



# Evaluation of the nutritional potential of peach palm flour and its application in crunchy snacks

Avaliação do potencial nutricional da farinha de pupunha e sua aplicação em salgadinhos crocantes

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The pupunheira (*Bactris gasipaes* Kunth) is a palm tree native to the Amazon rainforest, and its fruits have high nutritional quality and are highly appreciated by the population where the fruits occur. One of the ways of processing this raw material is the production of flour, which expands the possibilities of industrial application. Therefore, the objective of this study was to produce peach palm fruit flour, evaluate its physical-chemical, properties technological, antioxidant activity, and carotenoid content, elaborate snack-type biscuit formulations with different concentrations of peach palm flour in substitution for corn flakes, and evaluate the physical-chemical characteristics and carotenoid content of the biscuits. Peach palm flour had low moisture content (6.15%), protein (4.82%), and fiber (5.07%); however, it had a considerable carbohydrate content (77.62%), energy value (386,84 kcal), and carotenoids. The technological properties showed a high rate of water and oil absorption and emulsifying activity; however, it did not show foaming capacity or gel formation. The replacement of corn flakes by peach palm flour showed an increase in fiber, ash, lipids, and carotenoids and intensified the orange color of the cookies.

Palavras-chave: carotenoids, Amazonian fruits, snacks.

A pupunheira (*Bactris gasipaes* Kunth) é uma palmeira nativa da floresta amazônica, seus frutos são de alta qualidade nutricional e bastante apreciados pela população onde há ocorrência dos frutos. Uma das formas de beneficiamento desta matéria-prima é a produção de farinha, na qual amplia as possibilidades de aplicação industrial. Neste sentido, o objetivo desse estudo foi produzir uma farinha dos frutos de pupunha, e avaliar a sua composição físico-química, propriedades tecnológicas, atividade antioxidante, teor de carotenoides, e elaborar formulações de biscoitos tipo salgadinho com diferentes concentrações da farinha de pupunha em substituição ao floco de milho, bem como, avaliar as características físico-químicas e o teor carotenoides dos biscoitos. A farinha da pupunha apresentou baixos teores de umidade (6,15%), proteínas (4,82%) e fibras (5,07%), no entanto, apresentou um considerável teor de carboidratos (77,62%), valor energético (386,84 kcal) e carotenoides. Quanto às propriedades tecnológicas mostrou elevado índice de absorção de água e de óleo, e atividade emulsificante, entretanto não apresentou capacidade espumante nem formação de gel. A substituição do floco de milho pela farinha de pupunha mostrou aumento nos teores de fibras, cinzas, lipídios e carotenoides e intensificou a coloração alaranjada dos biscoitos.

Palavras-chave: carotenoides, frutos amazônicos, salgadinho.

## 1. INTRODUCTION

The peach palm (*Bactris gasipaes* Kunth) is a palm tree (Arecaceae) native to the Amazon biome that produces small elliptical fruits with different colors (green, yellow, orange, and red),

whose fruit pulp usually represents 72% of its weight, followed by seeds with 21% and 6% of the bark [1].

The fruits of peach palm have good nutritional and energetic quality, especially concerning pro-vitamin A, calcium, phosphorus, iron, B complex, carbohydrates and unsaturated fats [2], however, these fruits should not be consumed in nature due to the presence of calcium oxalate crystals, which irritate the mucous membrane of the mouth and inhibit the digestion of proteins, especially in children [3].

The presence of high levels of bioactive compounds with antioxidant properties, such as phenolic compounds and carotenoids, has been frequently investigated to expand knowledge about the beneficial potential of this fruit for human health, as well as stimulating the development of functional products contributing to the valorization of peach palm in the Amazonian scenario [1, 2, 5].

The fruits of peach palms are marketed in nature and adhered to the bunches, which makes their postharvest life period short, being commonly the waste of much of their production [6]. Therefore, it is important to apply conservation techniques to take better advantage of these fruits, such as dehydration. The dehydration or drying of food, in addition to preserving it for prolonged periods, concentrates substances, preserves their nutritional value, and facilitates transport and handling [7].

Thus, some studies show the potential for using peach palm fruits to produce flour [8, 9]. Due to its nutritional quality, some research highlights the feasibility of applying peach palm flour in the preparation of bakery products, such as cookies [4, 10, 11, 12, 13], cakes [2], extruded cereals [14] and also in the production of lager beers [15].

Given the above, the work aimed to produce and characterize peach palm flour as well as to analyze its incorporation in formulations of snack cookies.

## 2. MATERIALS AND METHODS

### 2.1 Materials

The fruits of peach palm in natura, were acquired in Medicilândia – PA (03°26'46" S, 52°53'20" W and 151 m altitude) Brazil in February 2022 and transported to the Food Technology Laboratory (LATECA), where the experiment was conducted.

### 2.2 Obtaining peach palm flour

The fruits were selected, sanitized with sodium hypochlorite at 100 ppm for 15 minutes, and rinsed in running water. The pulp and peel fractions of the fruits were used and then subjected to the cooking process for 30 minutes after the fruits were grated and dehydrated in an oven with air circulation at 65 °C (TECNAL, model Te-394/2) for approximately 48 hours (Figure 1).



