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Obtaining and evaluating antioxidant potential of ora-pro-nóbis (Pereskia aculeata Mill.) extracts in Beef Burgers

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Abstract: Lipid oxidation reduces the shelf life of meat products, making natural antioxidants promising alternatives to synthetic ones. Ora-pro-nóbis (*Pereskia aculeata Mill.*) presents high antioxidant potential. This study aimed to quantify the total phenolic compounds and flavonoids in ora-pro-nóbis extracts and evaluate their application in artisanal beef burgers. The leaves were dried, ground, and subjected to extraction using absolute ethanol and a 90:10 (v/v) hydroethanolic solution, at different extraction times, with and without mechanical stirring, in order to evaluate the efficiency of the extraction process. The extract obtained under stirring showed greater efficiency and was incorporated into the burgers. The addition of the extract delayed pH reduction without significantly affecting color. In the sensory analysis, there were no significant differences between the groups ($p > 0.05$, t-test), and both presented mean acceptance scores above 7.0. Ora-pro-nóbis showed potential as a natural antioxidant in meat products.
Keywords: Hydroethanolic extract. Phenolic compounds. Flavonoids.

Resumo: A oxidação lipídica reduz a vida útil de produtos cárneos, tornando os antioxidantes naturais alternativas promissoras aos sintéticos. A ora-pro-nóbis (*Pereskia aculeata Mill.*) apresenta elevado potencial antioxidante. Este estudo objetivou quantificar os compostos fenólicos e flavonoides totais de extratos de ora-pro-nóbis e avaliar sua aplicação em hambúrgueres bovinos artesanais. As folhas foram secas, trituradas e submetidas à extração utilizando etanol absoluto e solução hidroetanólica 90:10 (v/v), em diferentes tempos de extração, com e sem agitação mecânica, visando avaliar a eficiência do processo extrativo. O extrato obtido sob agitação apresentou maior eficiência e foi incorporado aos hambúrgueres. A adição do extrato retardou a redução do pH, sem alterar significativamente a cor. Na análise sensorial, não houve diferenças significativas entre os grupos ($p > 0,05$, teste t), sendo que ambos apresentaram médias de aceitação acima de 7,0. A ora-pro-nóbis mostrou potencial como antioxidante natural em produtos cárneos.
Palavras-chave: Extrato hidroetanólico. Compostos fenólicos. Flavonoides.

1. Introduction

The consumption of hamburgers has been increasing exponentially due to the expansion of fast food chains and, mainly because it is a versatile food, easy to prepare and low cost (Botelho et al., 2025). Due to these characteristics, the artisanal hamburger is a meat product that is well accepted by the Brazilian consumer. However, the shelf life of artisanal meat products is a recurring concern in the area of Food Technology, due to lipid oxidation, which deteriorates the food during storage and processing (de Araújo et al., 2022). Lipid oxidation depreciates the quality of food, changes its nutritional value and sensory characteristics, develops unpleasant flavors and odors, causes premature browning and depreciation of texture, making products undesirable and unfit for consumption, which influences their acceptability by the consumer (Rosa & Pintro, 2022). In meat products, lipid oxidation directly compromises the quality of meat and its derivatives, causing changes in color, tenderness and flavor. Furthermore, it favors the formation of undesirable and potentially toxic compounds, which reduces the shelf life and safety of processed foods. This oxidation process also promotes changes in the color of the meat, which is linked to the chemical transformations of the pigment myoglobin. During processing and exposure to oxygen, myoglobin is converted into oxymyoglobin, responsible for the characteristic bright red color of fresh meat. However, the continuous oxidation of the ferrous ion (Fe^{2+}) present in the pigment to its ferric state (Fe^{3+}) leads to the formation of metmyoglobin, which gives grayish-brown tones that reduce consumer acceptability (de Araújo et al., 2022). In this context, the presence of natural antioxidants can act to delay these reactions, preserving the characteristic color of the meat and contributing to greater product stability. It is common for the pH to decrease throughout storage, as well as the color of the burger to lose its characteristic red. Therefore, slower reductions in pH and color intensity indicate greater stability and better conservation of the product.

To minimize these effects, antioxidants are used in meat products with the aim of reducing or inhibiting oxidation, preserving food quality and consumer safety. These compounds act by inhibiting the formation and propagation of free radicals, delaying deterioration (Rosa & Pintro, 2022). Because they contain compounds with antioxidant potential, extracts from natural products have been widely used as substitutes for synthetic antioxidants, which can cause adverse effects on the human body (Orsine et al., 2023). Research indicates that synthetic antioxidants, although effective, are associated with potential risks, such as liver toxicity, allergic reactions and even impaired mineral absorption (Sá et al., 2016). Furthermore, the oxidative reactions in meat products synthesize lipid peroxides, malondialdehyde, ketones, among others that, in addition to deteriorating the food, present toxicity to human health (Dragoev, 2024).

