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DESENVOLVIMENTO DE CUPCAKES SEM GLÚTEN ELABORADOS COM FARINHA DA CASCA DO UMBU

DEVELOPMENT OF GLUTEN-FREE CUPCAKE MADE WITH UMBU PEEL FLOUR

DESARROLLO DE CUPCAKES SIN GLUTEN HECHAS CON HARINA DE CÁSCARA DE UMBU

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Resumo

A obtenção de farinha a partir da casca de umbu representa uma alternativa sustentável, promovendo o aproveitamento integral do fruto e sua incorporação em produtos de panificação, especialmente voltados ao público com restrição ao glúten. Este estudo desenvolveu formulações de *cupcakes* sem glúten enriquecido com a farinha da casca de umbu. Foi obtida a farinha da casca de umbu e elaboradas formulações de *cupcakes* padrão (0%), Tipo I (10%), Tipo II (20%) e Tipo III

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(30%) com substituição parcial da farinha de arroz pela farinha de casca de umbu. Foram realizadas análises químicas, determinações de compostos bioativos e de atividade antioxidante e avaliação sensorial. Na farinha, destacaram-se os teores de vitamina C (39,99±0,89 mg.100g^{-1}), compostos fenólicos totais (116,20±0,65 mg EAG.100g^{-1}), flavonoides amarelos (62,22±0,11 mg.100g^{-1}) e atividade antioxidante (95,78±0,09%). O *cupcake* Tipo I foi o mais aceito entre os enriquecidos, com médias próximas à formulação padrão principalmente nos atributos sabor, aroma e textura, mantendo índice de aceitabilidade acima de 70%. Na formulação selecionada, destacaram-se os resultados de carotenoides totais (7,91±0,13 mg.100g^{-1}), vitamina C (9,09±0,52 mg.100g^{-1}), compostos fenólicos totais (4,34±0,09 mg EAG.100g^{-1}) e atividade antioxidante (34,58±2,55%). Conclui-se que a farinha da casca de umbu demonstra importante potencial como ingrediente funcional, agregando valor nutricional e sustentável a produtos de panificação isentos de glúten, conferindo maior teor de compostos bioativos e capacidade antioxidante.

Palavras-chave: Dieta Livre de Glúten; Compostos Bioativos; Resíduos Agroindustriais; Tecnologia de Alimentos.

Abstract

Obtaining flour from umbu peel represents a sustainable alternative, promoting the full use of the fruit and its incorporation into bakery products, especially those aimed at consumers with gluten restrictions. This study developed gluten-free cupcake formulations enriched with umbu peel flour. Umbu peel flour was obtained, and standard (0%), Type I (10%), Type II (20%), and Type III (30%) cupcake formulations were prepared with partial substitution of rice flour with umbu peel flour. Chemical analyses, determinations of bioactive compounds and antioxidant activity, and sensory evaluation were performed. In the flour, the levels of vitamin C (39.99±0.89 mg.100g^{-1}), total phenolic compounds (116.20±0.65 mg GAE.100g^{-1}), yellow flavonoids (62.22±0.11 mg.100g^{-1}) and antioxidant activity (95.78±0.09%) stood out. The Type I cupcake was the most accepted among the enriched ones, with averages close to the standard formulation, mainly in the attributes of flavor, aroma and texture, maintaining an acceptability index above 70%. In the selected formulation, the results for total carotenoids (7.91±0.13 mg.100g^{-1}), vitamin C (9.09±0.52 mg.100g^{-1}), total phenolic compounds (4.34±0.09 mg GAE.100g^{-1}) and antioxidant activity (34.58±2.55%) stood out. It is concluded that umbu peel flour demonstrates significant potential as a functional ingredient, adding nutritional and sustainable value to gluten-free bakery products, conferring a higher content of bioactive compounds and antioxidant capacity.

Keywords: Gluten-Free Diet; Bioactive Compounds; Agroindustrial Waste; Food Technology.

Resumen

La obtención de harina a partir de la cáscara de umbu representa una alternativa sostenible, promoviendo el aprovechamiento integral del fruto y su incorporación en productos de panadería, especialmente aquellos dirigidos a consumidores con restricciones de gluten. Este estudio desarrolló formulaciones de cupcakes sin gluten enriquecidas con harina de cáscara de umbu. Se obtuvo harina de cáscara de umbu y se prepararon formulaciones de cupcakes estándar (0%), Tipo I (10%), Tipo II (20%) y Tipo III (30%) con sustitución parcial de harina de arroz por harina de cáscara de umbu. Se realizaron análisis químicos, determinaciones de compuestos bioactivos y actividad antioxidante, y evaluación sensorial. En la harina, se destacaron los niveles de vitamina C (39,99±0,89 mg.100g^{-1}), compuestos fenólicos totales (116,20±0,65 mg GAE.100g^{-1}), flavonoides amarillos (62,22±0,11 mg.100g^{-1}) y actividad antioxidante (95,78±0,09%). El cupcake Tipo I fue el más aceptado entre los enriquecidos, con promedios cercanos a la formulación estándar, principalmente en los atributos de sabor, aroma y textura, manteniendo un índice de aceptabilidad superior al 70%. En la formulación seleccionada, sobresalieron los resultados de carotenoides

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totales (7,91 ± 0,13 mg.100g^{-1}), vitamina C (9,09 ± 0,52 mg.100g^{-1}), compuestos fenólicos totales (4,34 ± 0,09 mg GAE.100g^{-1}) y actividad antioxidante (34,58 ± 2,55%). Se concluye que la harina de cáscara de umbu demuestra un potencial significativo como ingrediente funcional, añadiendo valor nutricional y sostenible a los productos de panadería sin gluten, confiriéndoles un mayor contenido de compuestos bioactivos y capacidad antioxidante.

Palabras clave: Dieta sin gluten; Compuestos bioactivos; Residuos agroindustriales; Tecnología de alimentos.

1. Introduction

"Caatinga" is the only biome exclusively found in Brazil, covering approximately 912,529 km², which corresponds to 10% of the national territory, and is located predominantly in the Northeast (TABARELLI et al., 2018). In the state of Bahia, it encompasses much of the Northeast and Central regions, surrounding the Chapada Diamantina (QUEIROZ et al., 2005). Among Caatinga fruit species, the umbu tree stands out, notable for its drought resistance and for its fruits and roots rich in vitamin C and minerals (BARRETO; CASTRO, 2010; BASTOS et al., 2016). These fruits are widely marketed by family farmers, either fresh or as pulp, juices, sweets, "umbuzada" (traditional drink preparation), ice cream, and crystallized umbu (COSTA et al., 2015).

Agro-industrial processing of umbu generates residues such as seeds and peels, which are generally discarded. However, fruit residues may contain essential oils, proteins, enzymes, secondary metabolites, and lipids (ALVES et al., 2019), representing a loss of nutrients and bioactive compounds with potential application in higher value-added coproducts (ALVES et al., 2021). In addition, the utilization of agro-industrial residues contributes to reducing environmental impacts, diversifying their end uses, and generating income from low-cost products (PIMENTEL et al., 2011; BRANDÃO; MOREIRA, 2023).

Umbu peel contains minerals, vitamin C, carotenoids, chlorophyll, anthocyanins, flavonoids, and total phenolic compounds, which has stimulated interest in its use as an ingredient in new foods, especially in the form of flour (ALVES et al., 2021). In baking, wheat flour is the main ingredient; however, it contains gluten, a protein network composed of gliadin and glutenin, responsible

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for technological properties such as viscosity and elasticity. Nevertheless, individuals with allergies, intolerances, or sensitivity to gluten require substitutes (VIEIRA et al., 2015; MORAES; SILVA, 2023). The development of gluten-free products is a challenge for food technology, which seeks formulations with technological quality and nutritional value comparable to wheat-based products (AGUIAR et al., 2022). Rice, pea, amaranth, and soy flours, used alone or in combination, are commonly employed in this context (MORAES; SILVA, 2023).