Figure 1. Obtaining flour and peach palm: pulp and bark (A); cooking (B); drying (C); and flour (D).

After cooling, the dry fractions were crushed in a knife mill (Willey SL-31) to obtain flour with fine granulometry (0.42 mm). The flour elaborated was packed in zippered metalized bags, thus keeping it protected against the incidence of luminosity in the refrigerator (8 °C).

### 2.3 Physicochemical characterization

The proximal composition of peach palm flour followed the methods established by the Association of Official Analytical Chemists (AOAC, 2012) [34], for moisture content at 105 °C to constant weight (method 934.06), considering 6.25 proteins as nitrogen conversion (920.152), lipids with Soxhlet extractor (method 920.85) and ashes with the incineration of the material in muffle at 550 °C (method 940.26).

Total crude fiber was digested in a fiber determiner in H<sub>2</sub> SO<sub>4</sub> 1.25% w/v and NaOH 1.25% w/v (method 962.09). The content of available carbohydrates was calculated by the difference between one hundred and the sum of the contents of the proximal composition previously obtained. The energy value was determined from the relationship established by Atwater and Bryant (1900), where each gram of protein or carbohydrate releases 4 kcal of energy, while for each gram of lipid, this value is 9 kcal.

The total soluble solids content was determined using a portable refractometer (VXO-90, Vortex), and the result was expressed in °Brix. The pH was measured using a previously calibrated benchtop pH meter (Incoterm PHB 550). The total titratable acidity was determined by the 16/IV method of the Adolfo Lutz Institute (2008) [16]. The titration was performed with 0.01 M sodium hydroxide solution until pink staining, and the results are expressed in % of citric acid.

The instrumental color parameters were determined using a colorimeter (Konica Minolta, CR 410), and the results were expressed using the CIE LAB scale: L\*, A\*, b\*, chroma (C\*), and hue angle (° h). The extraction of carotenoids was performed according to Higby (1962) [17], and readings taken at 450 nm. The results were expressed in mg/100 g.

### 2.4 Characterization of the technological properties of peach palm flour

The water absorption index (IAW), oil absorption index (IAO), and water solubility (SA) were calculated according to the methodology proposed by Okezie and Bello (1988) [18] and according to the description of Equations (1), (2) and (3).

$$IAW = \frac{\text{Absorbed water}}{\text{Sample weigh (g)}} \quad (1)$$

$$IAO = \frac{\text{Absorbed oil}}{\text{Sample weigh (g)}} \quad (2)$$

$$SA = \frac{\text{Evaporation residue}}{\text{Sample weigh (g)}} \times 100 \quad (3)$$

The emulsifying activity and emulsion stability were determined using the methodology described by Yasumatsu et al. (1972) [19] and were calculated according to Equations (4) and (5).

$$\text{Emulsifying activity} = \frac{\text{Emulsified layer (ml)}}{\text{Total volume } \in \text{ the tube (ml)}} \quad (4)$$

$$\text{Emulsion stability} = \frac{\text{Remaining emulsified layer (ml)}}{\text{Emulsified layer } \in \text{ the tube (ml)}} \quad (5)$$

The sparkling capacity and gel formation capacity were determined by the methodology of Coffman and Garcia (1977) [20], and calculated by Equation (6).

$$\% \text{ Increase of Volume} = \frac{\text{Final volume} - \text{Initial volume}}{\text{Initial volume}} \times 100(6)$$

For the gel formation capacity, dispersions of different concentrations (2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, and 20%) were prepared in 20 ml of water and heated to 90 °C for 30 minutes. The dispersions were then cooled to room temperature and refrigerated at 4 °C for 2 hours. The tubes were inverted and analyzed for gel formation.

## 2.5 Determination of antioxidant capacity and phenolic compounds

Initially, preliminary tests were carried out with different solvents (80% methyl alcohol, 70% acetone, and 50% methanol + 70% acetone) to verify the best extracting solution. The extract was obtained by weighing 5 g of peach palm flour and adding 80 ml of 70% acetone, the sample was homogenized and kept away from light for two hours at room temperature (30 °C). The extract was then filtered and transferred to a volumetric balloon, stored in amber flasks, and frozen until the analyses, following the methodology of Rufino et al. (2007) [21].

The antioxidant capacity was determined using DPPH (2,2-diphenyl-1-picrylhydrazil), following the methodology of [21], and the results were expressed as the percentage of free radical scavenging (SRL%). The determination of total phenolic compounds was performed using the Folin-Ciocalteu reagent, according to the methodology described by Waterhouse (2002) [22]. The results were expressed in milligrams of gallic acid equivalent (EAG)/100 g of sample.

## 2.6 Formulations crunchy snacks

After preliminary tests, four formulations of crunchy snacks were elaborated with the addition of peach palm flour, one control, and the others with the substitution of corn flake and wheat flour, as shown in Table 1.

Table 1. Formulations of the biscuits with peach palm flour.

