


## Research Article

# Production of Nutritious Flour from Residue Custard Apple (*Annona squamosa* L.) for the Development of New Products

Felipe Thiago Caldeira Souza <sup>1</sup>, Elenilson Rivando Santos,<sup>1</sup>  
Jeisiely da Cruz Silva,<sup>1</sup> Iara Barros Valentim,<sup>2</sup> Thalyta Christie Braga Rabelo,<sup>3</sup>  
Nicole Ranielly Farias de Andrade,<sup>3</sup> and Leane Kellen de Souza Silva<sup>3</sup>

<sup>1</sup>Laboratory of Industrial Processes, Federal Institute of Alagoas, IFAL, Penedo, AL, Brazil

<sup>2</sup>Federal Institute of Alagoas, IFAL, Maceió, AL, Brazil

<sup>3</sup>College Figueiredo Costa, FIC, Maceió, AL, Brazil

Correspondence should be addressed to Felipe Thiago Caldeira Souza; felipethiago01@gmail.com

Received 16 October 2017; Accepted 12 February 2018; Published 19 March 2018

Academic Editor: Mahesha Poojary

Copyright © 2018 Felipe Thiago Caldeira Souza et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Currently, the fruit processing industry generates a high volume of waste in fruits that have not reached a quality standard for consumption or by-products generated throughout the production process. To reduce this waste, mitigating measures, such as reuse in food formulations, have been proposed. In this work the custard apple bagasse flour (*Annona squamosa* L.) (CAB) was produced and incorporated into cookie formulations in different proportions (5 to 50%) evaluating its acceptability. The CAB flour was characterized by physicochemical analysis, proximate composition, mineral analysis, determination of the phenolic content, and antioxidant capacity. The results of the physicochemical and proximate characterizations show that the processed flour presents values and specifications suitable for food formulations. The mineral composition of the CAB flour responds to more than 20% of the daily intake of nutrients, highlighting the Cu, Fe, Mn, Zn, Ca, and Mg. The composition of phenolic compounds for CAB flour and cookies formulations presented values ranging from 200 to 658 mg GAE/100 g, similar to flour and formulations prepared of residues tropical fruit, while DPPH<sup>\*</sup> inhibition showed a variation of 9.68–10.75%. Cookies made from the CAB flour showed high acceptability making the flour promising in the nutritional incorporation in food formulations.

## 1. Introduction

The production, commercialization, and consumption of tropical fruits have increased significantly in the international market due to their sensory, nutritional, and therapeutic properties; however, the food industry generates high amount of residues from these fruits [1, 2]. According to a recent survey by the Food and Agriculture Organization of the United Nations (FAO), about 1.3 billion tons of foods are wasted worldwide each year, which accounts for one-third of total food industry production [3, 4]. Allied to this fact, the fruit processing industry deals with a large percentage of by-products, such as peel, seeds, and bagasse, which increase the proportion of residues at the end of processing.

The custard apple (*Annona squamosa* L.) belongs to the Annonaceae family, with about 129 genus and more than

2000 species, being a fructiferous found in tropical and subtropical regions, adapted to the climatic conditions of China, Africa, South America, Australia, India, Mexico, the United States, and Thailand. The expansion of custard apple consumption is related to the medicinal and nutritional properties, as well as its pleasant flavor. The fruit of the tree is widely known and consumed due to its medicinal and nutritional properties, as well as its pleasant flavor. The health related components of the fruit include vitamins A, B, C, E, and K1, antioxidants, polyunsaturated fatty acids, and the presence of essential minerals. Furthermore, this plant has proved that it has a variety of compounds like acetogenins which are responsible for antifeedant, antimalarial, cytotoxic, and immunosuppressive activities and diterpenes isolated from the title plant have anti-HIV principle and antiplatelet aggregation activity [5–7].

Brazil is the second largest producer of custard apple in the world, after only Mexico (Seagri 2015), especially semiarid region of the Northeast, which owns 94% of the area under cultivation in Brazil, with the characteristic feature of family farming [8]. One of the bottlenecks in custard apple production is the high postharvest metabolic activity, accelerating the maturation process over a limited period of time, and limiting fruit shelf life. Due to its high moisture content, it becomes extremely perishable, especially in regions with high temperature, associated with absence or inadequate postharvest management and microbial infection, constituting a negative factor in its conservation [9]. In addition, the literature reports that about 30% to 40% of fruits harvested do not reach the best standards, being marketed at lower prices [8].

Recently, mitigating measures aimed at reducing fruit waste and reuse of by-products throughout production are reported in the literature [3, 10, 11]. Mostly, fruits that do not reach commercial standards, as well as after treatment residues, present similar or higher contents of bioactive compounds in relation to the final product [12]. In this way, the development of new products or food formulations through the incorporation of these residues becomes an alternative to minimize losses during the processing of fruits.

In this context, for the development of new products or food formulations, a nutritious meal was developed from custard apple bagasse, evaluating the physicochemical properties, proximate composition, mineral analysis, total phenolic content, and antioxidant activity. After obtaining the CAB flour, cookies type biscuits were prepared in different concentrations, verifying the organoleptic properties and acceptability among the consumers.

## 2. Materials and Methods

**2.1. Obtaining and Sanitizing of Custard Apple Fruit.** The custard apple used in this study was purchased from a local supermarket (Alagoas, Brazil). Initially, the sanitization occurred by passing the fruits through a washing step with running water in order to discard the parts that could not be used, after which they were immersed into a solution of chlorinated water at 200 ppm. They were then dried at 25°C for 30 min and manually peeled for separation of the pulp, seed, and peel.

**2.2. Preparation of Custard Apple Bagasse Flour.** After the cleaning process, separation of the components, and removal of the juice, the bagasse was spread on nonstick trays and taken to a greenhouse to dry at 65°C for 24 h. Then it was crushed with the help of a domestic blender and then sieved to obtain the flour. Finally, it was packed in a sealed glass container and stored until the analyses were carried out.

**2.3. Physicochemical Characterization.** For determination of pH, total titratable acidity in citric acid, soluble solids, and vitamin C was weighed 5 g of flour and diluted in 50 mL of distilled water; the contents were stirred until the particles were uniformly suspended, allowing the mixture to stand for 30 min, followed by filtration on filter paper [13]. The pH

was measured in a pH meter (Ionlab model pH 200 ATC) calibrated with pH 4 and 7 buffer solution, while the soluble solids (°Brix) analysis was measured in a refractometer (RUDOLPH J47). Total titratable acidity in citric acid was achieved by titration with 0.1 mol/L potassium hydroxide solution (KOH) until it reached a pH of 8.1. The results were expressed in grams of citric acid/100 g sample [13]. The vitamin C content was obtained by titrating the sample diluted with 0.03 mol/L iodine solution with starch indicator. The results were expressed as percentages per 100 g of sample [14]. The result was calculated by using

$$\text{Ascorbic acid (\%)} = \frac{V}{F} \times P, \quad (1)$$

where  $V$  is volume of potassium iodate used in titration of the sample,  $F$  is potassium iodate equivalence factor according to normality (0.8806), and  $P$  is samples weight (g); results were expressed in percentage of ascorbic acid.