Umbu peel flour emerges as a promising alternative for enriching baked goods, as it is gluten-free, low-cost, nutritionally rich, and obtained through the sustainable use of agro-industrial residues (ALVES et al., 2021). In this context, the present study developed formulations of gluten-free cupcakes enriched with umbu peel flour, aiming to meet the demands of restrictive diets and to explore the nutritional and functional potential of this ingredient.

2. Methodology

2.1 Study site and ethical aspects

The present study was conducted at the Multidisciplinary Health Institute (IMS), Anísio Teixeira Campus (CAT), Federal University of Bahia (UFBA), in the municipality of Vitória da Conquista, Bahia, Brazil. This research was approved by the Research Ethics Committee for Human Beings (IMS/CAT–UFBA), protocol number 81332324.2.0000.5556.

2.2 Acquisition of umbu fruits

Ripe umbu fruits (*Spondias tuberosa* Arr. Cam.) were obtained from COOPROAF (Production and Marketing Cooperative of Family Farming Products from Southwest Bahia) in the municipality of Manoel Vitorino, Bahia, Brazil.

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2.3 Sample preparation

After acquisition, the umbu fruits were taken to the Bromatology Laboratory, and only those with firm texture and free of defects or injuries were selected. They were then washed and sanitized by immersion in a sodium hypochlorite solution (200 ppm) for 10 minutes. Subsequently, the fruits were pulped, and both the pulp and peels were placed in dark plastic bags and stored in a freezer at −20 °C. Part of the peels was used for chemical analyses and for determining antioxidant content and activity, while the remaining portion was used to produce the flour.

2.4 Preparation of umbu peel flour

After thawing, the peels were uniformly arranged on stainless steel trays and subjected to drying in a forced-air circulation oven (Nova Instruments, model NI 1515iC) at 65◦C for an average period of 5 hours. Drying was carried out until a moisture content equal to or lower than 15% was achieved, which is considered adequate for material preservation through the reduction of water activity, according to the parameters established by RDC Resolution No. 711, dated July 1, 2022, which sets forth the sanitary requirements applicable to flours.

Subsequently, the dehydrated samples were ground in an industrial blender and then further processed using a mixer in order to promote greater particle size reduction and obtain a more homogeneous flour. No sieving step was performed, with the aim of fully preserving the constituents of the raw material. The resulting flour was packed in dark plastic bags and stored in hermetically sealed plastic containers at room temperature (Figure 1)

Figure 1: Flowchart for obtaining umbu peel flour.

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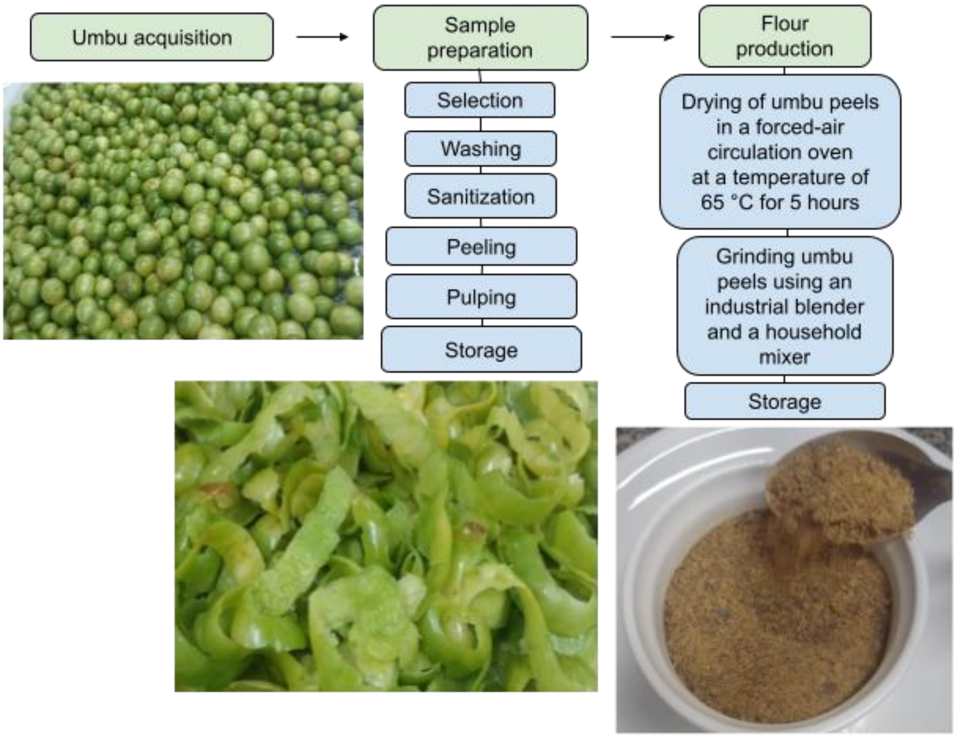

Source: Authors, 2026.

2.5 Development of gluten-free cupcake formulations with umbu peel flour

A standard formulation was adopted for the preparation of cupcakes, using rice flour as a complete substitute for wheat flour, in order to obtain a gluten-free product. From this base, the rice flour was partially replaced by umbu peel flour, in the following proportions: Standard (0%), Type I (10%), Type II (20%) and Type III (30%) (Table 1). The definition of these levels aimed to achieve functional enrichment while maintaining sensory acceptability.

Table 1. Gluten-free cupcake formulations with the incorporation of umbu peel flour - Standard (0%), Type 1 (10%), Type II (20%) and Type III (30%).

Ingredients	Standard	Type I	Type II	Type III

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	0%	**10%**	**20%**	**30%**
Rice flour (g)	70	63	56	49
Umbu peel flour (g)	0	7	14	21
Whole chicken egg (unit)	1	1	1	1
Crystal sugar (g)	65	65	65	65
Whole milk powder	13	13	13	13
Apple cider vinegar (g)	5	5	5	5
Soybean oil (g)	37	37	37	37
Baking powder (g)	5	5	5	5
Water (g)	65	65	65	65
Sea salt (g)	1	1	1	1

Source: Authors, 2026.

Preparation method

Powdered milk was reconstituted and coagulated with apple cider vinegar. Next, the oil was mixed with sugar using a hand mixer. Then, the egg, milk, flours, and salt were added, with 30 seconds of mixing after each addition. Finally, baking powder was incorporated, mixing only until the batter became homogeneous. The mixture was then portioned into cupcake molds and baked in a preheated oven at 165 °C for approximately 20 minutes.

2.6 Chemical analyses of umbu peel flour and cupcakes

Chemical analyses were performed in triplicate. Titratable acidity (TA) was determined by titration with 0.1 N sodium hydroxide (NaOH), with results expressed as g citric acid·100 g^{-1} for umbu peel flour and as g lactic acid·100 g^{-1} for cupcakes. Hydrogen potential (pH) was measured using a pH meter (Edge $^{®pH}$ HI2002 – Made in Romania) (IAL, 2008). Moisture content was determined by direct heating at 105 °C until constant weight; ash content (fixed mineral residue) corresponded to the

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residue obtained by incineration at 550 °C until light-colored ash was obtained (IAL, 2008). Total lipids were determined by cold extraction according to the method of Folch et al. (1957).

2.7 Determination of bioactive compounds in umbu peel flour and cupcakes

Bioactive compounds were determined in triplicate, and all analytical steps were protected from light. Total phenolic compounds (TPC) were determined according to the ISO method (2005), using 10% Folin–Ciocalteu reagent and 7.5% sodium carbonate solution, and compared against a gallic acid standard curve. Absorbance was read in a molecular absorption spectrophotometer (Analyser) at 765 nm (ISO, 2005). Yellow flavonoid content followed the method of Francis (1982), using an extracting solution (ethanol, analytical grade: 1.5 M HCl—85:15) and spectrophotometric reading at 374 nm. Total anthocyanins were determined according to Lees and Francis (1972), using the same extracting solution (ethanol, analytical grade: 1.5 M HCl—85:15) and measuring absorbance at 535 nm. Total carotenoids were determined by extraction with acetone and partitioning into hexane, with spectrophotometric reading at 450 nm (RODRIGUEZ-AMAYA; KIMURA, 2004). Total chlorophyll was determined according to Bruinsma (1963), with extraction in 80% acetone and spectrophotometric reading at 652 nm. Ascorbic acid was determined according to the methodology described by Strohecker and Henning (1967), using a DFI solution (2,6-dichlorophenolindophenol, 0.002%), and results were calculated using equation 1:

$$\text{Ascorbic acid (mg.100 g}^{-1}) = A \times B \times 100 / 1000 \times C$$

Where A corresponds to DFI volume consumed, B is the DFT titer, and C is the sample weight.