Makings	F1	F2	F3	F4
Cornflake	70.00 g	-	-	-
Wheat flour	68.50 g	68.50 g	34.25 g	-
Pupunha flour	-	70.00 g	104.25 g	138.50 g
Olive oil	10 ml	10 ml	10 ml	10 ml
Salt	4 g	4 g	4 g	4 g
Onion Powder	3.77 g	3.77 g	3.77 g	3.77 g
Garlic Powder	5.23 g	5.23 g	5.23 g	5.23 g
Cumin Powder	0.2 g	0.2 g	0.2 g	0.2 g
Clove Powder	0.1 g	0.1 g	0.1 g	0.1 g
Parsley	1.63 g	1.63 g	1.63 g	1.63 g
Water	100 ml	110 ml	135 ml	200 ml

F1 – Control; F2 – Total replacement of cornflake by peach palm flour; F3 – Total replacement of cornflake and partial replacement of wheat flour by peach palm flour; F4 – Total replacement of cornflake and wheat flour by peach palm flour.

After weighing the dry ingredients, the liquids were added to the mixture. Upon reaching a homogeneous and uniform consistency, the dough was shaped into triangular shapes with a thickness of 3 mm. The cookies were baked in an electric oven at 180 °C for 30 minutes.

## 2.7 Experimental design and statistical analysis

The results of the physicochemical and technological characterization and antioxidant activity of peach palm flour were obtained from the analysis of three replications, and the data were expressed as an average  $\pm$  standard deviation. The experiment of the development of biscuit formulations was conducted in a completely randomized design (DIC) containing three replications, and the data of the analysis of the physicochemical composition and total carotenoids were submitted to analysis of variance (ANOVA) and the comparison of means by Tukey's test at 5% significance in the statistical program SISVAR version 5.6.

## 3. RESULTS AND DISCUSSION

### 3.1 Physicochemical composition of peach palm flour

Table 2 describes the values found for the physicochemical composition and colorimetric parameters of peach palm flour. The moisture of the flour is linked to the quality and stability of the product during storage. The peach palm flour presented a moisture content of 6.15%, compliance with the RDC legislation N° 726 of 01 July the 2022, which recommends a moisture content of less than 12% for farinaceous [23].

Table 2. *Physicochemical composition of peach palm flour.*

Parameters	Peach palm flour
Moisture content (%)	6.15 $\pm$ 0.06
Ashes (%)	1.97 $\pm$ 0.56
Lipids (%)	6.34 $\pm$ 0.37
Crude fiber (%)	5.07 $\pm$ 0.28
Proteins (%)	4.82 $\pm$ 0.29
Carbohydrate <sup>1</sup> (%)	75.65 $\pm$ 0.43
VET (kcal)	378.94 $\pm$ 0.52
ph	6.31 $\pm$ 0.10
°Brix <sup>2</sup>	9.00 $\pm$ 0.35
Total acidity <sup>3</sup>	0.99 $\pm$ 0.01
L*	58.03 $\pm$ 1.88
a*	6.85 $\pm$ 0.72
b*	31.25 $\pm$ 6.41
Chroma	38.33 $\pm$ 3.51
Hue	79.10 $\pm$ 1.12

<sup>1</sup>Obtained by the difference of the other components; <sup>2</sup>Total soluble solids; <sup>3</sup>Citrus acid (%). Data are reported as the mean  $\pm$  standard deviation.

The ash content found in the present study was 1.97%, higher than that recorded by Prado et al. (2022) [9] (1.52%) and Souza et al. (2022) [8] (1.40%). Higher percentages of ash may indicate high mineral contents. In a study conducted with Amazonian fruits, Araujo et al. (2021) [24] showed that peach palm is an important source of manganese, potassium, and iron and a good source of zinc, since 100 g of pulp offers 36.6, 8.2, 4.0 and 4.0% of the recommended daily intake of these minerals, respectively.

Regarding the lipid content, it was observed that peach palm flour presented a lower fat content (6.34%) when compared to the contents reported by Prado et al. (2022) [9] when reported 13%, and Souza et al. (2022) [8], which found approximately 12.92%. It is worth mentioning that fruits with high lipid content are not interesting for flour production because they can oxidize food easily and quickly, making them a better choice of varieties with lower lipid percentages [25].

Fiber concentrations in peach palm flour can range from 1.70 to 11.10% due to the wide variety of peach palm genotypes and soil types [9, 26]. The average percentage for crude fiber was 5.07%, which is close to that found by Souza et al. (2022) [8], with an average of 5.19%.

According to the Normative Instruction N° 75/20, for a given food to be classic as a protein source, it must contain at least 5 g of the nutrient in 100 g of the food, which represents 10% of the recommended daily intake in 100 g of food [27]. Thus, peach palm flour reached 4.82% protein, lower than the minimum amount indicated by the legislation classified as a protein source. Other authors have also reported low percentages of proteins in peach palm flour [4, 8, 9].

Carbohydrates are important sources of energy and make up the structural part of cells. The amount of carbohydrates available was 75.65%, and this value corroborates the values reported by Pires et al. (2019) [4] and Santos et al. (2023) [26], which reported 75.02% and 86.35%, respectively.

The energy value of peach palm flour (378.94 kcal) was close to that of buriti bark flour (358.78 kcal) [28]. This high energy value comes from carbohydrates (75.65 g 100 g<sup>-1</sup>), which are responsible for 79.85 g 100 g<sup>-1</sup> of the calories present in flour, while the content of lipids and proteins together correspond to 20.14 g 100 g<sup>-1</sup>. Therefore, this result suggested the use of this flour as an ingredient in formulations for the energy enrichment of processed products.