The water absorption capacity (WAC) was determined by the weight difference of the water absorbed by the sample. Initially 0.5 g of sample was mixed with 5 mL of distilled water contained in a test tube, centrifuging at 3000 rpm for 15 min. After centrifugation the sample remained standing for 30 min and the water residue was weighed [15]. Calculation of the water adsorption capacity is shown in

$$\text{WAC (\%)} = \frac{\text{Weight of water (g)}}{\text{Weight of sample (g)}} \times 100. \quad (2)$$

**2.4. Proximate Composition Characterization.** For the ash determination, approximately 1 g of flour was weighed in a preincinerated crucible. The calcination process was carried out for 5 h at 550°C. The crucible with the sample was left in a desiccator until it cooled and was later weighed [16].

The moisture content was quantified from 1 g of the sample in a preheated crucible and tared. The sample was heated at 105°C in a greenhouse for 3 h, cooled in a desiccator to room temperature, and weighed [13].

The lipid content was determined by weighing about 1 g of sample on a previously tared and oven dried filter paper at 105°C for 30 min. Then, the sample cartridge was introduced into the Soxhlet extractor by flowing with petroleum ether over the 6 h period. Subsequently, the cartridge was removed from the extractor and dried in an oven at 105°C for 30 min and then placed in a desiccator until it reached room temperature to be weighed [16].

For the determination of total nitrogen, a microdiger/distiller (Tecnal-mod.TE 0363/TE007) was used by the Kjeldahl method [17].

To determine the crude fiber, approximately 2 g of the sample ( $W$ ) was weighed on the analytical balance and defatted by the Soxhlet method using petroleum ether followed by drying at 60°C for 1 h to remove the solvent. After defatting the sample, acid digestion (1.25%  $\text{H}_2\text{SO}_4$ ) was refluxed for 30 min from boiling and washing of the sample with hot water until the neutralization of the same. Then alkaline (1.25% NaOH) digestion was carried out with reflux for 30 min from boiling and washing the sample with hot water until

neutralization thereof. After washing the sample using 5 mL of acetone and 5 mL of ethyl alcohol, transfer of the sample to Gooch's crucible for vacuum filtration [13]. Finally, the sample was placed in the oven at 105°C until constant weight and then weighed ( $W_1$ ) and placed in the muffle at 550°C for 2 h and again weighed ( $W_2$ ) to calculate the percentage of crude fiber, according to

$$\text{Crude fiber content (\%)} = \frac{(W_1 - W_2)}{W} \times 100. \quad (3)$$

The total carbohydrate content of the sample was calculated as (4). Its total caloric value was calculated by applying the conversion values for carbohydrates (4 kcal), lipids (9 kcal), and protein (4 kcal) [3, 18].

$$\begin{aligned} \text{Total crude carbohydrates (\%)} \\ = 100 - (\text{Moisture} + \text{crude protein} + \text{fat} + \text{ash}). \end{aligned} \quad (4)$$

**2.5. Mineral Composition Characterization.** The phosphorus and potassium quantification was performed by the vanadomolybdic method in the spectrophotometer (Hach DR 5000) and flame photometry (Micronal B462), respectively [19]. The calcium, magnesium, copper, iron, manganese, and zinc minerals were determined by acid digestion using the method [20]. After digestion, the minerals were quantified by the Atomic Absorption Spectrophotometric (AAS) technique (Analytik Jena, AA 300).

**2.6. Preparation of Hydroethanolic Extracts.** The hydroethanolic extracts of the cookies biscuit samples were obtained by the hydroalcoholic extraction method according to Oliveira et al. [21] with some modifications. A sample containing 5 g of CAB flour and cookies with 0%, 5%, 15%, 30%, and 50% of flour were homogenized in 20 mL of 80% ethanol, under constant stirring at 30°C, for 20 min. After this step, the samples were centrifuged at 3500 rpm for 20 min. To the obtained precipitate, 20 mL of 80% ethanol was added to perform a further extraction for 20 min and then centrifugation was performed for 20 min. The same procedure was repeated one more time. All the supernatants were pooled and concentrated using the rotavaporator (BuchiRotavapor R-114) at 40°C and then stored in a glass vessel and kept under refrigeration at 4°C for further analysis.

**2.7. Determination of Total Phenolic Content.** The concentration of the phenolic compounds of the CAB flour hydroethanolic extracts and cookies with 0%, 5%, 15%, 30%, and 50% of the CAB flour was determined using the Folin-Ciocalteu reagent (FCR) method, as described by Cicco et al. [22] with some modifications. 120  $\mu$ L aliquots of the extracts were placed in the test tubes with 180  $\mu$ L of Milli Q water. Then, 300  $\mu$ L of FCR and, after 2 min, 2.4 mL of 5% (w/v) sodium carbonate were added, totaling a volume of 3 mL. The final concentration within the cuvette was 100  $\mu$ g/mL of the hydroethanol extracts (80%). The tubes were vortex and kept in the dark in a water bath at a temperature of 40°C for 20 min. Then, a 3 mL aliquot of the sample was

placed in a quartz cuvette (capacity = 3 mL, optical path = 1 cm) and the absorbance at 760 nm was measured using a spectrophotometer (Mutispec-1501 model Shimadzu, Japan). The total phenol content was obtained from the calibration curve prepared in a concentration range (1.12–10.53 mg/L) and expressed as mass of gallic acid equivalents per gram of extract (mg GAE/g).

**2.8. Activity of 2,2-Diphenyl-1-picrylhydrazyl Radical (RSA-DPPH<sup>\*</sup>).** The determination of the antioxidant capacity of CAB flour hydroethanolic extracts and cookies with 0%, 5%, 15%, 30%, and 50% of CAB flour was made according to Sánchez-Moreno et al. [23] with some modifications. The antioxidant capacity was determined by monitoring the reaction between the DPPH<sup>\*</sup> free radical and the extracts by measuring the absorbance at 516 nm in a spectrophotometer (UV-vis model Multispec-1501 Shimadzu, Japan). Hydroethanolic solutions of cookies with 0%, 5%, 15%, 30%, and 50% CAB flour were prepared so that their final concentration inside the cuvette was 100  $\mu$ g/mL. Thus, 0.30 mL of powder extract dissolved in methanol (0.25, 0.5, and 1.0 mg mL<sup>-1</sup>) was mixed with 2.7 mL of DPPH<sup>\*</sup> radical solution (40  $\mu$ g/mL in methanol) in a 3 mL quartz cuvette. The mixture was homogenized using the micropipette pointer (pushing and pulling liquids) and kept in the dark prior to analysis. The DPPH<sup>\*</sup> absorption values at 516 nm were obtained every 5 min during a period of 50 min. First, a blank was made with 0.3 mL of sample solution and 2.7 mL of methanol.

The percentage of DPPH<sup>\*</sup> radical sequestering capacity (% RSA, DPPH<sup>\*</sup>) of each extract was calculated as

$$\% \text{ RSA} = \frac{1 - AC}{AD} \times 100, \quad (5)$$

where AC is the absorbance of the solution when the extract was added at a particular concentration in 30 min and AD is the absorbance of the DPPH<sup>\*</sup> solution.

