. A. de, Silva, F. A. da, Pinto, D. M., Rodrigues, L. J., Silva, E. P., & Paula, N. R. F. de. (2011). Characterization of fruits from the savanna: Araça (Psidium guinnensis Sw.) and Marolo (Annona crassiflora Mart.). *Food Science and Technology*, *31*(3), 723-729. https://doi.org/10.1590/S0101-20612011000300026

Essers, S. A. J. A., Bosveld, M., Van Grift, R. M. D., & Voragen, A. G. J. (1993). Studies on the quantification of specific cyanogens in cassava products and introduction of a new chromogen. *Journal of the Science of Food and Agriculture*, *63*(3), 287-296. https://doi.org/10.1002/jsfa.2740630305

Faller, A. L. K., & Fialho, E. (2009). Polyphenol availability in fruits and vegetables consumed in Brazil. *Revista de Saúde Pública*, *43*(2), 211-218. https://doi.org/10.1590/S0034-89102009005000010

Formagio, A. S. N., Vieira, M. C., Volobuff, C. R. F., Silva, M. S., Matos, A. I., Cardoso, C. A. L., & Carvalho, J. E. (2015). In vitro biological screening of the anticholinesterase and antiproliferative activities of medicinal plants belonging to Annonaceae. *Brazilian Journal of Medical and Biological Research*, *48*(4), 308-315. https://doi.org/10.1590/1414-431X20144127

Golmakani, M., Moayyedi, M., Raissjalali, A., Pesaran, Y., & Aghajani, A. (2015). Investigation of Physicochemical, Nutritional , Textural , and Sensory Properties of Iranian Yazdi Cupcake Enriched with Spirulina (Arthrospira platensis). *International Conference on Latest Trends in Food, Biological & Ecological Sciences*, *12*, 30-34.

Gomes, M. S., Fraga, S., Moura, N. F., & Silva, R. S. Aproveitamento de cascas de banana para a produção de farinha e aplicação como ingrediente em bolos. *Anais do XXV Congresso Brasileiro de Ciência e Tecnologia de Alimentos*, Gramado, 2016.

Hassan, Z. M., Manyelo, T. G., Selaledi, L., & Mabelebele, M. (2020). The effects of tannins in monogastric animals with special reference to alternative feed ingredients. *Molecules*, *25*(20), 4680. https://doi.org/10.3390/molecules25204680

Luzia, D. M. M., & Jorge, N. (2013). Bioactive substance contents and antioxidant capacity of the lipid fraction of Annona crassiflora Mart. seeds. *Industrial Crops and Products*, *42*, 231-235. https://doi.org/10.1016/j.indcrop.2012.05.027

Melo, A. P. C., Seleguini, A., Leite, A. F., Souza, E. R. B., & Naves, R. V. (2015). Fenologia reprodutiva do araticum e suas implicações no potencial produtivo. *Comunicata Scientiae*, *6*(4), 495-500. https://doi.org/10.14295/cs.v6i4.722

Menezes, E. G. T., Oliveira, E. R., Carvalho, G. R., Guimaraes, I. C., & Queiroz, F. (2019). Assessment of chemical, nutritional and bioactive properties of Annona crassiflora and Annona muricata wastes. *Food Science and Technology*, *39*(Suppl. 2), 662-672. https://doi.org/10.1590/fst.22918

Merril, A. L., & Watt, B. K. (1973). *Energy value of foods: basis and derivation*. United States Departament of Agriculture, 105 p.

Oliveira, J., de Souza, N. T., & Polesi, L. F. (2020). Elaboração de massa alimentícia sem glúten a partir de farinha de babaçu e pupunha. In Cordeiro, C. A. M. (ed.), *Tecnologia de Alimentos: Tópicos Físicos, Químicos e Biológicos* (v. 2, pp. 259-278). Científica Digital.