The pH of peach palm flour presented a mean value of 6.37, while Prado et al. (2022) [9], obtained a lower mean value (3.99), and low levels of soluble solids were also observed with a mean of 9° Brix. The peach palm flour presented a low acidity of 0.99%, meeting the standard established by Brazilian legislation that recommends a maximum value of acidity of 2% in flours [29].

In addition, the colorimetric parameters of peach palm flour were also evaluated. The luminosity (L\*) was 58.03, the parameter (a\*) was 6.85, and the parameter (b\*) was 31.25. The chromaticity was 38.33, with the predominance of intensity in the orange region, certified by the value of the hue angle (79.10). The flour has a bright color with an orange tone, which was expected due to the coloration of the fruit.

A similar hue was reported by Prado et al. (2022) [9] in peach palm flour, with values of 67.4 (L\*), 8.6 (a\*), 71.2 (b\*), 71.7 (C\*), and 44.8 (h°), where it obtained a lighter flour with a yellowish color.

### 3.2 Technological properties and antioxidant activity

Table 3 shows the results for the technological properties of peach palm flour, antioxidant activity determined by the DPPH method, total phenolics, and carotenoids.

Table 3. *Technological properties, antioxidant activity and bioactive compounds of peach palm flour.*

Parameters	Peach palm flour
IAA (g 100 g <sup>-1</sup> )	3.33 ± 0.70
IAO (g 100 g <sup>-1</sup> )	3.33 ± 0.35
ISA (%)	14.78 ± 1.01
Emulsifying activity (%)	54.59 ± 2.71
Emulsion stability (%)	55.33 ± 2.56
Sparkling capacity (%)	–
Foam stability (%)	–
Gel formation (%)	–
Total phenolics (Mg EAG 100 g <sup>-1</sup> )	51.44 ± 2.87
Total carotenoids (µg 100 g <sup>-1</sup> )	2410.00 ± 0.06
DPPH (% SRL)	11.13 ± 1.95

Values expressed as the mean ± standard deviation.

Peach palm flour had the same water and oil absorption capacity of  $3.33 \text{ g } 100 \text{ g}^{-1}$ , as shown in Table 3. In a study with buriti peel flour, the authors found results close to these [28].

The water absorption index and the oil absorption index are important properties in the study of the use of flour as an ingredient in formulations of meat and bread products, as it allows the addition of water to facilitate the handling of the dough and avoid drying out during processing [30].

The ISA found was 14.78%, which is higher than those reported by Prado et al. (2022) [9] at 7.98% and Rigon et al. (2022) [31] at 4.48%, who also analyzed peach palm flour from other varieties. One of the characteristics that must be observed is the ISA parameter, through which the degree of cooking of the starch can be checked and the solubility conditions in an aqueous medium can be assessed.

Peach palm flour showed a high emulsifying activity of 54.59%, which makes it interesting for the food industry. Values close to this were found in commercial golden flaxseed (55.56%) and white bean (52.22%) flours [30].

For the emulsion stability parameter, peach palm flour presented 55.33%. The emulsifying properties are usually influenced by the amounts of soluble proteins in the flour and provide greater stability in the emulsion [30].

Peach palm flour did not present foam formation, which was also observed by Santana et al. (2017) [30] for oatmeal, golden and brown flaxseed, and grape flours. According to Porte et al. (2011) [32], flours that do not present this technological property are not intended for the preparation of foods that require this property, such as for use in the manufacture of ice creams and mousses.

The flour under study did not present the gel formation capacity in the tests performed, which may limit its usefulness in the manufacture of porridges and creams that depend on consistent and continuous gelation.

Phenolic compounds participate in the defense mechanisms of fruit against adverse biotic and abiotic factors. Rufino et al. (2010) [33] classified the phenolic content present in fruits into three categories: low ( $< 100 \text{ mg EAG } 100 \text{ g}^{-1}$ ), medium ( $100\text{--}500 \text{ mg EAG } 100 \text{ g}^{-1}$ ), and high ( $> 500 \text{ mg EAG } 100 \text{ g}^{-1}$ ). According to this classification, the content of phenolic compounds found in peach palm flour is in the low concentration range with an average value of  $51.44 \text{ mg EAG } 100 \text{ g}^{-1}$ . [5], evaluated the phenolic compounds in three Amazonian fruits, and for the peach fruit he found  $46.96 \text{ mg of EAG } 100 \text{ g}^{-1}$ , also falling into the low concentration range.

Chisté and his collaborators (2021) [1] traced the profile of phenolic compounds in peach palm fruits with different pulp colorations and quantified the stateside as the majority compound in the yellow (45%) and orange (32%) varieties, while vicenin-2 was detected in high relative concentration (21%) in orange pulp fruits, in contrast to the 6% found in yellow pulp fruits, both of which are compounds with known biological potential.