**2.9. Preparation of Cookies.** Table 1 presents the formulations of the cookies made from the CAB flour varying the proportions. Initially, the wheat and CAB flour were added and homogenized, followed by the addition of the other ingredients. The cookies after molding were baked at 180°C for 25 min. They were then cooled and packed in plastic containers.

**2.10. Sensory Analysis.** The sensory analysis of the biscuits was performed with 33 people without previous training in the age group of 16 to 59 years, with 18 women and 15 men. Samples were identified in nonrepetitive digits, randomly served on a plate with a glass of water to rinse the mouth before the subsequent test. The samples were evaluated according to colour, flavor, aroma, appearance, texture, and overall acceptance by means of the hedonic scale of 9 points (1 = greatly disagree to 9 = I liked very much), through an evaluation card analyzing the organoleptic properties [24].

**2.11. Statistical Analysis.** The results obtained on the design of the sensorial acceptability were analyzed statistically using

TABLE 1: Formulations used to prepare cookies.

Ingredients	Formulation				
	0%	5%	15%	30%	50%
Wheat flour (g)	120.0	114.0	102.0	84.0	60.0
CBA flour (g)	0.0	6.0	18.0	36.0	60.0
Brown sugar (g)	75.0	75.0	75.0	75.0	75.0
Crystal sugar (g)	45.0	45.0	45.0	45.0	45.0
Margarine (g)	50.0	50.0	50.0	50.0	50.0
Yeast (g)	0.5	0.5	0.5	0.5	0.5

TABLE 2: Characteristics of CBA flour.

Parameter	CBA flour
Acidity (g citric acid/100 g)	0.12 ± 0.00
Vitamin C (% ascorbic acid)	1.31 ± 0.04
pH	5.63 ± 0.05
Soluble solids (°BRIX)	7.5 ± 0.04
Water absorption capacity (g/100 g)	4.36 ± 1.36
Moisture (%)	10.41 ± 1.06
Ash (%)	2.17 ± 0.29
Fat (%)	5.35 ± 0.42
Protein (%)	5.68 ± 0.00
Crude fibre (%)	3.45 ± 0.59
Carbohydrate (%)	76.39 ± 1.77
Calories (Kcal/100 g)	376.43

Values expressed as mean ± standard deviation.

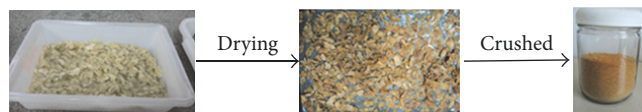


FIGURE 1: Steps to obtain the CBA flour.

Analysis of Variance (ANOVA) and Tukey test at the 5% level of significance, to compare the means using the Action Stat Pro.

### 3. Results and Discussion

Figure 1 shows the dehydration and crushing stages to obtain the CAB flour. After the drying process, there was a final yield of 20%, which was caused by the elimination of water and other components.

**3.1. Physicochemical and Proximate Composition Characterization of CAB Flour.** The values obtained for the physicochemical characterization of the CAB flour are expressed in Table 2.

The pH value found for the CAB flour was 5.63, while the total acidity was 0.12 g citric acid/100 g. The determination of these parameters, mainly the acidity, can provide important data to evaluate the conservation state of the product, since the processes of decomposition by hydrolysis or oxidation can affect the sensory and nutritional characteristics of the product [3]. The value found was lower than that of common

wheat flour, minimizing the propagation of bacteria and consequently the deterioration of the product.

The CAB flour presented a solids content of 7.5 °Brix, associated with the presence of sucrose and glucose, providing a bittersweet flavor to the final product [27].

The water absorption capacity was 4.36 g, resulting in values higher than those found for flour produced from soybean, corn, rice, and beans [3, 10, 28]. This property determines the ability of the food to absorb water by the starch granules. In this way, the greater the property, the easier the access of the water between the starch chains, thus improving its application in products such as breads and cakes, due to the maintenance of moisture, increasing the yield of the final products. Moreover, this parameter can be vital in retaining the taste and palatability of food [10].

The moisture content was 10.41%, a value lower than the 15 % allowed for vegetable flours by Brazilian legislation [29]. Low moisture content prolongs the storage time of food and contributes to the textural quality and the inhibition of chemical and biochemical reactions, due to the fact that it minimizes the proliferation of undesirable microorganisms such as fungi and bacteria [3, 30].

The ash content of a food product refers to the inorganic residue remaining from the burning of organic matter, which, according to the Brazilian Government Food Agency legislation, should be at most 4.0% [31]. From the results the low ash content was observed, around 2.17%, associated with the presence of minerals present in the pulp, which were preserved after the dehydration process, showing that the preparation of flour from fruits and vegetables is rich in minerals required for human consumption [32, 33].

Since the fat determination represents the amount of fat present in the food, its value high fat content of any product can lead to rapid degradation process. Consequently, this degradation alters the organoleptic properties and nutritional value, transforming the food into a toxic product due to the formation of free radicals [34]. The fat content found for the CAB flour was 5.35%, being within the standards established by ANVISA [31], and it should present a total fat level of up to 6 g/100 g in the elaboration of any food products processing.

The protein content found for the CAB flour was 5.68%, lower than that established by ANVISA [31], making this flour inadequate for incorporation into food formulations for the purpose of protein enrichment.

The CAB flour had crude fiber content, around 3.5%. According to Sumczynski et al. [35] the main constituents of the crude fiber are composed of cellulose and lignin are



TABLE 3: Mineral composition of CBA flour.

Mineral	Mineral content (mg·100 g <sup>-1</sup> )	DRI <sup>a</sup> (mg) Adult	% DRI from 100 g of flour
Phosphorus	80	700	11.42
Potassium	500	4700	10.6
Copper	4.0	0.9	444.4
Iron	7.8	8.0	97.5
Manganese	0.71	2.3	30.8
Zinc	8.5	11	77.27
Calcium	189.9	1000	18.99
Magnesium	262.5	420	65.62

<sup>a</sup>Dietary reference intake (DRI) for adults, according to Food and Nutrition Information Center [25].

parts of fruits. Despite this low fiber content, the CAB flour is classified according to ANVISA [31], as a fiber source food, since it had a fiber content higher than 3.0%.

The calorific value of 376.63 Kcal/100 g found for CAB flour meets 18% daily values established by ANVISA [31]. This high caloric concentration is the result of the amount of carbohydrates present in the custard apple, in particular sucrose and glucose, according to the results of the analysis of soluble solids (°BRIX), evidencing the feasibility of the incorporating of this flour in formulations for energy enrichment.

**3.2. Mineral Composition Characterization.** Knowledge of the mineral composition of food products is fundamental to achieve food and nutritional security, obtaining information and subsidies for public health authorities to establish nutritional goals, quality control, and evaluation of nutrient intake by individuals [36]. The results obtained for mineral composition (Table 3) were quite significant, with emphasis on Cu, Fe, Mn, Zn, Ca, and Mg, serving more than 20% of the daily nutrient intake index [36, 37].