Pereira, A. C., & Santos, E. R. (2015). Frutas nativas do Tocantins com potencial de aproveitamento econômico. *Agri-Sciences Environmental*, *1*(1), 22-37. https://doi.org/10.36725/agries.v1i1.44

Prado, L. G., Arruda, H. S., Araujo, N. M. P., de Oliveira Braga, L. E., Banzato, T. P., Pereira, G. A., Figueiredo, M. C., Ruiz, A. L. T. G., Eberlin, M. N., Carvalho, J. E., Vendramini-Costa, D. B., & Pastore, G. M. (2020). Propriedades antioxidante, antiproliferativa e cicatrizante da casca e da semente do araticum (Annona crassiflora Mart.). *Food Research International*, *133*(7), 109168. https://doi.org/10.1016/j.foodres.2020.109168

Roesler, R., Malta, L. G., Carrasco, L. C., Holanda, R. B., Sousa, C. A. S., & Pastore, G. M. (2007). Atividade antioxidante de frutas do cerrado. *Food Science and Technology*, *27*(1), 53-60. https://doi.org/10.1590/S0101-20612007000100010

Rufino, M. do S. M., Alves, R. E., Brito, E. S., Filho, J. M., & Moreira, A. V. B. (2006). *Metodologia Científica: Determinação da atividade antioxidante total em frutas no sistema B-caroteno/ácido linoléico*. Embrapa.

Rufino, M. do S. M., Alves, R. E., Brito, E. S., Morais, S. M., Sampaio, G. C., Jimenez, J. P., & Calixto, F. D. S. (2007). *Determinação da atividade antioxidante total em frutas pela captura do radical livre DPPH*. Comunicado Técnico Embrapa (v. 127). Embrapa.

São Paulo (1978). *Decreto-lei nº 12.486, de 20 de outubro de 1978*. Normas Técnicas Especiais Relativas a Alimentos e Bebidas. Assembleia Legislativa do Estado de São Paulo. Retrieved from http://www.al.sp.gov.br/repositorio/legislacao/decreto/1978/decreto%20n.12.486,%20de%2020.10.1978.pdf

Schiassi, M. C. E. V., Lago, A. M. T., de Souza, V. R., Meles, J. S., de Resende, J. V., & Queiroz, F. (2018). Mixed fruit juices from Cerrado: Optimization based on sensory properties, bioactive compounds and antioxidant capacity. *British Food Journal*, *120*(10), 2334-2348. https://doi.org/10.1108/BFJ-12-2017-0684

Shahidi, F., & Ambigaipalan, P. (2015). Phenolics and polyphenolics in foods, beverages and spices: Antioxidant activity and health effects. *Journal of Functional Foods*, *18*(Part B), 820-897. https://doi.org/10.1016/j.jff.2015.06.018

Sousa, S. R., de Almeida Lopes, Â. C., Gomes, R. L. F., Vasconcelos, L. F. L., Araújo, A. S. F., Castro, A. A. J. F., Farias, R. R. S., Lopes, R. N., & Costa, M. F. (2020). Aspectos botânicos, fitoquímicos e nutricionais do araticum (Annona coriacea Mart.): uma revisão. *Brazilian Journal of Development*, *6*(11), 89071-89088. https://doi.org/10.34117/bjdv6n11-360

Storck, C. R., Nunes, G. L., Oliveira, B. B., & Basso, C. (2013). Folhas, talos, cascas e sementes de vegetais: composição nutricional, aproveitamento na alimentação e análise sensorial de preparações. *Ciência Rural*, *43*(3), 537-543. https://doi.org/10.1590/S0103-84782013000300027

Teotônio, D. O., Costa, B. A. F., Gomes, P. T. G., Santos, M. P., Amaral, E. F. G., Clerici, M. T. P. S., Leoro, M. G. V., & Schmiele, M. (2021). Fructo-oligosaccharides, hydrolyzed soy protein and yeast (Saccharomyces sp.) extract as potential cryoprotectans in glutenfree frozen dough and bread quality. *Research, Society and Development*, *10*(3), e44510313556. https://doi.org/10.33448/rsd-v10i3.13556

Ueda, J. M., Pedrosa, M. C., Heleno, S. A., Carocho, M., Ferreira, I. C., & Barros, L. (2022). Food additives from fruit and vegetable by-products and bio-residues: a comprehensive review focused on sustainability. *Sustainability*, *14*(9), 5212. https://doi.org/10.3390/su14095212

Zieliński, H., & Kozłowska, H. (2000). Antioxidant activity and total phenolics in selected cereal grains and their different morphological fractions. *Journal of Agricultural and Food Chemistry*, *48*(6), 2008-2016. https://doi.org/10.1021/jf990619o