Natural antioxidants can be obtained from leaves, stems, fruits, seeds and barks of plants, including by-products of the agricultural industry. Extraction can be done using different methods and solvents, such as water and ethanol. In the extracts, the high concentration of phenolic compounds, flavonoids and tannins confers significant antioxidant properties (Rosa & Pintro, 2022). Phenolic compounds and flavonoids are among the main antioxidants of plant origin, acting in the neutralization of reactive oxygen species (ROS) through electron or hydrogen donation mechanisms, in addition to the chelation of metal ions. These properties contribute to the reduction of oxidative stress and the protection of biomolecules, such as lipids and proteins, being widely associated with the antioxidant potential of plant extracts (Gulçin, 2025; Xu & Wang, 2025). The ora-pro-nóbis (*Pereskia aculeata Mill.*), an unconventional food plant with high nutritional value, has considerable

levels of protein, fiber, iron, calcium, potassium, zinc and magnesium (Mazzonetto et al., 2025). Jacoben et al. (2024) evaluated extracts from ora-pro-nóbis leaves (*Pereskia aculeata Mill.*) and found significant levels of phenolic compounds and flavonoids, confirming its potential as a natural source of antioxidants.

This research aims to quantify the total phenolic compounds and flavonoids present in ora-pro-nóbis extracts and to apply the best-performing extract to artisanal beef burgers, in order to evaluate its effect on color stability and pH-factors that are crucial for the preservation and shelf-life extension of the meat product.

2. Methods

2.1 Raw material

The ora-pro-nóbis leaves (*Pereskia aculeata Mill.*) were purchased at ``*Mercado Municipal de Uberaba*`` (City Market in Uberaba), Minas Gerais. After selection, the samples were washed in a 100 mg/L sodium hypochlorite (NaClO) solution, rinsed under running water, and oven-dried at 60 °C for six hours, being removed and weighed every 30 minutes until a constant mass was reached. Subsequently, they were ground in household blenders to obtain a fine flour, which was used to prepare the extracts.

2.2 Obtaining the extracts

Two types of extracts were prepared: one using absolute ethanol and the other using a 90:10 (v/v) hydroethanolic solution. In each assay, 1.50 g of the flour obtained from the dried leaves was used, to which 30 mL of the corresponding solvent was added. The samples were left to stand for periods of 1, 3, 7, 15, 18, and 22 days to evaluate the effect of prolonged extraction time. Concurrently, assays using the hydroethanolic solution were conducted over shorter durations (10, 20, 30, 40, 50, and 60 minutes), both with and without agitation, to investigate extraction efficiency and kinetics over short time intervals. Agitation was performed using a magnetic stirrer (Tecnal, model TE-0851) set to 3.00% of its maximum speed and maintained at room temperature, without activating the heating system. To separate the solid phase at the end of each interval, the samples were centrifuged at 4000 rpm for 15 minutes (Solab centrifuge, SL-700). Subsequently, the supernatant was collected, transferred to 50 mL Falcon tubes, and stored at -18 °C for 24 hours until analysis.

2.3 Determination of total phenolic compounds

The quantification of total phenolic compounds was performed in duplicate using the Folin-Ciocalteu spectrophotometric method (Wolff et al., 2019), based on the oxidation of phenolic compounds by the reagent, using gallic acid. ($C_7H_6O_5$) as a standard. Initially, a 200 mg/L stock solution was prepared by dissolving 0.02 g of gallic acid in 100 mL of distilled water. From the dilution, solutions of 25, 50, 100, 150 and 200 mg/L $C_7H_6O_5$, used to construct the calibration curve. To this end, aliquots of 0.25 mL of the standard solutions were mixed with 0.25 mL of Folin-Ciocalteu reagent 1:1 (v/v), 0.50 mL of 20.00% solution (w/v) Na_2CO_3 (sodium carbonate) and 4.00 mL of distilled water; the absorbance of the solutions was measured using a spectrophotometer (Biospectro, model SP-22) at 760 nm after a five-minute incubation period. The analytical blank was prepared by replacing the standard solution with

distilled water, while keeping the proportions of the other reagents unchanged. Subsequently, the same conditions were applied to the samples, replacing the standards with aliquots of the extracts. The results were expressed as gallic acid equivalents per liter (mg GAE/L).