As for carotenoids, it was observed that peach palm flour has a high content of total carotenoids,  $2410.00 \text{ } \mu\text{g}/100\text{g}$ , when compared to the levels reported by Monteiro et al. (2022) [35], who reported that orange-colored flour contained more carotenoids than the yellow color, being  $105.39 \text{ } \mu\text{g}/\text{g}$  and  $13.89 \text{ } \mu\text{g}/\text{g}$  respectively. It is worth highlighting that the health benefits of carotenoids are attributed to their bioaccessibility and bioavailability [36].

The antioxidant activity by DPPH presents the values for the capture of free radicals, and the lower the value found, the greater the antioxidant activity of the sample [37]. Considering these factors, peach palm flour showed considerable antioxidant activity by the free radical capture method of 11.13 %SRL.

### 3.3 Physicochemical composition of crunchy snacks

The values of the physicochemical composition obtained for the biscuit samples with the addition of peach palm flour are shown in Table 4. The average moisture values obtained in the biscuit formulations ranged from 1.98% to 4.36%, and sample F1 differed significantly only from sample F2 (Table 4); however, all formulations had low moisture contents.

According to Maroli et al. (2022) [38], the reduction of moisture in bakery products is of great importance, as this parameter is related to product conservation, directly influencing its sensory characteristics, such as texture and crispness.

Concerning ash content, it was observed that sample F1 differed significantly and had lower values (2.79%), indicating that peach palm flour contributed to the increase in total minerals in the biscuit samples.

As reported by Santos et al. (2023) [26], peach palm flour contains minerals such as manganese (0.6 g/kg), potassium (9.5 g/kg), iron (165.1 mg/kg), and a good source of zinc (35.8 mg/kg), which may contribute to the nutritional quality of the final product.

Table 4. Physicochemical composition of the crunchy snacks with the addition of peach palm flour.

Parameters	F1	F2	F3	F4
<b>Moisture content (%)</b>	2.76 ± 1.11 <sup>b</sup>	4.36 ± 0.08 <sup>a</sup>	3.04 ± 0.19 <sup>ab</sup>	1.98 ± 0.06 <sup>b</sup>
<b>Ashes (%)</b>	2.79 ± 0.06 <sup>c</sup>	3.62 ± 0.01 <sup>b</sup>	3.96 ± 0.01 <sup>a</sup>	3.68 ± 0.01 <sup>b</sup>
<b>Lipids (%)</b>	5.17 ± 0.64 <sup>d</sup>	8.29 ± 0.23 <sup>c</sup>	10.01 ± 0.17 <sup>b</sup>	13.40 ± 0.07 <sup>a</sup>
<b>Crude fiber (%)</b>	0.61 ± 0.11 <sup>c</sup>	2.69 ± 0.07 <sup>b</sup>	4.18 ± 0.53 <sup>a</sup>	3.71 ± 0.41 <sup>a</sup>
<b>Protein (%)</b>	7.89 ± 0.32 <sup>a</sup>	7.49 ± 0.11 <sup>a</sup>	6.37 ± 0.02 <sup>b</sup>	4.22 ± 0.11 <sup>c</sup>
<b>Carbohydrate<sup>1</sup> (%)</b>	80.78 ± 1.25 <sup>a</sup>	73.55 ± 0.23 <sup>b</sup>	72.44 ± 0.84 <sup>b</sup>	73.01 ± 0.23 <sup>b</sup>
<b>VET (kcal)</b>	401.21 ± 4.90 <sup>b</sup>	398.77 ± 1.24 <sup>b</sup>	405.33 ± 4.44 <sup>b</sup>	429.52 ± 1.10 <sup>a</sup>
<b>Total carotenoids (µg/100 g)</b>	125 ± 3.00 <sup>d</sup>	520 ± 0.00 <sup>c</sup>	1315 ± 4.00 <sup>b</sup>	1562 ± 2.00 <sup>a</sup>
<b>L*</b>	74.90 ± 0.01 <sup>a</sup>	68.75 ± 0.01 <sup>c</sup>	68.96 ± 0.01 <sup>b</sup>	68.43 ± 0.01 <sup>d</sup>
<b>a*</b>	6.12 ± 0.01 <sup>d</sup>	11.50 ± 0.01 <sup>b</sup>	11.32 ± 0.01 <sup>c</sup>	12.62 ± 0.01 <sup>a</sup>
<b>b*</b>	24.94 ± 0.02 <sup>d</sup>	30.54 ± 0.01 <sup>c</sup>	31.33 ± 0.01 <sup>b</sup>	37.06 ± 0.01 <sup>a</sup>

<sup>1</sup>Obtained by the difference of the other components; F1 – Control; F2 – Total replacement of the cornflake by peach palm flour; F3 – Total replacement of the cornflake and partial replacement of wheat flour by peach palm flour; F4 – Total replacement of cornflake and wheat flour by peach palm flour. Equal letters in the same line do not differ from each other by Tukey's test at the level of 5% significance ( $p \leq 0.05$ ).

Regarding the lipid content of the formulated products, the levels increased significantly with the increase in the proportion of peach palm flour added. In this context, the literature highlights that peach palm flour has approximately 39.67% monounsaturated fatty acids and 6.59% polyunsaturated fatty acids, of which 5.18% linoleic acid and 1.17% linolenic acid fatty acids that have a beneficial effect on health [39].