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2.8 Determination of antioxidant activity of umbu peel flour and cupcakes

Antioxidant capacity was determined in triplicate using the DPPH method (2,2-diphenyl-1-picrylhydrazyl). Hydroethanolic extracts of the fruits were evaluated by the DPPH assay using a negative control (methanol) and a positive control consisting of a butylated hydroxytoluene (BHT) solution at 0.10 $mg \cdot mL^{-1}$, with absorbance read in a molecular absorption spectrophotometer at 515 nm (BRAND WILLIAMS et al., 1995; RUFINO et al., 2007).

2.9 Microbiological analyses

Microbiological analyses were performed for umbu peel flour and for the cupcakes subjected to sensory analysis. For the flour, microbiological standards were assessed for Salmonella/25 g by the method (ISO, 2020), presumptive Bacillus cereus/g by the plate count method (ISO, 2004), and Escherichia coli/g by the plate count method (ISO, 2001). For cupcakes, the following microbiological analyses were performed: presumptive Bacillus cereus/g; Salmonella/25 g; Escherichia coli/g; and molds and yeasts (ISO, 2008a; ISO, 2008b). The results obtained were compared with Normative Instruction No. 161, of July 1, 2022, of the Brazilian Ministry of Health—National Health Surveillance Agency (ANVISA), which establishes microbiological standards for foods.

2.10 Sensory analysis

Sensory analysis of the cupcakes, including the control formulation and those containing 10%, 20%, and 30% umbu peel flour, was conducted with 100 untrained panelists, aged 18 years or older, of both sexes, volunteers from the academic community of the Multidisciplinary Health Institute, Anísio Teixeira Campus, Federal University of Bahia, Vitória da Conquista, Bahia, Brazil, who signed an Informed Consent Form (ICF). Individuals with intolerance or allergy to any ingredient in the formulation were excluded.

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The samples were presented in a randomized and balanced manner among the assessors in a sensory analysis laboratory in order to minimize possible order effects and interference with sensory perception. Each participant received a portion corresponding to ¼ of a cupcake, served at room temperature, and the analyses were conducted within 24 hours after product preparation. Between sample evaluations, the panelists cleansed their palates with water in order to reduce residual influence among the formulations evaluated.

The acceptance test used a 9-point hedonic scale, ranging from “liked extremely” to “disliked extremely,” to evaluate aroma, texture, flavor, appearance, and overall acceptance. Purchase intention was measured using a 5-point scale, from “definitely would buy” to “definitely would not buy.” Samples were coded with three-digit numbers, and water was provided to cleanse the palate between tastings (MAIA et al., 2015). The acceptability index (AI) was calculated according to equation 2:

$$AI\ (\%) = \frac{(A\ x\ 100)}{B}$$

Where A corresponds to the mean score obtained for the product and B to the maximum possible score (DUTCOSKY, 2013).

2.11 Data analysis

The data obtained in the present study, with the exception of the sensory analysis, were generated from a homogeneous sample pool, and each experimental condition was analyzed in technical triplicate. The results were expressed as mean ± standard deviation. Comparisons between the formulations and the control formulation were performed using the unpaired Student’s t-test with Bonferroni correction for multiple comparisons. The significance level was adjusted considering four comparisons, corresponding to the four formulations with different flour concentrations relative to the control cupcake, resulting in an adjusted α of 0.0125 (4/0.05). The analyses were carried out using GraphPad InStat 3.0 software. Since

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the replicates corresponded to technical repetitions rather than independent biological replicates, the statistical results should be interpreted with caution and were used for exploratory and comparative purposes among the evaluated conditions.

For the sensory analysis data, one-way analysis of variance (one-way ANOVA) was applied, followed by Tukey's test, adopting a significance level of $p \leq 0.05$, using SAS® OnDemand for Academics software.

3. Results and discussion

3.1 Chemical characterization, bioactive compound content and antioxidant activity of umbu peel flour

Table 2 shows the data regarding the chemical characterization, bioactive compound content and antioxidant activity of umbu peel flour.

Table 2 - Chemical characterization, content of bioactive compounds and antioxidant activity of umbu peel flour (mean ± standard deviation).

Parameters	**Umbu peel flour**
pH	2,33 ± 0,03
Total titratable acidity (g citric acid.100 g^{-1})	11,25 ± 0,01
Moisture (g.100 g^{-1})	14,08 ± 0,27
Ash (g.100 g^{-1})	3,26 ± 0,11
Total lipids (g.100 g^{-1})	0,66 ± 0,12
Total carotenoids (mg.100 g^{-1})	2,61 ± 0,01
Total chlorophyll (mg.100 g^{-1})	6,64 ± 0,08

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Vitamin C (mg.100 g^{-1})	39,99 ± 0,89
Total phenolic compounds (mg GAE.100 g^{-1})	116,20 ± 0,65
Yellow flavonoids (mg.100 g^{-1})	62,22 ± 0,11
Total anthocyanins (mg.100 g^{-1})	1,72 ± 0,02
Antioxidant activity (%)	95,78 ± 0,09

*GAE - Gallic Acid Equivalent. Source: Authors, 2026.

pH of umbu peel flour was similar to that reported by Alves et al. (2021) for the same type of flour (2.96), whereas titratable acidity was higher than that observed by those authors (7.97 g citric acid·100 g^{-1}), reflecting a greater concentration of organic acids in the peel. This acidity, mainly attributed to organic acids present in plant-cell vacuoles, is related to food preservation, as it may favor or inhibit the growth of spoilage or pathogenic microorganisms (CHITARRA & CHITARRA, 1990; MAFE et al., 2024).

Moisture content was higher than that found by Alves et al. (2021) in umbu peel flour (9.16 g·100 g^{-1}) and similar to that obtained by Xavier et al. (2025) in cajarana peel flour (14.75 g·100 g^{-1}), remaining, however, within the maximum limit of 15% (g·100 g^{-1}) established by Resolution RDC No. 711 of July 1, 2022. Ash content was similar to that reported by Alves et al. (2021) for umbu peel flour (3.76 g·100 g^{-1}) and higher than that found in cajarana peel flour (2.55 g·100 g^{-1}) (XAVIER et al., 2025). This parameter reflects mineral concentration—micronutrients that are important for human health and are often more concentrated in fruit peels than in the pulp (MOREIRA et al., 2021; MARQUES et al., 2010).

Regarding total lipid content, the value observed in the present study was lower than that reported by Bramont et al. (2018) for seriguela peel flour (1.25 g·100 g^{-1}) and similar to that reported by Xavier et al. (2025) for cajarana peel flour (0.53 g·100 g^{-1}). The low lipid content gives the flour a lower caloric value, since fruit peel

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tissues generally do not serve as major energy reserves (MORAIS et al., 2017; LESMANA et al., 2021).

As for bioactive compounds, umbu peel flour stood out for its levels of total phenolic compounds, yellow flavonoids, and vitamin C.

Phenolic compounds are associated with antioxidant activity and with important biological effects such as antimicrobial, anti-inflammatory, antitumor actions, and cardiovascular protection (YILMAZ et al., 2011; GONZÁLEZ-CENTENO et al., 2012; SARAIVA et al., 2018). In the present study, the level of these compounds was similar to that found by Oliveira et al. (2021) in banana peel flour (124.48 mg GAE·100 g^{-1}) and lower than that reported by Bramont et al. (2018) in jackfruit peel flour (191.10 mg GAE·100 g^{-1}).