2.4 Determination of total flavonoid compounds

The determination of flavonoids was performed in duplicate using the spectrophotometric method with rutin ($C_{27}H_{30}O_{16}$) as standard. A stock solution 1 was prepared mg/mL $C_{27}H_{30}O_{16}$, obtained by dissolving 0.01 g in 10 mL of ethanol. Through dilution, 0.0312 solutions were obtained; 0.0625; 0.1250; 0.2500 and 0.5000 mg/mL $C_{27}H_{30}O_{16}$, used to construct the calibration curve. Aliquots 2.5 mL of the standard solutions were mixed with 0.15 mL of a 5.00% (w/v) sodium nitrite solution. ($NaNO_2$), 0.15 mL of 10.00% (w/v) aluminum chloride solution ($AlCl_3$) and 1 mL of 1.00 mol/L NaOH (sodium hydroxide) solution; absorbance was measured using a spectrophotometer (Biospectro, model SP-22) at 510 nm. An analytical blank was prepared by substituting the standard solution with ethanol while maintaining the same reagent proportions. Subsequently, the same conditions were applied to the samples, replacing the standards with extract aliquots. To ensure adherence to the Beer-Lambert law and guarantee that measurements fell within the linearity range, a 1:3 (v/v) dilution was performed on the calibration curve standard solutions, and a 1:9 (v/v) dilution was performed on the samples. Results were expressed as mg of rutin equivalents per milliliter (mg RE/mL).

Following the quantification of phenolic compounds and flavonoids, the extract exhibiting the highest content of bioactive compounds was selected and incorporated into the meat matrix during the formulation of artisanal beef burgers. Incorporation was achieved by directly mixing the extract with the ground meat, followed by manual homogenization until complete distribution, with the aim of evaluating its antioxidant potential in the final product.

2.5 Preparation of the burgers

The burgers were prepared by hand with beef previously purchased ground in a supermarket, requiring double grinding and packaging in separate packaging by type. The base formulation was composed of 45.00% beef chuck, 45.00% beef brisket and 10.00% beef tallow, in addition to 15.00% ice water, 2.00% refined salt, 4.00% textured soy protein powder, 0.20% monosodium glutamate, 0.20% garlic powder, 0.15% onion powder and 0.10% black pepper, the percentages being calculated in relation to the total weight of the meat mass (chuck, breast and suet). The necessary quantities of each ingredient were weighed according to the formulation and homogenized manually, incorporating the additives in the following order: refined salt, monosodium glutamate, garlic powder, onion powder, black pepper, textured soy protein and ice water. Finally, the ora-pro-nóbis extract was added, manually homogenizing the mixture until the ingredients were completely incorporated. After manual homogenization of the ingredients, the samples were divided into two groups: control (without addition of extract) and treated (with incorporated extract). Each burger was shaped with approximately 15 g, placed in disposable coffee cups, covered with aluminum foil and stored under refrigeration at approximately 5 ºC until analysis was carried out.

2.6 Addition of ora-pro-nóbis extract to hamburgers

To determine the concentration of ora-pro-nóbis leaf extract to be applied to the hamburgers, samples containing 1.00, 2.00, and 3.00% (w/w) extract relative to the meat weight were prepared. At this stage, pH and color parameters were evaluated in duplicate on days 0 and 7 of storage. After determining the optimal concentration, a new trial with a more detailed evaluation schedule was conducted. Control and treated hamburgers were prepared in duplicate and analyzed for pH and color parameters on days 0, 2, 4, 7, and 9 of storage.

2.7 Determination of pH and color parameters

To determine pH, 3 g meat aliquots were homogenized in 50 mL of distilled water in a beaker by manually breaking up the sample and stirring sporadically with a spatula for five minutes. Readings were then taken using a pH meter previously calibrated with standard buffer solutions. Measurements were performed in duplicate for both control samples and samples containing the extract at storage intervals of 0, 2, 4, 7, and 9 days.

Color parameters (L*, a*, b*, C*, and h*) were determined using a colorimeter (Delta Vista, model Delta Color). In this system, L* represents lightness (0 = black and 100 = white), a* the red/green axis, b* the yellow/blue axis, C* chroma, and h* hue angle. For analysis, the equipment's sample holder was filled with aliquots of the hamburger samples, and the colorimeter was positioned over the sample holder surface to take the measurements. Determinations were also performed in duplicate for control and extract-containing samples at storage intervals of 0, 2, 4, 7, and 9 days.

2.8 Sensory analysis

The sensory evaluation consisted of an acceptance test conducted using 30 g hamburger patties (control and treated with 3.00% extract), which were freshly fried and divided into four equal parts. Samples were served in containers coded with random three-digit numbers to 60 untrained panelists seated in individual booths.

Panelists first evaluated one of the samples (control or treated) for color and odor using a structured nine-point hedonic scale, ranging from 1 (dislike extremely) to 9 (like extremely). Subsequently, the other sample was presented and evaluated under the same conditions. The sensory evaluation was conducted at the Food Technology Laboratory of UFTM (``*Universidade Federal do Triângulo Mineiro``; Federal University in Triângulo Mineiro*) with panelists over the age of 18. Prior to the evaluation, participants received the Informed Consent Form (ICF), which was read and signed by those who agreed to participate in the study. The study was approved by the Research Ethics Committee (CAAE: 81713924.1.0000.5154).