One of the most important minerals in the human diet, which prevents the incidence of anemia, is iron. The deficiency of this mineral occurs when the demand for Fe is high, especially in the growth phase, menstrual cycle, and pregnancy. According to USDA [37] the daily recommendation of iron intake for children and adults of both sexes ranges from 7 mg to 27 mg. The CAB flour had a content of 7.8 mg/100 g, a result superior to foods such as milk (0.02 mg/100 g), oatmeal (2.09 mg/100 g), rice flour (2.7 mg/100 g), wheat flour (0.8 mg/100 g), and corn flour (1.1 mg/100 g) [38, 39]. The National Health Surveillance Agency [31] recommends that wheat and maize flour should be enriched with iron for a final concentration of 4.2 mg/100 g. The incorporation of this flour into baked goods such as breads, cakes, salads, and biscuits may be a viable alternative for iron supplementation, given that this nutrient is the most common nutritional deficiency in developing countries, especially in Brazil [31, 38, 40].

Calcium was one of the main minerals present in CAB flour with 189.8 mg/100 g, contributing with 18.99% of the nutritional recommendation [37]. The amount of calcium found in this work is higher compared to wheat flour (18 mg/100 g), corn flour (34 mg/100 g), rye flour (24 mg/100 g), *Annona crassiflora* flour (117 mg/100 g), and similar to and/or the same as soybean flour (206 mg/100 g) and acerola bagasse flour (264.32 mg/100 g) [41–43]. This

mineral is abundant in the human body, contributing about 2% of body weight, is responsible for mineralization of bones and teeth, performing intracellular regulation in most body tissues, muscular contraction, and nervous function [44]. The incorporation of CAB flour in food products may be promising as a source of calcium for lactose intolerant individuals, since milk and its derivatives are considered the best sources of calcium.

Copper and zinc are essential micronutrients for humans and vital components of various enzymes responsible for cellular metabolism [45]. According to the results, the 100 g portion of CAB flour had 4.0 mg Cu, which was higher than that found for wheat flour (1.51 mg/100 g), rice flour (2.2 mg/100 g), maize flour (0.9 mg/100 g), and papaya peel flour (1.09 mg/100 g) [46, 47], while the Zn content in the CAB flour was 8.5 mg/100 g and higher than the *Annona crassiflora* flour (3.41 mg/100 g), wheat flour (7.59 mg/100 g), papaya peel flour (0.23 mg/100 g), apple pomace flour (0.17 mg/100 g), and orange pomace flour (0.23 mg/100 g), demonstrating to be promising for food formulations [41, 42, 46, 48]. The minerals Cu and Zn present in CAB flour account for more than 75% of the daily nutrient intake index (DRI) of nutrients, especially for copper [36, 37].

The potassium content for CAB flour was 500 mg/100 g, contributing with 10.5% of the nutritional recommendation [37]. The potassium content was higher than rice flour (97.4 mg/100 g), wheat flour (150 mg/100 g), and corn flour (148.7 mg/100 g) and lower than quinoa flour (553.8 mg/100 g) [46]. This mineral is very important for the human body, acts as the main enzymatic cofactor maintaining the acid-base balance of the human body, playing an essential role in the functioning of nerves and muscles, and reducing the risk of stroke and coronary heart disease [49].

Magnesium is the essential intracellular cation for the physiological metabolism of the human body, because it intervenes to regulate the activity of more than 300 enzymatic reactions. The CAB flour had a content 262.5 mg/100 g of magnesium, representing 65.62% of the daily nutritional recommendation, a proportion higher than green banana flour (30.84 mg/100 g), wheat flour (8.25 mg/100 g), rice flour (7.3 mg/100 g), bean flour (47.20 mg/100 g), papaya Hawaii flour (210 mg/100 g), banana green flour (30,80 mg/100 g), and *Annona crassiflora* flour (14.23 mg/100 g) [42, 46, 47, 50, 51]. Scientific research has shown that even minimal variations in the concentration of this mineral can deplete certain

TABLE 4: Total content of phenols and DPPH<sup>\*</sup> radical of the hydroethanolic extracts of the CAB flour and cookies with 0%, 5%, 15%, 30%, and 50% of the CAB flour and fruit residues flours as reference.

Samples	Yield (%)	TPC mg EAG/g dry extract	TPC mg EAG/100 g flour	DPPH <sup>*</sup> RSA%
CAB flour	84.62	7.78 ± 0.33 <sup>ab</sup>	658.34 ± 27.92 <sup>a</sup>	9.68 ± 0.91 <sup>a</sup>
0% CAB flour	45.49	5.44 ± 2.73 <sup>ab</sup>	247.46 ± 124.18 <sup>bc</sup>	10.75 ± 0.91 <sup>a</sup>
5% CAB flour	44.28	4.50 ± 1.36 <sup>ab</sup>	199.26 ± 60.22 <sup>c</sup>	9.91 ± 1.33 <sup>a</sup>
15% CAB flour	54.00	3.73 ± 0.01 <sup>b</sup>	201.42 ± 0.54 <sup>c</sup>	10.43 ± 1.85 <sup>a</sup>
30% CAB flour	46.11	4.93 ± 0.79 <sup>ab</sup>	227.32 ± 36.42 <sup>c</sup>	10.46 ± 0.14 <sup>a</sup>
50% CAB flour	54.86	9.35 ± 3.56 <sup>a</sup>	512.94 ± 195.3 <sup>ab</sup>	9.88 ± 3.63 <sup>a</sup>
<i>Reference samples</i>				
Wheat flour <sup>a</sup>	nd	6.96 ± 0.1	nd	nd
Quinoa flour <sup>a</sup>	nd	2.81 ± 0.1	nd	nd
Acerola bagasse flour <sup>b</sup>	nd	10.82 ± 0.09	nd	nd
Residue pequi flour <sup>c</sup>	nd	17.42 ± 0.53	nd	nd
Residue passion fruit flour <sup>d</sup>	2.5	41.2 ± 4.2	103 ± 10.4	24.7
Residue pineapple flour <sup>d</sup>	30.2	9.1 ± 1.3	275 ± 38.0	19.8
Residue acerola flour <sup>d</sup>	7.1	94.6 ± 7.4	681 ± 53.5	81.6

<sup>a</sup>Chlopicka et al., [26]. <sup>b</sup>Marques et al., 2013. <sup>c</sup>Leão et al., 2017. <sup>d</sup>Oliveira et al., 2009. nd = not determined. Averages followed by the identical letters in the column do not differ statistically by the Tukey test ( $p < 0.05$ ).

cardiac arrhythmias, affecting cell metabolism, growth, and proliferation [52].

Manganese plays an important role in the development of bones and cartilage, as well as in the healing of wounds and constituents of various enzymes [53]. The CAB flour presented 0.71 mg/100 g constituting 30% of the daily diet of this mineral, inferior index to that found in the *Annona crassiflora* flour (1.85 mg/100 g), but superior to banana flour (0.14 mg/100 g) and wheat flour (0.43 mg/100 g), demonstrating its potential in food formulations [50, 54].