Yellow flavonoids are natural pigments associated with protection against cardiovascular and neurodegenerative diseases, diabetes, and cancer (LIMA et al., 2000; GOMES et al., 2022). The content obtained for umbu flour exceeded the values observed for jatobá-do-cerrado peel flour (0.21 mg·100 g^{-1}) (FILHO et al., 2019), although it was lower than that found for lychee peel flour (82.16 mg·100 g^{-1}) (QUEIROZ et al., 2015).

Another polyphenol evaluated in the flour was anthocyanins, which exhibit antioxidant and anti-inflammatory activity and contribute to the functional properties of foods (KUPPUSAMY et al., 2018; NAKRA et al., 2025). Total anthocyanin content was higher than that of jatobá-do-cerrado flour (0.03 mg·100 g^{-1}) (FILHO et al., 2019) and lower than that of seriguela peel flour (1.87 mg EQ/100 g) (BRAMONT et al., 2018).

Vitamin C, a bioactive compound that exerts antioxidant functions and participates in collagen and hormone synthesis, iron absorption, and the prevention of cardiovascular disease, cataracts, and cancer (FREIRE et al., 2013; ANTUNES et al., 2017), was similar (44.43 mg·100 g^{-1}) to that in buriti peel flour (34.9 mg·100 g^{-1}) (MORAIS et al., 2019) and higher than that in guavira flour (26.43 mg·100 g^{-1})

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(SALGADO et al., 2022). The vitamin C content in the flour corresponds to 44.43% of the recommended daily intake for men and 53.32% for women (IDR, 2023).

Bioactive pigments such as total chlorophyll (5.14 mg·100 g^{-1}) and total carotenoids (2.73 mg·100 g^{-1}) showed values similar to those reported by Alves et al. (2021) and Morais et al. (2019), exceeding those found in kiwi and buriti flours (ALMEIDA et al., 2020; MORAIS et al., 2019). These compounds have antioxidant and antimutagenic properties and contribute to the prevention of cardiovascular diseases; in the case of carotenoids, they also play an important role in combating vitamin A deficiency (VOLP et al., 2011; LILA et al., 2004; NOGUEIRA et al., 2019).

The antioxidant activity of umbu peel flour was also noteworthy, being higher than that reported by De Oliveira et al. (2024) for umbu-cajá by-products (72.01%) and that observed by Sousa et al. (2024) for buriti flour (80.47%). This performance may be attributed to the presence of bioactive compounds such as phenolics, flavonoids, and ascorbic acid, which are recognized for their ability to neutralize reactive oxygen species. Thus, the consumption of foods with high antioxidant activity may contribute significantly to the promotion of human health (DE LIMA et al., 2019).

The prominence of umbu peel flour in terms of total phenolic compounds, yellow flavonoids, vitamin C, and antioxidant activity highlights its high concentration of phytochemicals and functional potential. The study also demonstrated the feasibility of reusing this Caatinga by-product to produce flour for application in cupcakes.

3.2 Microbiological analyses of umbu peel flour and cupcake formulations

Table 3 shows the data relating to microbiological analyses of umbu peel flour, standard cupcake formulations and those with added umbu peel flour.

Table 3. Results of the microbiological quality of umbu peel flour and cupcakes Standard (0%), Type **I** (10%), Type **II** (20%) and Type **III** (30%).

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Microrganisms	**Umbu peel flour**	**Standard *Cupcake***	***Cupcake* Type I**	***Cupcake* Type II**	***Cupcake* Type III**
Salmonella spp. (absent in 25 g)	absent	absent	absent	absent	Absent
Bacillus cereus (CFU/g)	<10^2	<10^2	<10^2	<10^2	<10^2
Thermotolerant coliforms (MPN/g)	<10	<10	<10	1,1 x 10	<10
Escherichia coli (CFU/g)	<10	<10	<10	<10	<10
Molds and yeasts	NA*	<10^4	<10^4	<10^4	<10^4

*NA: Not applicable. Source: Authors, 2026.

The results show that the products comply with established microbiological standards, as they are below the limits established by current legislation (Normative Instruction No. 161, of July 1, 2022), demonstrating the hygienic-sanitary quality of the samples analyzed.

3.3 Sensory analysis of standard cupcake formulations and those with umbu peel flour

The incorporation of umbu peel flour in gluten-free cupcake formulations allows for the functional enrichment of the product. Therefore, these formulations were subjected to sensory evaluation. Figure 2 shows the Standard (0%), Type I (10%), Type II (20%) and Type III (30%) cupcakes, while Table 4 shows the results of the acceptance test of the different formulations.

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Figure 2: Photos of Standard (0%), Type I (10%), Type II (20%) and Type III (30%) cupcakes, from left to right (whole and sliced in half).

Source: Authors, 2026.

Table 4. Sensory analysis and acceptance index (AI) of cupcakes made with umbu peel flour: Standard (0%), Type I (10%), Type II (20%) and Type III (30%).

	Average scores* of cupcake formulations			
PARAMETERS	**STANDARD**	**TYPE I**	**TYPE II**	**TYPE III**
Overall acceptance	7,80 ± 1,21[a]	7,41±1,39[ab]	7,16 ±1,58[bc]	6,74±1,98[c]
AI%	86,66%	82,33%	79,55%	74,88%
Appearance	8,28±0,95[a]	7,65±1,18[b]	7,20±1,66[c]	6,92±1,81[c]
AI%	92,00%	85,00%	80,00%	76,88%
Aroma	7,48±1,51[a]	7,11±1,53[ab]	7,01±1,56[b]	6,69±1,79[b]
AI%	83,11%	79,00%	77,88%	74,33%
Flavour	7,53±1,42[a]	7,45±1,34[a]	7,02±1,76[ab]	6,79±1,98[b]
AI%	83,66%	82,77%	78,00%	75,44%

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Texture	7,76±1,35^{a}	7,44±1,43^{ab}	7,23±1,67^{b}	7,07±1,86^{b}
AI%	86,22%	82,66%	80,33%	78,55%
Purchase intention	3,94±1,00^{a}	3,71±0,95^{ab}	3,52±1,10^{b}	3,36±1,19^{b}

*Mean ± Standard Deviation. Means followed by different letters in each row differ significantly from each other (p≤0.05). Source: Authors, 2026.

All formulations showed mean scores above 5 for all sensory attributes evaluated, indicating good acceptability among the panelists (Paesani et al., 2021). Among the samples containing umbu peel flour, the Type I formulation stood out significantly by presenting the best overall sensory performance, being the one that least compromised the sensory characteristics of the product. The Type I cupcake obtained the highest mean scores for aroma, flavor, texture, overall appearance, and purchase intention when compared with the Type II and Type III formulations, demonstrating a better balance between functional enrichment and sensory quality. In addition, it showed statistically similar results to the control for practically all attributes evaluated, differing significantly only in appearance ($p \leq 0.05$). These results reinforce that the Type I formulation represented the most promising alternative among the versions containing umbu peel flour, as it combined better consumer acceptance with a more favorable technological potential for application in bakery products.

For overall acceptance, Type I did not differ from the control, whereas Type II showed values similar to Type I ($p > 0.05$), and Type III had the lowest mean score, differing from the others ($p \leq 0.05$), except from Type II. For appearance, the control scored higher, followed by Type I ($p \leq 0.05$), while Types II and III had the lowest mean scores, with no difference between them ($p > 0.05$), indicating a progressive decrease in acceptance as more flour was added. For aroma, Type I did not differ from the control ($p > 0.05$), and Types II and III, although presenting lower mean scores, showed no significant differences compared with Type I. Regarding flavor, the control, Type I, and Type II did not differ ($p > 0.05$), whereas Type III had the lowest mean score, with no difference relative to Type II. Similar results were

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observed for texture: Type I did not differ from the control ($p > 0.05$), and Types II and III, despite lower mean scores, did not differ from Type I.