Concerning crude fiber contents, sample F1 presented significantly lower values (0.61%), indicating that the addition of peach palm flour contributed to a significant increase in fiber contents. There was no significant difference between formulations F3 (4.18%) and F4 (3.71%). A similar result was reported by Santos et al. (2020) [19], who observed an increase of approximately 4.4 times in fiber content when compared to the control formulation.

Regarding the protein contents, it was observed that the addition of peach palm flour in total replacement to the corn flake preserving the initial concentration of wheat flour did not cause a significant change in its values; however, the partial replacement of wheat flour by peach palm flour or the addition of 100% peach palm flour significantly reduced the protein values of the biscuits.

Concerning carbohydrate contenting, it was observed that the control sample (F1) had a significantly higher value (80.78%), and there was no significant difference between the formulations with the addition of peach palm flour, with lower carbohydrate content in the snacks with the addition of Cabotiá pumpkin seed (70.63%), as analyzed by [38].

The addition of peach palm flour significantly increased the total carotenoid contents of the samples, with the addition of 100% peach palm flour replacing corn flakes and wheat flour

causing an increase of approximately 12 times in total carotenoid contents when compared with the control sample (F1) (Table 4).

Regarding the evaluation of staining, it was observed that all samples differed significantly for all variables ( $L^*$ ,  $a^*$ , and  $b^*$ ). For the values of  $L^*$ , it is possible to verify that the control sample presented significantly higher values (74.90), which is consistent with a lighter coloration of this formulation when compared to the formulations with the addition of peach palm. For the variables  $a^*$  (intensity of + red and –green) and  $b^*$  (intensity of + yellow and – blue), sample F4 with the addition of 100% peach palm flour presented the highest mean values, differing statistically from the other samples.



Figure 2. Snack biscuit formulations. F1 – Control; F2 – Total replacement of the corn flake by peach palm flour; F3 – Total replacement of corn flake and partial replacement of wheat flour by peach palm flour; F4 – Total replacement of cornflake and wheat flour by peach palm flour.

The color of the biscuit is an important parameter since it is the first eye contact that the consumer has with the product, and the incorporation of peach palm flour in the formulations attributed a tone to the cookies, leaving them more attractive dispensing with the addition of food dyes (Figure 2).

#### 4. CONCLUSION

Pupunha flour has high nutritional potential with an emphasis on its energy value and carotenoid contents. For the technological properties, it showed a high index of water and oil absorption and emulsifying activity; however, it did not present foaming capacity or gel formation.

The substitution of cornflake for peach palm flour in cookies showed an increase in fiber, ash, lipid, and carotenoid contents. It is also possible to completely replace wheat flour and cornflake with peach palm flour in the preparation of biscuits, increasing carotenoid contents and intensifying the orange coloration, avoiding the addition of dyes in the products.