Phosphorus is a mineral present in all cells of the human body playing important role in protein synthesis, growth, maintenance, and repair of cells and tissues. The CAB flour had 11.42% of the daily intake index with 80 mg/100 g, a result inferior to that found in wheat flour (90.8 mg/100 g), rice (95.4 mg/100 g), and maize flour (81.3 mg/100 g) and higher than the *Annona crassiflora* flour (62.09 mg/100 g) [42, 46]. The values of minerals found make the incorporation of CAB flour as supplementation and nutrient supplementation in food products promising, such as wheat cereal flours, used in bread products, which are generally deficient in minerals essential for human nutrition [10].

**3.3. Total Phenolic Content and Antioxidant Capacity DPPH<sup>\*</sup> Radical.** Table 4 shows the yields obtained from the hydroethanol extracts, the total phenolic content (TPC), DPPH<sup>\*</sup> antioxidant activity of the CAB flour of the 0%, 5%, 15%, 30%, and 50% CAB flour, and samples of references of other fruits as a comparison parameter. The CAB flour presented an extraction efficiency compared to the cookies, associated with the higher fiber content present. Oliveira et al. [21] evaluated methanolic extraction for pineapple, acerola, and passion fruit flours, with a higher extract yield for pineapple flour, attributing this

characteristic to the higher fiber content in relation to other fruits.

According to Table 4, the TPC for extracts of CAB flour and cookies 0%, 5%, 15%, 30%, and 50% of CAB flour varied from 3.73 to 9.35 mg GAE/g. The samples of CAB flour and the cookie with 50% of flour presented higher concentrations of phenolic compounds in relation to the other cookies produced because of the superior amount of fiber. The value of phenolic content found for CAB flour showed superiority and/or similarity when compared to wheat, quinoa, and pineapple flour but obtained values lower than flours obtained from the residues of pequi, passion fruit, and mainly acerola in dry residue extract. However, when considering the extraction yield and the phenolic concentration converted to 100 g of CAB flour, a superior result was obtained in relation to passion fruit flour and similar to acerola flour. According to Oliveira et al. [21], this characteristic is essential in the dietary prescription of flours, since the CAB flour obtained greater extraction of phenols, being the most recommended to the detriment of the fruit flours shown in Table 4. In this way, CAB flour presents a significant amount of phenols being able to act as natural antioxidants capable of reducing degenerative diseases such as arteriosclerosis, cardiovascular disease, and cancer [10].

The results observed for the sequestering activity of the DPPH<sup>\*</sup> radical of the hydroethanol extracts showed a variation of 9.68–10.75%, showing no significant difference between the samples. However, when comparing the results of CAB flour and cookie formulations, a lower result was obtained in comparison to the flour of other fruits, according to Table 4. These results can be related to the part of the fruit residue that is being reused for elaboration of the flour. Leão et al. [55] report that phenolic compounds are associated with

TABLE 5: Evaluation of the tasting tests of cookie with different formulations.

Parameter	Formulation, age range (27 to 59 years)				
	0%	5%	15%	30%	50%
Appearance	6.4 ± 2,06 <sup>a</sup>	7.1 ± 1,40 <sup>a</sup>	7.2 ± 1,52 <sup>a</sup>	6.9 ± 1,86 <sup>a</sup>	7.4 ± 1,30 <sup>a</sup>
Colour	6.8 ± 1,78 <sup>a</sup>	7.2 ± 1,94 <sup>a</sup>	7.2 ± 2,04 <sup>a</sup>	7.4 ± 1,35 <sup>a</sup>	7.8 ± 1,37 <sup>a</sup>
Texture	6.1 ± 2,38 <sup>a</sup>	6.4 ± 2,16 <sup>a</sup>	6.2 ± 2,05 <sup>a</sup>	5.7 ± 1,57 <sup>a</sup>	6.0 ± 2,67 <sup>a</sup>
Aroma	6.5 ± 1,68 <sup>a</sup>	6.5 ± 1,84 <sup>a</sup>	6.9 ± 1,48 <sup>a</sup>	6.5 ± 1,95 <sup>a</sup>	7.0 ± 2,07 <sup>a</sup>
Flavor	6.7 ± 1,86 <sup>a</sup>	6.9 ± 1,70 <sup>a</sup>	6.7 ± 1,90 <sup>a</sup>	6.6 ± 1,80 <sup>a</sup>	6.7 ± 2,21 <sup>a</sup>
Overall acceptance	6.2 ± 2,06 <sup>a</sup>	6.5 ± 1,68 <sup>a</sup>	6.6 ± 1,80 <sup>a</sup>	6.6 ± 1,58 <sup>a</sup>	6.3 ± 2,35 <sup>a</sup>
Parameter	Formulation, age range (16 to 24 years)				
	0%	5%	15%	30%	50%
Appearance	5.3 ± 1,57 <sup>ab</sup>	6.3 ± 1,74 <sup>a</sup>	5.5 ± 1,72 <sup>ab</sup>	5.6 ± 2,11 <sup>ab</sup>	5.8 ± 2,12 <sup>ab</sup>
Colour	5.5 ± 2,17 <sup>ab</sup>	6.3 ± 1,81 <sup>a</sup>	6.4 ± 1,82 <sup>a</sup>	6.1 ± 2,11 <sup>ab</sup>	6.4 ± 2,43 <sup>a</sup>
Texture	4.4 ± 2,25 <sup>b</sup>	6.2 ± 2,02 <sup>a</sup>	5.5 ± 2,54 <sup>ab</sup>	4.0 ± 2,54 <sup>b</sup>	4.1 ± 2,32 <sup>b</sup>
Aroma	6.0 ± 2,09 <sup>ab</sup>	6.3 ± 1,88 <sup>a</sup>	6.2 ± 2,16 <sup>ab</sup>	6.0 ± 2,23 <sup>ab</sup>	5.7 ± 2,56 <sup>ab</sup>
Flavor	5.7 ± 2,29 <sup>ab</sup>	6.5 ± 2,33 <sup>a</sup>	6.5 ± 2,03 <sup>a</sup>	5.2 ± 2,55 <sup>ab</sup>	4.1 ± 2,42 <sup>b</sup>
Overall acceptance	5.8 ± 1,74 <sup>ab</sup>	6.6 ± 2,08 <sup>a</sup>	6.2 ± 2,15 <sup>ab</sup>	5.0 ± 1,95 <sup>b</sup>	4.6 ± 2,11 <sup>b</sup>

Results expressed as mean ± standard deviation; 9-point hedonic scale (1 = greatly disagreed to 9 = greatly liked). Averages followed by the identical letters in the column do not differ statistically by the Tukey test ( $p < 0.05$ ).