For purchase intention, Type I did not differ from the control ($p > 0.05$), while Types II and III had lower mean scores, but without a significant difference relative to Type I.

It can be observed that the inclusion of umbu peel flour in the formulations leads to a progressive reduction in acceptability, especially regarding appearance and overall acceptance. This effect is possibly due to the interaction between the chemical parameters and the food matrix, since the presence of phenolic compounds may confer astringency and alter the aroma, while pigments may affect color, resulting in a darker appearance and negatively influencing visual acceptance. The high acidity of the flour indicates the presence of organic acids, which may impact flavor, together with the low pH, which contributes to a more acidic taste (Oliveira et al., 2014; Hosseininejad et al., 2022; Di Salvo et al., 2023).

The acceptability index (AI) corroborated these findings, with values above 70% for all attributes, a level considered satisfactory for the acceptance of food products (Dutcosky, 2013).

3.4 Chemical characterization, bioactive compound content, and antioxidant capacity of the Control and Type I cupcakes

Table 5 presents data on chemical characterization, bioactive compound content, and antioxidant activity of the Control and Type I cupcakes. All parameters differed from each other ($p \leq 0.05$), except for ash content, which showed no statistically significant difference ($p > 0.05$).

Table 5 - Chemical characterization, content of bioactive compounds and antioxidant activity of Standard and Type I cupcakes (mean ± standard deviation).

Parameters	Standard	Type I

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	Cupcake	***Cupcake***
pH	7,59 ±0,12[a]	6,25 ± 0,01[b]
Total titratable acidity (g lactic acid.100 g $^{-1}$)	0,13 ± 0,03[a]	0,34 ± 0,009[b]
Moisture (g.100g^{-1})	22,10 ± 1,04[a]	30,17 ± 0,43[b]
Ashes (g.100g^{-1})	1,40 ± 0,05[a]	1,52 ± 0,10[a]
Total lipids (g.100g^{-1})	15,45 ± 1,29[a]	12,52 ± 0,60[a]
Total carotenoids (mg.100g^{-1})	3,50 ± 0,12[a]	7,91 ± 0,13[b]
Total chlorophyll (mg.100g^{-1})	0,25 ± 0,02[a]	0,53 ± 0,03[b]
Vitamin C (mg.100g^{-1})	4,56 ± 0,27[a]	9,09 ± 0,52[b]
Total phenolic compounds (mg GAE.100g^{-1})	0,86 ± 0,04[a]	4,34 ± 0,09[b]
Yellow flavonoids (mg.100 g^{-1})	0,48 ± 0,02[a]	1,68 ± 0,00[b]
Total anthocyanins (mg.100g^{-1})	0,06 ± 0,01[a]	0,43 ± 0,00[b]
Antioxidant activity (%)	8,44 ± 1,25[a]	34,58 ± 2,55[b]

GAE - Gallic Acid Equivalent. Source: Authors, 2026.

The control cupcake showed a significantly higher pH ($p \leq 0.05$) than Type I, whereas total titratable acidity was higher ($p \leq 0.05$) in Type I, possibly due to the addition of umbu peel flour, which is characterized by low pH. Similar results were observed by Santos et al. (2018) in breads enriched with papaya by-product flour, which showed increased acidity and decreased pH in enriched products compared with the control.

Moisture content was significantly higher ($p \leq 0.05$) in the Type I cupcake, possibly due to the increase in total dietary fiber, which promotes water retention during baking; Although the dietary fiber content was not measured in the present study, this hypothesis is based on previous studies, such as Galeno and Rezende (2013), who carried out a physicochemical evaluation of cakes produced with

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different levels of passion fruit peel flour and observed this relationship. Andrade et al. (2015) reported a similar effect in cakes supplemented with taro residue flour, with moisture increasing from 23.22 g·100 g^{-1} in the control to 27.17 g·100 g^{-1} in the enriched formulation. Ash content did not differ significantly ($p > 0.05$) between the cupcake samples, as also observed by Silva et al. (2018) in cupcakes supplemented with umbu-cajá residue flour (control: 1.28 g·100 g^{-1}; enriched: 2.11 g·100 g^{-1}).

Regarding total lipid content, there was no statistically significant difference ($p>0.05$) compared with the control cupcake. Similar results were reported by Hryhorenko et al. (2023), who found no significant difference in lipid content in gluten-free bread enriched with 10% whole red sorghum flour (1.58 g·100 g^{-1}) compared with the control (1.50 g·100 g^{-1}).

As for phytochemicals, the Type I cupcake showed higher concentrations of total carotenoids and chlorophyll ($p \leq 0.05$) than the control, which may be attributed to the addition of 10% umbu peel flour. Similar results were reported by Machado et al. (2024), who observed higher carotenoid levels in breads enriched with coquinho-azedo by-product flour (6.06 µg/g versus 4.48 µg/g in the control). Although chlorophyll quantification in baked goods is uncommon, Inácio et al. (2025) associated the greenish color of breads enriched with ora-pro-nóbis flour with the presence of this pigment.

Vitamin C content was also significantly higher ($p \leq 0.05$) in the Type I cupcake, reflecting the high content of this compound in umbu peel, as reported by Alves et al. (2021), who found 20.05 mg·100 g^{-1} in fresh peel. Likewise, total phenolic compounds, yellow flavonoids, and total anthocyanins were higher ($p \leq 0.05$) in the Type I cupcake. Since these belong to the class of phenolic compounds, the simultaneous increase in these compounds is consistent with the composition of the raw material used. Souza et al. (2022) observed a similar effect in muffins enriched with olive pomace flour, with 88.76 mg·100 g^{-1} in the enriched product and 50.93 mg·100 g^{-1} in the control product.

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Antioxidant activity was significantly higher ($p \leq 0.05$) in the Type I cupcake, probably due to the addition of umbu peel flour, which contributed phytochemicals, especially phenolic compounds and vitamin C, responsible for increasing this activity (Seraglio et al., 2018).

The cupcake enriched with umbu peel flour presented higher levels of bioactive compounds and greater antioxidant activity, indicating its functional potential and possible health benefits, including protection against noncommunicable chronic diseases, which may contribute to protection against chronic non-communicable diseases. The results indicate functional potential, but do not allow direct physiological effects to be claimed, due to the limitations of in vitro antioxidant methods. In addition, it meets the needs of individuals who must restrict gluten intake, providing an inclusive product with satisfactory technological characteristics and higher bioactive potential.

Avoiding waste of native Caatinga fruits, which is common in rural communities, is essential to preserve natural resources and expand local income generation (CAMACAM; MESSIAS, 2022). In this context, technologies that promote full utilization of these fruits add value and contribute to sustainability. Products such as gluten-free cupcakes enriched with umbu peel flour meet gluten-free dietary needs, offering functional potential, similarly to what has been observed in gluten-free baked goods made with ora-pro-nóbis flour (BENETOLE et al., 2020) and in cookies enriched with baru flour (VIEIRA et al., 2020). Moreover, it is important to emphasize that, in the present study, all gluten-free cupcake formulations enriched with umbu flour achieved good acceptance, with scores above 5 and acceptability indices above 70%.

4. Conclusion

Umbu peel flour showed high functional potential, evidenced by its expressive concentrations of vitamin C, total phenolic compounds, yellow flavonoids, and high antioxidant activity, highlighting it as a promising ingredient for the development of foods with added nutritional and functional value.

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The gluten-free cupcakes prepared with this flour were shown to be potentially suitable for gluten-restricted diets, provided that they are produced under strict cross-contamination control. In addition, they exhibited an improved functional profile and good sensory acceptance. Among the formulations evaluated, Type I cupcake stood out as the most promising, combining the best sensory performance, with the highest mean scores for flavor, aroma, texture, overall acceptance, and purchase intention, together with a chemical profile superior to that of the control, characterized by higher levels of vitamin C, total phenolic compounds, yellow flavonoids, and antioxidant activity.