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## 6. REFERENCES

1. Chisté RC, Costa ELN, Monteiro SF, Mercadante AZ. Carotenoid and phenolic compound profiles of cooked pulps of orange and yellow peach palm fruits (*Bactris gasipaes*) from the Brazilian Amazonia. *J Food Compos Anal.* 2021 Jun;99:103873. doi: 10.1016/j.jfca.2021.103873
2. Martínez-Girón J, Rodríguez-Rodríguez X, Pinzón-Zárate LX, Ordóñez-Santos LE. Caracterización fisicoquímica de harina de residuos del fruto de chontaduro (*Bactris gasipaes* Kunth, Arecaceae) obtenida por secado convectivo. *Corpoica Cienc y Tecnol Agropecu.* 2017;18(3):599-613. doi: 10.21930/rcta.vol18\_num3\_art:747
3. Matos KAN, Praia Lima D, Pereira Barbosa AP, Zerlotti Mercadante A, Campos Chisté R. Peels of tucumã (*Astrocaryum vulgare*) and peach palm (*Bactris gasipaes*) are by-products classified as very high carotenoid sources. *Food Chem.* 2019 Jan 30;272:216-21. doi: 10.1016/j.foodchem.2018.08.053
4. Pires MB, Amante ER, Lopes AS, Rodrigues AMC, da SILVA LHM. Peach palm flour (*Bactris gasipae* KUNTH): Potential application in the food industry. *Food Sci Technol.* 2019;39(3):613-9. doi: 10.1590/fst.34617
5. Miranda PHS, Morais RA, Sousa HMS, Gualberto LS, Freitas BCB, Asquieri ER, et al. Effects of pectinase treatment on the optimization and extraction of pigments from bacupari, tucumã, and peach palm using response surface methodology. *J Braz Chem Soc.* 2023;00(e-20230124):1-15. doi: 10.21577/0103-5053.20230124
6. Coelho TC, Ferreira MGR, Cutrim MBA, Bezerra DHS, Costa Neto A, Rocha CHS, et al. Estratégias e dificuldades encontradas na comercialização de hortifrutícolas em São Luís – MA. *Res Soc Dev.* 2021;10(5):e1310514632. doi: 10.33448/rsd-v10i5.14632
7. Martins HF, Carvalho SSRA, Bispo JAC, de Souza SMA, Martinez EA. Maracujá-amarelo (*Passiflora edulis* f. *Flavicarpa*): cinética da sevagem artificial e natural da casca. *Brazilian J Dev.* 2019;5 (11):23234-33. doi: 10.34117/bjdv5n11-043
8. de Souza PG, Pantoja L, dos Santos AS, Marinho HA, e Silva JBA. Avaliação físico-química da farinha de pupunha (*Bactris gasipaes* Kunth) para uso alimentício. *Braz J Sci.* 2022;1(2):65-74. doi: 10.14295/bjs.v1i2.37
9. de Prado JM, de Passos GR, dos Santos TB, da Silva CNS, Lemes AC, Batista KA, et al. Production and characterization of a carotenoid-rich peach palm flour. *J Eng Exact Sci.* 2022;8(8):14866-01i. doi: 10.18540/jcecvl8iss8pp14866-01i
10. Carvalho AV, de Oliveira MSP, Carvalho MN, Gomes ICL. Obtenção de produtos de panificação a partir da substituição parcial da farinha de trigo por farinha de pupunha. *Res Soc Dev.* 2023 Jun;12(6):e16112642167. doi: 10.33448/rsd-v12i6.42167
11. Menezes BAD, Pinto VC, Mattietto RDA, Lopes AS. Tecnologia para obtenção de biscoito adicionado de farinha de pupunha adicionado de farinha de pupunha. *Comun Técnico.* 2019;(307):1-8.
12. Ribeiro GS, Monteiro MKC, do Carmo JR, Pena RS, Chisté RC. Peach palm flour: production, hygroscopic behaviour and application in cookies. *Heliyon.* 2021 May;7(5):e07062. doi: 10.1016/j.heliyon.2021.e07062
13. Yves JSS, Silva ACA, de Carvalho RA, Colnago LA, Vanin MF. Rapid quantification of phenolic content and antioxidant activity in cookies produced with amazonian palm fruit flour using Micro-NIR spectrometer and PLS regression. *Microchem J.* 2023 Dec;195:109398. doi: 10.1016/j.microc.2023.109398
14. Santos IL, Schmiele M, Aguiar JPL, Steel CJ, Silva EP, Souza FCA. Evaluation of extruded corn breakfast cereal enriched with whole peach palm (*Bactris gasipaes*, Kunth) flour. *Food Sci Technol.* 2020;40(2):458-64. doi: 10.1590/fst.04019
15. de Souza PG, Pantoja L, dos Santos AS, Marinho HA, de Almeida e Silva JB. Avaliação físico-química de cervejas lagers com pupunha (*Bactris gasipaes*) em bioprocessos com leveduras livres e imobilizadas. *Conjecturas.* 2022 Jul;22(8):1159-72. doi: 10.53660/CONJ-1319-Y20
16. Instituto Adolfo Lutz (IAL). Métodos físicos-químicos para análise de Alimentos. São Paulo: Instituto Adolfo Lutz; 2008.
17. Higby WK. A simplified method for determination of some aspects of the carotenoid distribution in natural and carotene-fortified orange juice. *J Food Sci.* 1962 Jan;27(1):42-9. doi: 10.1111/j.1365-2621.1962.tb00055.x
18. Okezie B, Bello AB. Physicochemical and functional properties of winged bean flour and isolate compared with soy isolate. *J Food Sci.* 1988 Mar;53:450-4. doi: 10.1111/j.1365-2621.1988.tb07728.x
19. Yasumatsu K, Sawada K, Moritaka S, Misaki M, Toda J, Wada T, et al. Whipping and emulsifying properties of soybean products. *Agric Biol Chem.* 1972;36(5):719-27. doi: 10.1080/00021369.1972.10860321
20. Coffman CW, Garcia VV. Functional properties and amino acid content of a protein isolate from