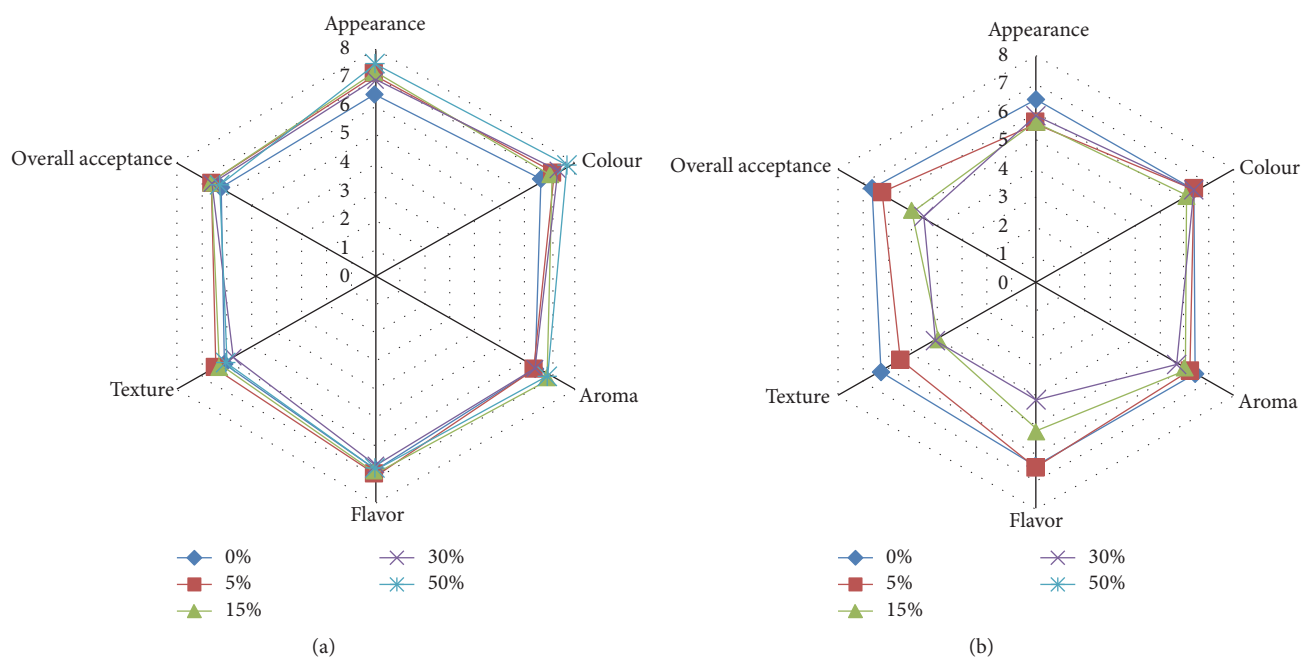


FIGURE 2: Graphical representation for organoleptic properties: age range of 27 to 59 years and (b) age range of 16 to 24 years.

important functions in plants, including pigmentation and defense, as well as in fruit peels and seeds and to a lesser extent in pulp, justifying the low DPPH<sup>\*</sup> value found for the CAB flour and cookies made from the bagasse pulp.

**3.4. Sensory Analysis of Cookies.** Table 5 presents the evaluations of the organoleptic properties in relation to the age range of the tasters.

The results of the acceptability tests showed that the age group was a preponderant factor during the evaluation of cookies as observed in Figure 2. According to Pineli et al. [43] the process of consumers choice and perception of food

is multifactorial, associated with several nonsensory aspects such as brand, familiarity with product, and price.

Consumers in the age group (a) presented higher scores on all organoleptic properties and on the overall evaluation regardless of the proposed formulation. Despite the 50% substitution of wheat flour, there was no decay in the acceptability of the consumers, and, for most of the parameters evaluated, preference was higher compared to the sample containing only wheat flour, allowing the nutritional increase in the proposed formulations. On the other hand, for consumers in the age group (b), there was a decrease in the evaluations, but, for the 5% and 15% formulations, the testers stated

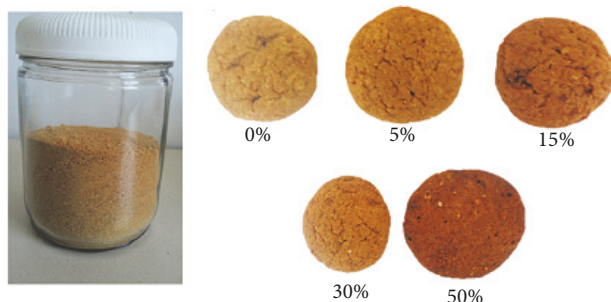


FIGURE 3: CAB flour and cookies with different formulations.

that they liked it slightly (score 6.0), presenting a higher acceptability index than the sample containing only wheat flour. These results demonstrate that cookies made from the CAB flour presented similar acceptability to the cookies of commercial wheat flour, grape marc, banana, rice, and tapioca [50, 56, 57] before the evaluators, highlighting the age group A and making it promising in the supplementation and incorporation in food formulations improving the nutritional properties. Cookies made with different proportions of CAB flour are shown in Figure 3.

#### 4. Conclusion

The physicochemical and proximate characteristics of the CAB flour presented values and specifications for elaboration of food products, besides containing high concentration of phenolic components. The incorporation of the CAB flour in the formulation of cookies showed good acceptance before the consumers, presenting, in some formulations, preference greater when compared to the cookie elaborated with 100% of wheat flour. The results indicate that flour made from custard apple bagasse pulp can be incorporated in food formulations to improve nutritional properties, being an alternative to add value to the residue and to minimize losses along the production chain of custard apple.

#### Conflicts of Interest

This paper did not lead to any conflicts of interest regarding the publication of this manuscript.

#### Acknowledgments

The authors thank the Federal Institute of Alagoas for the financial support of the research and innovation productivity grants of the PAPPE/IFAL and the scientific initiation program PIBIC/IFAL.