Despite the favorable results, this study has the limitation of lacking more comprehensive instrumental technological analyses, which reinforces the need for future investigations involving parameters such as specific volume, mass loss during baking, instrumental color, instrumental texture, firmness, water activity, storage stability, and residual gluten determination.

Thus, the use of umbu peel, a by-product often discarded by the agro-industrial chain, represents an innovative and sustainable strategy for the full valorization of the raw material, contributing to waste reduction, added economic value, strengthening of the regional bioeconomy, and promotion of the technological use of native Caatinga fruits.

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References

AGUIAR, E. V. *et al*. An integrated instrumental and sensory techniques for assessing liking, softness and emotional related of gluten-free bread based on blended rice and bean flour. **Food Research International**, [S. l.], v. 154, art. 110999, 2022. DOI: https://doi.org/10.1016/j.foodres.2022.110999.

REMUNOM
ISSN 2178-6925

Received: 13/03/2026 - **Accepted:** 16/05/2026
Vol: 13.10
DOI: 10.66104/pacwds77
Pages: 1-32

ALMEIDA, R. L. J. *et al*. Análise físico-química e microbiológica de farinha de medição de casca de kiwi. **Research, Society and Development**, [S. l.], v. 9, n. 3, e92932522, 2020. DOI: https://doi.org/10.33448/rsd-v9i3.2522.

ALVES, I. A. *et al*. Potencial nutricional e funcional da farinha da casca de umbu (Spondias tuberosa Arruda Cam.). **Revista Brasileira de Agrotecnologia**, [S. l.], v. 11, n. 2, p. 964–974, 2021.

ALVES, T. V. G. *et al*. Bioactive compounds and antioxidant potential for polyphenol-rich cocoa extract obtained by agroindustrial residue. **Natural Product Research**, [S. l.], v. 33, n. 4, p. 589–592, 2019. DOI: https://doi.org/10.1080/14786419.2017.1399381.

ANDRADE, L. A. *et al*. Farinha desmucilada de taro utilizada na elaboração de bolos. **Científica**, Jaboticabal, v. 43, p. 203–214, 2015. DOI: https://doi.org/10.15361/1984-5529.2015v43n3p203-214.

ANTUNES, B. F. *et al*. Determinação de vitamina C e atividade antioxidante de frutas nativas do Brasil. **Revista da Jornada de Pós-Graduação e Pesquisa - Congrega Urcamp**, p. 1300–1310, 2017.

BARRETO, L. S.; CASTRO, M. S. **Boas práticas de manejo para o extrativismo sustentável do umbu**. Brasília, DF: Embrapa Recursos Genéticos e Biotecnologia, 2010.

BASTOS, J. S.; MARTINEZ, E.A.; SOUZA, S.M.A. de. Características físico-químicas da polpa de umbu (Spondias tuberosa Arruda Camara) comercial: Efeito da concentração. **Journal of Bioenergy and Food Science**, Macapá, v.3, n.1, p.11-16, jan./mar., 2016. DOI: 10.18067/jbfs.v3i1.48.

BENETOLE, B. M. *et al*. Produto de panificação com farinha de arroz enriquecida com farinha de ora-pro-nóbis (Pereskia aculeata). **Nucleus**, [S. l.], v. 17, n. 2, 2020. DOI: 10.3738/1982.2278.3809.

REMUNOM
ISSN 2178-6925

Received: 13/03/2026 - **Accepted:** 16/05/2026
Vol: 13.10
DOI: 10.66104/pacwds77
Pages: 1-32

BRAMONT, W. B. *et al*. Comparação da composição centesimal, mineral e fitoquímica de polpas e cascas de dez diferentes frutas. **Revista Virtual de Química**, [S. l.], v. 10, n. 4, p. 811–823, 2018. DOI: 10.21577/1984-6835.20180059.

BRAND-WILLIAMS, W.; CUVELIER, M. E.; BERSET, C. Use of a free radical method to evaluate antioxidant activity. **Lebensmittel-Wissenschaft und-Technologie**, [S. l.], v. 28, n. 1, p. 25–30, 1995.

BRASIL. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. **Instrução Normativa - IN nº 161, de 1º de julho de 2022**. Brasília, DF: Ministério da Saúde, 2022. Disponível em: https://www.in.gov.br/en/web/dou/-/instrucao-normativa-in-n-161-de-1-de-julho-de-2022-413366880. Acesso em: 20 maio 2024.

BRASIL. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. **Resolução da Diretoria Colegiada - RDC nº 711, de 1º de julho de 2022**. Brasília, DF: Ministério da Saúde, 2022.

BRUINSMA, J. The quantitative analysis of clorophylls A and B in plant extracts. **Photochemistry and Photobiology**, [S. l.], v. 2, p. 241–249, 1963.

CAMACAM, B. L. M.; MESSIAS, C. M. B. O. Food potential of fruits and plants of the caatinga: integrative review. **Research, Society and Development**, [S. l.], v. 11, n. 9, e39911931997, 2022. DOI: https://doi.org/10.33448/rsd-v11i9.31997.

CHITARRA, M. I. F.; CHITARRA, A. B. **Pós-colheita de frutos e hortaliças**: fisiologia e manuseio. Lavras: ESAL/FAEPE, 1990.

COSTA, F. R. B.; SILVA, M. M. A.; ARAÚJO, V. S. **Uso sustentável do umbuzeiro**: estratégia de convivência com o semiárido. Campina Grande: INSA, 2015.

DE OLIVEIRA, J. N. de *et al*. Evaluating the potential prebiotic effects of umbu-cajá (Spondias spp.) fruit processing by-product flour on the human intestinal microbiota. **LWT**, [S. l.], v. 210, 2024. DOI: https://doi.org/10.1016/j.lwt.2024.116764.

REMUNOM
ISSN 2178-6925

Received: 13/03/2026 - **Accepted:** 16/05/2026
Vol: 13.10
DOI: 10.66104/pacwds77
Pages: 1-32

DI SALVO, E.; LO VECCHIO, G.; DE PASQUALE, R.; DE MARIA, L.; TARDUGNO, R.; VADALÀ, R.; CICERO, N. Natural pigments production and their application in food, health and other industries**. Nutrients,** [s. l.], v. 15, n. 8, p. 1923, 2023. Disponível em: https://doi.org/10.3390/nu15081923. Acesso em: 09 maio 2026.

DUTCOSKY, S. D. **Análise sensorial de alimentos**. 4. ed. Curitiba: Champagnat, 2013.

FRANCIS, F. J. Analysis of anthocyanins. In: MARKAKIS, P. (ed.). **Anthocyanins as food colors**. [S. l.]: Academic Press, 1982. p. 181–207.

FREIRE, J. M. *et al*. Quantificação de compostos fenólicos e ácido ascórbico em frutos e polpas congeladas de acerola, caju, goiaba e morango. **Ciência Rural**, Santa Maria, v. 43, n. 12, p. 2291–2295, 2013. DOI: https://doi.org/10.1590/S0103-84782013005000132.

GALENO, G. N.; REZENDE, A. J. Avaliação físico-química de bolos com diferentes níveis de farinha da casca de maracujá. **Revista de Divulgação Científica Sena Aires**, [s. l.], n. 2, p. 129-133, jul./dez. 2013.

GOMES, B. B. *et al*. Efeitos das antocianinas na saúde: uma revisão sistemática. **Research, Society and Development**, [S. l.], v. 11, n. 4, e6411427069, 2022. DOI: https://doi.org/10.33448/rsd-v11i4.27069.

GONZÁLEZ-CENTENO, M. R. *et al*. Proanthocyanidin composition and antioxidant potential of the stem winemaking byproducts from 10 different grape varieties (Vitis vinifera L.). **Journal of Agricultural and Food Chemistry**, [S. l.], v. 60, n. 48, p. 11850–11858, 2012. DOI: https://doi.org/10.1021/jf303047k.