- mung bean flour. *Int J Food Sci Technol.* 1977;12(october):473-84. doi: 10.1111/j.1365-2621.1977.tb00132.x
21. Rufino MSM, Alves RE, de Brito ES, de Moraes SM, Sampaio CG, Pérez-Jiménez J, et al. Determinação da atividade antioxidante total em frutas pela captura do radical livre DPPH. *Comunicado Técnico Online EMBRAPA.* 2007;127:1-4.
  22. Waterhouse AL. Determination of total phenolics. *Curr Protoc Food Anal Chem.* 2002;6(1):I1-1. doi: 10.1002/0471142913.fai0101s06
  23. Brasil. Ministério da Saúde, Agência Nacional de Vigilância Sanitária (ANVISA). Instrução Normativa - IN nº 726, de 1º de julho 2022. Dispõe sobre os requisitos sanitários dos cogumelos comestíveis, dos produtos de frutas e dos produtos de vegetais. Brasília (DF). *Diário Oficial da União;* 2022. Available from: <http://antigo.anvisa.gov.br/legislacao#/visualizar/487512>
  24. Araujo NMP, Arruda HS, Marques DRP, de Oliveira WQ, Pereira GA, Pastore GM. Functional and nutritional properties of selected Amazon fruits: A review. *Food Res Int.* 2021 Sep;147(February):110520. doi: 10.1016/j.foodres.2021.110520
  25. Barros SKA, de Souza ARM, Damiani C, Pereira AS, Alves DG, Clemente RC, et al. Obtenção e caracterização de farinhas de caroço de açaí (*Euterper oleracea*) e de casca de bacaba (*Oenocarpus bacaba*). *Res Soc Dev.* 2021;10(4):e2710413724. doi: 10.33448/rsd-v10i4.13724
  26. Santos YJS, Facchinatto WM, Rochetti AL, Carvalho RA, Le Feunteun S, Fukumasu H, et al. Systemic characterization of pupunha (*Bactris gasipaes*) flour with views of polyphenol content on cytotoxicity and protein in vitro digestion. *Food Chem.* 2023;405(PA):134888. doi: 10.1016/j.foodchem.2022.134888
  27. Brasil. Ministério da Saúde, Agência Nacional de Vigilância Sanitária (ANVISA). Instrução Normativa - IN nº 75, de 8 de Outubro de 2020. Estabelece os requisitos técnicos para declaração da rotulagem nutricional nos alimentos embalados. Brasília (DF). *Diário Oficial da União;* 2020. Available from: <https://www.in.gov.br/en/web/dou/-/instrucao-normativa-in-n-75-de-8-de-outubro-de-2020-282071143>
  28. Moraes RA, Sousa Melo KK, Oliveira TTB, Teles JS, Peluzio JM, Souza Martins GA. Caracterização Química, física e tecnologia da farinha obtida a partir da casca de Buriti (*Mauritia flexuosa* L. f.). *Brazilian J Dev.* 2019;5(11):23307-22. doi: 10.34117/bjdv5n11-050
  29. Brasil, Ministério da Agricultura Pecuária (MAPA). Instrução Normativa nº 52, de 7 de novembro de 2011. Estabelecer o Regulamento Técnico da Farinha de Mandioca na forma da presente Instrução Normativa e dos seus Anexos I, II e III. Brasília (DF). *Diário Oficial da União;* 2011. Available from: <http://track.flash.pt/go/bcd014c5eb5aa-385813f49a4110132a012523318e-281f682fae4e1Ctge3Piedye1s7Rd>
  30. Santana GS, de Oliveira Filho JG, Egea MB. Características tecnológicas de farinhas vegetais comerciais. *Rev Agric Neotrop.* 2017;4(2):88-95. doi: 10.32404/rean.v4i2.1549
  31. Rigon EES, Oliveira-Folador G, Sora GTS, Paula CL, Polesi LF. Physicochemical and functional composition of peach palm flour. *Open Sci Res.* 2022;1:111-9. doi: 10.37885/211207084
  32. Porte A, Silva EF, Almeida VDS, Silva TX, Porte LHM. Propriedades funcionais tecnológicas das farinhas de sementes de mamão (*Carica papaya*) e de abóbora (*Cucurbita* sp). *Rev Bras Prod Agroindustriais.* 2011 Mar 30;13:91-6. doi: 10.15871/1517-8595/rbpa.v13n1p91-96
  33. Rufino MSM, Alves RE, de Brito ES, Pérez-Jiménez J, Saura-Calixto F, Mancini-Filho J. Bioactive compounds and antioxidant capacities of 18 non-traditional tropical fruits from Brazil. *Food Chem.* 2010 Aug;121(4):996-1002. doi: 10.1016/J.FOODCHEM.2010.01.037
  34. AOAC. Official Method of Analysis: Association of Analytical Chemists. 19th ed. Washington (US): AOAC; 2012. p. 121-130.
  35. Monteiro SF, Costa ELN, Ferreira RSB, Chisté RC. Simultaneous extraction of carotenoids and phenolic compounds from pulps of orange and yellow peach palm fruits (*Bactris gasipaes*) by ultrasound-assisted extraction. *Food Sci Technol.* 2022;42:1-9. doi: 10.1590/fst.34021
  36. Soares SD, dos Santos OV, do Nascimento FDCA, Pena RS. A review of the nutritional properties of different varieties and byproducts of peach palm (*Bactris gasipaes*) and their potential as functional foods. *Int J Food Prop.* 2022;25(1):2146-64. doi: 10.1080/10942912.2022.2127761
  37. Nascimento MRF, de Souza VF, de Oliveira KCC, Ascheri JLRA, Marinho AFM. Capacidade antioxidante de farinha de caroço de seriguela (*Spondias purpurea* L.). In: *Nutrição em foco: Uma abordagem holística.* 3. ed. Piracanjuba (GO): C Livre; 2020. p. 554-71. doi: 10.37423/200601522
  38. Maroli AC, Vazzoler I, Miliorança J, Lara LP, Barden R, Miorelli S, et al. Utilização da semente da abóbora cabotiá na elaboração de snack salgado. *Reve-TECH Tecnol para Compet Ind.* 2022;15(3):1-14. doi: 10.18624/etech.v15i3.1210
  39. Santos OV, Soares SD, Dias PCS, Duarte SPA, dos Santos MPL, do Nascimento FCA. Chromatographic profile and bioactive compounds found in the composition of pupunha oil (*Bactris*

*gasipaes* Kunth): Implications for human health. *Rev Nutr.* 2020;33:1-12. doi: 10.1590/1678-9805202033E190146