#### References

- [1] R. Martínez, P. Torres, M. A. Meneses, J. G. Figueroa, J. A. Pérez-Álvarez, and M. Viuda-Martos, "Chemical, technological and in vitro antioxidant properties of mango, guava, pineapple and passion fruit dietary fibre concentrate," *Food Chemistry*, vol. 135, no. 3, pp. 1520–1526, 2012.
- [2] J. L. Bicas, G. Molina, A. P. Dionísio et al., "Volatile constituents of exotic fruits from Brazil," *Food Research International*, vol. 44, no. 7, pp. 1843–1855, 2011.
- [3] M. S. L. Ferreira, M. C. P. Santos, T. M. A. Moro, G. J. Basto, R. M. S. Andrade, and É. C. B. A. Gonçalves, "Formulation and characterization of functional foods based on fruit and vegetable residue flour," *Journal of Food Science and Technology*, vol. 52, no. 2, pp. 822–830, 2015.
- [4] J. Gustavsson, C. Cederberg, U. Sonesson, and R. A. M. van Otterdijk, *Global Food Losses and Food Waste: Extent, Causes and Prevention*, Food and Agriculture Organization of the United Nations (FAO). The Swedish Institute for Food and Biotechnology, Düsseldorf, Germany, 2011.
- [5] K. Liu, H. Li, C. Yuan, Y. Huang, Y. Chen, and J. Liu, "Identification of phenological growth stages of sugar apple (*Annona squamosa* L.) using the extended BBCH-scale," *Scientia Horticulturae*, vol. 181, pp. 76–80, 2015.
- [6] D. K. Yadav, N. Singh, K. Dev et al., "Anti-ulcer constituents of *Annona squamosa* twigs," *Fitoterapia*, vol. 82, no. 4, pp. 666–675, 2011.
- [7] R. Senthil and R. Silambarasan, "Annona: a new biodiesel for diesel engine: a comparative experimental investigation," *Journal of the Energy Institute*, vol. 88, no. 4, pp. 459–469, 2015.
- [8] E. E. P. De Lemos, "The production of annona fruits in Brazil," *Revista Brasileira de Fruticultura*, vol. 36, no. 1, pp. 77–85, 2014.
- [9] I. R. C. Santos, *Escurecimento enzimático em frutos: Polifenoloxidase de atemóia. (Annona cherimola Mill. X Annona squamosa L.)*, Dissertação de mestrado, Universidade estadual Paulista Júlio de Mesquita, 2009.
- [10] R. Bhat and N. B. Yahya, "Evaluating belinjau (*Gnetum gnemon* L.) seed flour quality as a base for development of novel food products and food formulations," *Food Chemistry*, vol. 156, pp. 42–49, 2014.
- [11] E. Naziri, N. Nenadis, F. T. Mantzouridou, and M. Z. Tsimidou, "Valorization of the major agrifood industrial by-products and waste from Central Macedonia (Greece) for the recovery of compounds for food applications," *Food Research International*, vol. 65, pp. 350–358, 2014.
- [12] J. F. Ayala-Zavala, V. Vega-Vega, C. Rosas-Domínguez et al., "Agro-industrial potential of exotic fruit byproducts as a source of food additives," *Food Research International*, vol. 44, no. 7, pp. 1866–1874, 2011.
- [13] A. Lutz, *Chemical and Physical Methods for Food Analysis*, Analytical Standards of the Adolfo Lutz Institute, São Paulo, Brazil, 4th edition, 2005.
- [14] O. A. Ohlweiler, *Química Analítica Quantitativa*, Livros técnicos e científicos, Rio de Janeiro, Brazil, 2nd edition, 1976.
- [15] L. R. Beuchat, "Functional and electrophoretic characteristics of succinylated peanut flour protein," *Journal of Agricultural and Food Chemistry*, vol. 25, no. 2, pp. 258–261, 1977.
- [16] H. M. Cecchi, *Fundamentos Teóricos e Práticos em Análise De Alimentos*, Unicamp publisher, Campinas, Brazil, 2nd edition, 2003.
- [17] AOAC Internacional, *Official Methods of Analysis*, Association of Official Analytical Chemists, Washington, DC, USA, 16th edition, 1996.
- [18] H. G. Müller and G. Tobin, *Nutrition and Food Processing*, Croom Helm Ltd, London, UK, 5th edition, 1980.
- [19] O. Zeneban, N. S. Pascuet, and P. Tiglea, *Métodos Físico-Químicos Para Análise De Alimentos*, Instituto Adolfo Lutz, São Paulo, Brazil, 4th edition, 2008.