HOSSEININEJAD, S. et al. Evaluation of the bioactive compounds, and physicochemical and sensory properties of gluten-free muffins enriched with persimmon 'Rojo Brillante' flour. **Foods**, Basel, v. 11, n. 21, p. 3357, 2022. DOI: https://doi.org/10.3390/foods11213357. Acesso em: 09 maio 2026.

REMUNOM
ISSN 2178-6925
Received: 13/03/2026 - **Accepted:** 16/05/2026
Vol: 13.10
DOI: 10.66104/pacwds77
Pages: 1-32

HRYHORENKO, N. *et al*. Gluten-free bread enriched with whole-grain red sorghum flour gains favourable technological and functional properties and consumers acceptance. **Journal of Cereal Science**, [s. l.], v. 110, p. 103646, 2023. DOI: https://doi.org/10.1016/j.jcs.2023.103646. Acesso em: 14 maio 2026.

INÁCIO, N. *et al*. Aptidão de farinha mista de sorgo e mandioca para produção de pão sem glúten. **Nutrição Brasil**, [S. l.], v. 24, n. 1, p. 1301–1320, 2025. Disponível em: https://doi.org/10.62827/nb.v24i1.3054.

INSTITUTO ADOLFO LUTZ. **Normas analíticas do Instituto Adolfo Lutz**: métodos físico-químicos para análise de alimentos. 3. ed. São Paulo: Instituto Adolfo Lutz, 2008. v. 1.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. **ISO 16649-2:2001**: Microbiology of food and animal feeding stuffs — Horizontal method for the enumeration of β-glucuronidase-positive Escherichia coli — Part 2: Colony-count technique at 44 °C using 5-bromo-4-chloro-3-indolyl β-D-glucuronide. Geneva: ISO, 2001.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. **ISO 7932:2004**: Microbiology of food and animal feeding stuffs — Horizontal method for the enumeration of presumptive Bacillus cereus — Colony-count technique at 30 degrees C. Geneva: ISO, 2004.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. **ISO 14502-1:2005**: Determination of substances characteristic of green and black tea: Content of total polyphenols in tea — Colorimetric method using Folin-Ciocalteu reagent. Geneva: ISO, 2005.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. **ISO 21527-1:2008**: Microbiology of food and animal feeding stuffs — Horizontal method for the enumeration of yeasts and moulds — Part 1: Colony count technique in products with water activity greater than 0.95. Geneva: ISO, 2008.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. **ISO 6579-1:2017/Amd 1:2020**: Microbiology of the food chain — Horizontal method for the

REMUNOM
ISSN 2178-6925

Received: 13/03/2026 - **Accepted:** 16/05/2026
Vol: 13.10
DOI: 10.66104/pacwds77
Pages: 1-32

detection, enumeration and serotyping of Salmonella — Part 1: Detection of Salmonella spp. Geneva: ISO, 2020.

KUPPUSAMY, P. *et al*. Quantification of major phenolic and flavonoid markers in forage crop Lolium multiflorum using HPLC-DAD. **Revista Brasileira de Farmacognosia**, [S. l.], v. 28, n. 3, p. 248–274, 2018. DOI: https://doi.org/10.1016/j.bjp.2018.03.006.

LESMANA, D. *et al*. Valorização de farinha de resíduos agropecuários à base de cascas para produtos alimentícios: uma revisão sistemática sobre composição próxima e propriedades funcionais. **ACS Ciência e Tecnologia de Alimentos**, [S. l.], v. 2, n. 1, p. 3–20, 2021. DOI: https://doi.org/10.1021/acsfoodscitech.1c00353.

LILA, M. A. *et al*. Plant pigments and human health. In: DAVIS, S. (ed.). **Plant pigments and their manipulation**. [S. l.]: CRC Press/Blackwell Publ, 2004. p. 248–274.

LIMA, V. L. A. G. *et al*. Flavonóides em seleções de acerola (Malpighia sp L.): 1- Teor de antocianinas e flavonóis totais. **Ciência Rural**, Santa Maria, v. 30, n. 6, p. 1063–1068, 2000.

MENEZES FILHO, A. C. P. *et al*. Parâmetros físico-químicos, tecnológicos, atividade antioxidante, conteúdo de fenólicos totais e carotenóides das farinhas dos frutos do jatobá-do-cerrado (Hymenaea stigonocarpa Mart. ex Hayne). **Multi-Science Journal**, [S. l.], v. 2, n. 1, p. 93–100, 2019. DOI: https://doi.org/10.33837/msj.v2i1.900.

MACHADO, C. A. A. *et al*. Preparação, caracterização e aplicação de farinha de subproduto da agroindústria de coquinho-azedo (Butia capitata) em produtos de panificação. **Semina: Ciências Agrárias**, Londrina, v. 46, n. 1, p. 109–130, 2024. DOI: https://doi.org/10.5433/1679-0359.2025v46n1p109.

MAFE, A. N. *et al*. A review on food spoilage mechanisms, food borne diseases and commercial aspects of food preservation and processing. **Food Chemistry Advances**, [S. l.], art. 100852, 2024. DOI: https://doi.org/10.1016/j.focha.2024.100852.

Received: 13/03/2026 - **Accepted:** 16/05/2026
Vol: 13.10
DOI: 10.66104/pacwds77
Pages: 1-32

MARQUES, A. *et al*. Composição centesimal e de minerais de casca e polpa de manga (Mangifera indica L.) cv. Tommy Atkins. **Revista Brasileira de Fruticultura**, Jaboticabal, v. 32, n. 4, p. 1206–1210, 2010. DOI: https://doi.org/10.1590/S0100-29452010005000117.

MORAES, E. M.; SILVA, L. H. Substitutos da farinha de trigo na preparação de produtos de panificação sem glúten – uma revisão. **Research, Society and Development**, [S. l.], v. 12, n. 3, e3512328931, 2023. DOI: https://doi.org/10.33448/rsd-v12i3.28931.

MORAIS, D. R. *et al*. Composição centesimal, teores minerais e composição de ácidos graxos das diferentes partes e cascas secas de frutas tropicais cultivadas no Brasil. **Journal of the Brazilian Chemical Society**, São Paulo, v. 28, n. 2, p. 308–318, 2017. DOI: https://doi.org/10.5935/0103-5053.20160178.

MORAIS, R. A. *et al*. Caracterização química, física e tecnológica da farinha obtida a partir da casca de Buriti (Mauritia flexuosa L. f.). **Brazilian Journal of Development**, Curitiba, v. 5, n. 11, p. 23307–23322, 2019. DOI: https://doi.org/10.34117/bjdv5n11-050.

MOREIRA, D. B. *et al*. Determinação do teor de cinzas em alimentos e sua relação com a saúde. **Revista Ibero-Americana de Humanidades, Ciências e Educação**, [S. l.], v. 7, n. 10, p. 3041–3053, 2021. DOI: https://doi.org/10.51891/rease.v7i10.3011.

NAKRA, S. *et al*. Drying as a preservation strategy for medicinal plants: physicochemical and functional outcomes for food and human health. **Phytomedicine Plus**, [S. l.], 2025. DOI: https://doi.org/10.1016/j.phyplu.2025.100762.

NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, AND MEDICINE. **Dietary reference intakes**: the essential guide to nutrient requirements. Washington, DC: The National Academies Press, 2006. DOI: https://doi.org/10.17226/11537.

REMUNOM
ISSN 2178-6925
Received: 13/03/2026 - **Accepted:** 16/05/2026
Vol: 13.10
DOI: 10.66104/pacwds77
Pages: 1-32

NOGUEIRA, T. B. B. *et al*. Acessibilidade, biodisponibilidade e consumo de alimentos ricos em carotenoides e vitamina A em crianças de até 5 anos. **SEMEAR: Revista de Alimentação, Nutrição e Saúde**, [S. l.], v. 1, n. 1, p. 1–13, 2019. Disponível em: https://www.researchgate.net/profile/Talita-Nogueira/publication/340634820_Acessibilidade_biodisponibilidade_e_consumo_de_alimentos_fontes_de_carotenoides_e_vitamina_A_em_criancas_de_ate_5_anos/links/5e96240ea6fdcca7891677d6/Acessibilidade-biodisponibilidade-e-consumo-de-alimentos-fontes-de-carotenoides-e-vitamina-A-em-criancas-de-ate-5-anos.pdf. Acesso em: 20 julho 2024.