- [20] AOAC International, *Official Methods of Analysis*, Association of Official Analytical Chemists, Washington, DC, USA, 15th edition, 1990.
- [21] A. C. D. Oliveira, I. B. Valentim, C. A. Silva et al., "Total phenolic content and free radical scavenging activities of methanolic extract powders of tropical fruit residues," *Food Chemistry*, vol. 115, no. 2, pp. 469–475, 2009.
- [22] N. Cicco, M. T. Lanorte, M. Paraggio, M. Viggiano, and V. Lattanzio, "A reproducible, rapid and inexpensive Folin-Ciocalteu micro-method in determining phenolics of plant methanol extracts," *Microchemical Journal*, vol. 91, no. 1, pp. 107–110, 2009.
- [23] C. Sánchez-Moreno, J. A. Larrauri, and F. Saura-Calixto, "Free radical scavenging capacity and inhibition of lipid oxidation of wines, grape juices and related polyphenolic constituents," *Food Research International*, vol. 32, no. 6, pp. 407–412, 1999.
- [24] A. K. S. Abud and N. Narain, "Incorporation of fruit pulp residue flour into cookies: an alternative to combat waste," *Brazilian Journal Food Technology*, vol. 12, pp. 257–265, 2009.
- [25] Food Nutrition Information Center, *Dietary Recomend Intakes*, 2016, [http://fnic.nal.usda.gov/nal\\_display/index.php?info\\_center=4&tax\\_level=3&tax\\_subject=256&topic\\_id=1342&level3\\_id=5140/](http://fnic.nal.usda.gov/nal_display/index.php?info_center=4&tax_level=3&tax_subject=256&topic_id=1342&level3_id=5140/).
- [26] J. Chlopicka, P. Pasko, S. Gorinstein, A. Jedryas, and P. Zagrodzki, "Total phenolic and total flavonoid content, antioxidant activity and sensory evaluation of pseudocereal breads," *LWT—Food Science and Technology*, vol. 46, no. 2, pp. 548–555, 2012.
- [27] T. O. Akanbi, S. Nazamid, and A. A. Adebawole, "Functional and pasting properties of a tropical breadfruit (*Artocarpus altilis*) starch from Ile-Ife, Osun state, Nigeria," *International Food Research Journal*, vol. 16, no. 2, pp. 151–157, 2009.
- [28] L. H. Silva, P. F. P. Costa, G. W. Nomiya, I. P. Souza, and Y. K. Chang, "Physicochemical and technological characterization of whole soybean flour fermented by *Aspergillus oryzae*," *Brazilian Journal of Food Technology*, vol. 15, pp. 300–306, 2012.
- [29] B. N. B. Lima, F. F. Lima, M. I. B. Tavares, A. M. M. Costa, and A. P. T. R. Pierucci, "Determination of the centesimal composition and characterization of flours from fruit seeds," *Food Chemistry*, vol. 151, pp. 293–299, 2014.
- [30] A. Aydin, P. Peter, and F. J. M. Smulders, "The physico-chemical and microbiological properties of wheat flour in Thrace," *Turkish Journal of Agriculture & Forestry*, vol. 33, no. 5, pp. 445–454, 2009.
- [31] Agência Nacional De Vigilância Sanitária (ANVISA), *egulamento Técnico sobre Informação Nutricional Complementar*, Diário Oficial da União, 2012, <http://portal.anvisa.gov.br/documents/2033880/2568070/rdc0054.12.11.2012.pdf/c5ac23fd-974e-4f2c-9fbc-48f7e0a31864/>.
- [32] M. T. P. S. Clerici, C. Kallmann, F. O. G. Gaspi, M. A. Morgano, F. Martinez-Bustos, and Y. K. Chang, "Physical, chemical and technological characteristics of *Solanum lycocarpum* A. St.—HILL (Solanaceae) fruit flour and starch," *Food Research International*, vol. 44, no. 7, pp. 2143–2150, 2011.
- [33] C. T. M. Pereira, C. R. D. P. Silva, A. Lima, M. D. Pereira, C. N. Costa, and A. A. C. Neto, "Obtenção, caracterização físico-química e avaliação da capacidade antioxidante in vitro da farinha de residuo de acerola (*Malpighia glabra L.*)," *Acta Tecnológica*, vol. 8, pp. 50–56, 2013.
- [34] J. Sochr, K. Cinkova, and L. Svorc, "Degradation markers in nutritional products a review," *Journal Analytical Pharmaceutical Chemistry*, vol. 1005, pp. 1–7, 2014.
- [35] D. Sumczynski, Z. Bubelova, J. Sneyd, S. Erb-Weber, and J. Mlcek, "Total phenolics, flavonoids, antioxidant activity, crude fibre and digestibility in non-traditional wheat flakes and muesli," *Food Chemistry*, vol. 174, pp. 319–325, 2015.
- [36] Núcleo de Estudos e pesquisas em Alimentação (NEPA), *Tabela Brasileira E Composição De Alimentos*, Campinas State University, São Paulo, Brazil, 4th edition, 2011.
- [37] United State Department of Agriculture (USDA), *Principles for Nutrition Labeling and Fortification. Committee on Use of Dietary Reference Intakes in Nutrition Labeling Food and Nutrition Board*, National Academies Press, Washington, DC, USA, 2002.
- [38] T. Pedron, F. R. Segura, F. F. da Silva, A. L. de Souza, H. F. Maltez, and B. L. Batista, "Essential and non-essential elements in Brazilian infant food and other rice-based products frequently consumed by children and celiac population," *Journal of Food Composition and Analysis*, vol. 49, pp. 78–86, 2016.
- [39] M. Łabanowska, M. Kurdziel, M. Filek, S. Walas, A. Tobiasz, and A. Weselucha-Birczyńska, "The influence of the starch component on thermal radical generation in flours," *Carbohydrate Polymers*, vol. 101, no. 1, pp. 846–856, 2014.
- [40] R. E. Jordão, J. L. D. Bernaldi, and A. A. B. Filho, "Prevalence of iron-deficiency anemia in Brazil: a systematic review," *Revista de Pediatria*, vol. 27, pp. 90–98, 2009.
- [41] T. R. Marques, A. D. Corrêa, J. B. D. R. Lino, C. M. P. de Abreu, and A. A. Simão, "Chemical constituents and technological functional properties of acerola (*Malpighia emarginata DC.*) waste flour," *Food Science and Technology*, vol. 33, no. 3, pp. 526–531, 2013.
- [42] P. Villela, Â. G. Batista, and N. A. V. Dessimoni-Pinto, "Nutritional composition of *Annona crassiflora* pulp and acceptability of bakery products prepared with its flour," *Food Science and Technology*, vol. 33, no. 3, pp. 417–423, 2013.
- [43] L. D. L. D. O. Pineli, M. V. de Carvalho, L. A. de Aguiar et al., "Use of baru (Brazilian almond) waste from physical extraction of oil to produce flour and cookies," *LWT—Food Science and Technology*, vol. 60, no. 1, pp. 50–55, 2015.
- [44] H. Theobald, "Dietary calcium and health," *Nutrition Bulletin*, vol. 30, no. 3, pp. 237–277, 2005.
- [45] A. Mir-Marqués, M. L. Cervera, and M. de la Guardia, "A preliminary approach to mineral intake in the Spanish diet established from analysis of the composition of university canteen menus," *Journal of Food Composition and Analysis*, vol. 27, no. 2, pp. 160–168, 2012.
- [46] A.-S. Hager, A. Wolter, F. Jacob, E. Zannini, and E. K. Arendt, "Nutritional properties and ultra-structure of commercial gluten free flours from different botanical sources compared to wheat flours," *Journal of Cereal Science*, vol. 56, no. 2, pp. 239–247, 2012.
- [47] C. M. D. Santos, C. M. P. de Abreu, J. M. Freire, E. D. R. Queiroz, and M. M. Mendonça, "Chemical characterization of the flour of peel and seed from two papaya cultivars," *Food Science and Technology*, vol. 34, no. 2, pp. 353–357, 2014.
- [48] N. O'Shea, A. Ktenioudaki, T. P. Smyth et al., "Physicochemical assessment of two fruit by-products as functional ingredients: Apple and orange pomace," *Journal of Food Engineering*, vol. 153, pp. 89–95, 2015.
- [49] H. N. Ene-Obong, H. O. Okudu, and U. V. Asumugha, "Nutrient and phytochemical composition of two varieties of Monkey kola (*Cola parchycarpa* and *Cola lepidota*): an underutilised fruit," *Food Chemistry*, vol. 193, pp. 154–159, 2016.

- [50] L. H. Fasolin, G. C. De Almeida, P. S. Castanho, and E. R. Netto-Oliveira, "Cookies produced with banana meal: Chemical, physical and sensorial evaluation," *Ciência e Tecnologia de Alimentos*, vol. 27, no. 3, pp. 524–529, 2007.
- [51] K. d. Frota, M. A. Morgano, M. G. Silva, M. A. Araújo, and R. S. Moreira-Araújo, "Utilização da farinha de feijão-caupi (*Vigna unguiculata* L. Walp) na elaboração de produtos de panificação," *Ciência e Tecnologia de Alimentos*, vol. 30, pp. 16–22, 2009.
- [52] L. S. Fiorini, "Dossiê: Os minerais na alimentação," *Foods Ingredientes Brasil*, vol. 4, pp. 45–48, 2008.
- [53] U. C. Gupta and S. C. Gupta, "Sources and deficiency diseases of mineral nutrients in human health and nutrition: a review," *Pedosphere*, vol. 24, no. 1, pp. 13–38, 2014.
- [54] R. L. Tejera, G. Luis, D. González-Weller et al., "Metals in wheat flour; comparative study and safety control," *Nutrición Hospitalaria*, vol. 28, no. 2, pp. 506–513, 2013.
- [55] D. P. Leão, A. S. Franca, L. S. Oliveira, R. Bastos, and M. A. Coimbra, "Physicochemical characterization, antioxidant capacity, total phenolic and proanthocyanidin content of flours prepared from pequi (*Caryocar brasiliense* Camb.) fruit by-products," *Food Chemistry*, vol. 225, pp. 146–153, 2017.
- [56] S. D. S. Montes, L. M. Rodrigues, R. D. C. V. Cardoso, G. P. Camilloto, and R. S. Cruz, "Tapioca and rice flour cookies: technological, nutritional and sensory properties," *Ciência e Agrotecnologia*, vol. 39, no. 5, pp. 514–522, 2015.
- [57] A. R. Karnopp, A. M. Figueroa, P. R. Los et al., "Effects of whole-wheat flour and bordeaux grape pomace (*Vitis labrusca* L.) on the sensory, physicochemical and functional properties of cookies," *Food Science and Technology*, vol. 35, no. 4, pp. 750–756, 2015.



**Hindawi**

Submit your manuscripts at  
[www.hindawi.com](http://www.hindawi.com)