OLIVEIRA, F. B. *et al*. Produção e caracterização de farinha de casca de banana. **Research, Society and Development**, [S. l.], v. 10, n. 8, e0910817017, 2021.

OLIVEIRA, L. de L. de; CARVALHO, M. V. de; MELO, L. Health promoting and sensory properties of phenolic compounds in food. Revista Ceres, Viçosa, v. 61, n. 7, p. 764-779, 2014. Disponível em: https://doi.org/10.1590/0034-737x201461000002. Acesso em: 09 maio 2026.

PAESANI, C. *et al*. Efeito de farinhas de milho integral estabilizadas nas características de qualidade de bolos em camadas sem glúten. **LWT**, [S. l.], v. 135, 109959, 2021. DOI: 10.1016/j.lwt.2020.109959.

PIMENTEL, A. A.; PEREIRA, A. S.; OLIVEIRA, C. G. Beneficiamento do umbu como alternativa de renda para a comunidade de Mutans/BA. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA PARA O PROGRESSO DA CIÊNCIA, 64., 2011, Goiânia. **64ª Reunião Anual da SBPC**, 2011.

QUEIROZ, E. R. *et al*. Composição química e fitoquímica das farinhas da casca e da semente de lichias (Litchi chinensis Sonn) cultivar 'Bengal'. **Ciência Rural**, Santa Maria, v. 45, n. 2, p. 329–334, 2015. DOI: https://doi.org/10.1590/0103-8478cr20140106.

QUEIROZ, L. P. *et al*. **Biodiversidade e conservação da Chapada Diamantina**. Brasília, DF: Ministério do Meio Ambiente, 2005.

REMUNOM
ISSN 2178-6925

Received: 13/03/2026 - **Accepted:** 16/05/2026
Vol: 13.10
DOI: 10.66104/pacwds77
Pages: 1-32

RODRIGUEZ-AMAYA, D. B.; KIMURA, M. **Harvestplus handbook for carotenoid analysis**. Washington, DC: International Food Policy Research Institute (IFPRI), 2004. (Technical Monograph 2).

RUFINO, M. S. M. *et al*. **Determinação da atividade antioxidante total em frutas pela captura do radical livre DPPH**. Fortaleza: Embrapa, 2007. (Comunicado Técnico nº 127).

SALGADO, C. S. *et al*. Adição de farinha de casca de guavira em pão: características físico-químicas e sensoriais. **Brazilian Journal of Food Technology**, Campinas, v. 25, e2021170, 2022. DOI: https://doi.org/10.1590/1981-6723.17021.

SARAIVA, B. R. *et al*. Valorização de resíduos agroindustriais: fontes de nutrientes e compostos bioativos para a alimentação humana. **Pubsaúde**, [S. l.], v. 1, n. 1, p. 1–10, 2018. DOI: https://dx.doi.org/10.31533/pubsaude1.a007.

SERAGLIO, S. K. T. *et al*. Determinação de compostos fenólicos por LC-MS/MS e capacidade antioxidante de acerola em três estádios de maturação comestíveis. **Revista do Congresso Sul Brasileiro de Engenharia de Alimentos**, [S. l.], p. 96–110, 2018. DOI: 10.5965/24473650412018096.

SILVA, D. *et al*. Elaboração de cupcake adicionado de farinha de resíduo de umbu cajá: características sensoriais e químicas. **Revista Ciência (In) Cena**, [S. l.], v. 2, n. 5, 2018. Disponível em: https://estacio.periodicoscientificos.com.br/index.php/cienciaincenabahia/article/view/802/716. Acesso em: 18 set. 2025.

SILVA, M. L. C. *et al*. Compostos fenólicos, carotenóides e atividade antioxidante em produtos vegetais. **Semina: Ciências Agrárias**, Londrina, v. 31, n. 3, p. 669–681, 2010. Disponível em: https://www.redalyc.org/pdf/4457/445744097017.pdf. Acesso em: 15 abr. 2025.

SOUSA, W. C. de; MORAIS, R. A.; ZUNIGA, A. D. G. Buriti (Mauritia flexuosa) shell flour: nutritional composition, chemical profile, and antioxidant potential as a strategy for valuing waste from native Brazilian fruits. **Food Research**

REMUNOM
ISSN 2178-6925
Received: 13/03/2026 - **Accepted:** 16/05/2026
Vol: 13.10
DOI: 10.66104/pacwds77
Pages: 1-32

International, [S. l.], v. 190, 2024. DOI: https://doi.org/10.1016/j.foodres.2024.114578.

SOUZA, E. C. *et al*. Desenvolvimento de muffin com incorporação de farinha de bagaço de azeitona, azeite de oliva extravirgem e proteína de soja hidrolisada. **Research, Society and Development**, [S. l.], v. 11, n. 2, e58511226012, 2022. DOI: https://doi.org/10.33448/rsd-v11i2.26012

STROHECKER, R.; HENINING, H. M. **Analisis de vitaminas**: métodos comprobrados. Madrid: Paz Montalvo, 1967.

TABARELLI, M. *et al*. Caatinga: legado, trajetória e desafios rumo à sustentabilidade. **Ciência e Cultura**, São Paulo, v. 70, n. 4, p. 25–29, 2018. DOI: http://dx.doi.org/10.21800/2317-66602018000400009.

VIEIRA, S. E. S. *et al*. Avaliação sensorial de biscoito sem glúten do tipo cookie desenvolvido com farinha de amaranto e enriquecido com farinha de baru. **Desafios - Revista Interdisciplinar da Universidade Federal do Tocantins**, Palmas, v. 7, n. esp., p. 42–51, 2020. DOI: https://doi.org/10.20873/uftsupl2020-8741.

VIEIRA, T. S. *et al*. Efeito da substituição da farinha de trigo no desenvolvimento de biscoitos sem glúten. **Brazilian Journal of Food Technology**, Campinas, v. 18, n. 4, p. 285–292, 2015. DOI: https://doi.org/10.1590/1981-6723.1815.

VOLP, A. C. P. *et al*. Pigmentos naturais bioativos. **Alimentos e Nutrição Araraquara**, Araraquara, v. 20, n. 1, p. 157–166, 2009. Disponível em: https://www.researchgate.net/profile/Paulo-Stringheta/publication/49600140_Pigmentos_naturais_bioativos/links/53ed2bdc0cf23733e80808bb/Pigmentos-naturais-bioativos.pdf. Acesso em: 20 abr. 2025.

VOLP, A. C. P. *et al*. Carotenoides: pigmentos naturais como compostos bioativos. **Revista Brasileira de Nutrição Clínica**, [S. l.], v. 26, n. 4, p. 291–298, 2011. Disponível em: http://www.braspen.com.br/home/wp-content/uploads/2016/12/10-Caroten%C3%B3ides-Pigmentos-Naturais-como-Compostos-Bioativos.pdf. Acesso em: 20 abr. 2025.

REMUNOM
ISSN 2178-6925

Received: 13/03/2026 - **Accepted:** 16/05/2026
Vol: 13.10
DOI: 10.66104/pacwds77
Pages: 1-32

XAVIER, J. A. F. *et al*. Pomaces de frutas cultivadas no semiárido brasileiro: revelando propriedades funcionais através de análises físico-químicas. **Revista Foco**, [S. l.], v. 18, n. 6, e8850, 2025. DOI: https://doi.org/10.54751/revistafoco.v18n6-166.

YILMAZ, E. E. *et al*. Extraction and identification of proanthocyanidins from grape seed (Vitis vinifera) using supercritical carbon dioxide. **Journal of Supercritical Fluids**, [S. l.], v. 55, n. 3, p. 924–928, 2011. DOI: https://doi.org/10.1016/j.supflu.2010.10.046.