2.9 Statistical treatment

Data regarding color parameters and sensory analysis were subjected to statistical analysis. For color parameters, analysis of variance (ANOVA) was applied, followed by Tukey's test. Sensory analysis results were evaluated using the t-test to compare the control and

treatment groups. All statistical analyses were performed at a 5.00% significance level ($p \leq 0.05$) using STATISTICA® 7 software (Statsoft, n.d.).

3. Results and discussion

3.1 Calibration curves

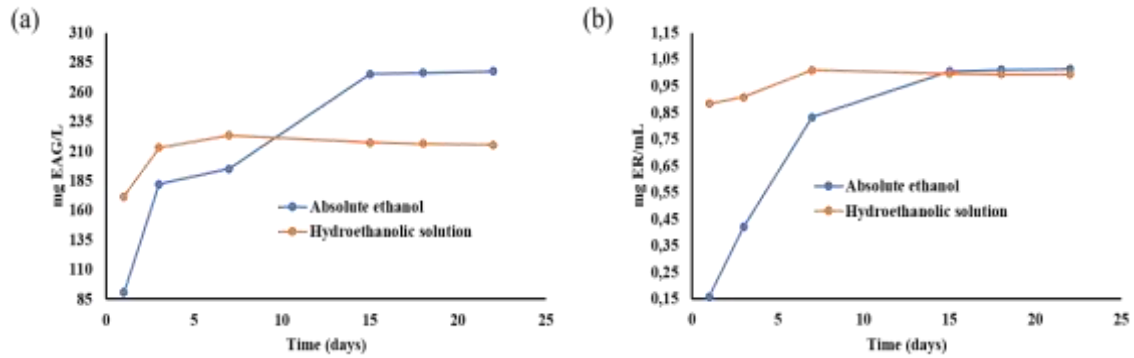
The calibration curve for total phenolic compounds was obtained and fitted to the equation $y = 0.0035x + 0.0457$, where y represents absorbance and x represents the gallic acid equivalent concentration. The obtained coefficient of determination was $R^2 = 0.9694$, indicating good linearity between the variables. For flavonoid compounds, the calibration curve was described by the equation $y = 5.3965x + 0.0089$, with $R^2 = 0.9931$, demonstrating excellent linearity within the evaluated concentration range. The high R^2 values confirm the reliability of the spectrophotometric methods used to quantify the total phenolic and flavonoid compounds present in ora-pro-nóbis flour. According to Chen and Chen (2022), the linearity of an analytical method refers to its ability to yield results proportional to the analyte concentration within a specified range, with linear regression serving as a key tool for its assessment. Although the coefficient of determination (R^2) is widely used as an indicator of model fit, the literature emphasizes that this parameter must be interpreted alongside other validation criteria to ensure the method's reliability (Lemyre et al., 2022).

3.2 Extraction of phenolic compounds and flavonoids

The comparison between the extractions carried out with absolute ethanol and 90:10 (v/v) hydroethanolic solution, analyzed in different resting periods (1 to 22 days), is presented in Figure 1. It is observed that the hydroethanolic solution (Figure 1a and 1b) reached the compound concentration plateau in a shorter period (between 3 and 7 days), while absolute ethanol showed stabilization between 7 and 15 days. The hydroethanolic solution presented maximum concentrations of 215.23 mg EAG/L for phenolic compounds and 0.99 mg ER/mL for flavonoids, while absolute ethanol reached slightly higher values, corresponding to 277.31 mg EAG/L and 1.01 mg ER/mL, respectively. Although absolute ethanol presented slightly higher concentrations, the gain obtained was not sufficient to justify its adoption, especially considering that time efficiency is a fundamental criterion in industrial and research processes that seek to optimize time and resources. The results corroborate the findings of Dai and Mumper (2010), who highlighted the relevance of using solvents, such as methanol, ethanol, acetone, ethyl acetate, as well as their combinations with each other and in different proportions with water, in the extraction of phenolic compounds from plant samples. Bezerra et al. (2022) reported higher yields of phenolic compounds with solvents containing water, compared to anhydrous solvents. This behavior differs from the results obtained in this study, in which pure ethanol showed a higher extraction rate. It must also be noted that the aforementioned work did not evaluate the extraction kinetics, which limits comparisons regarding the time to reach the concentration plateau. Considering the balance between efficiency, safety and applicability in food, the hydroethanolic solution was chosen for the extraction of ora-pro-nóbis flour in shorter periods, comparing the process with and without agitation.

Figure 1

Comparison of the evolution of the concentration of (a) phenolic compounds (mg GAE/L) and (b) flavonoid compounds (mg RE/mL) in pure ethanol and aqueous ethanol solution over time.

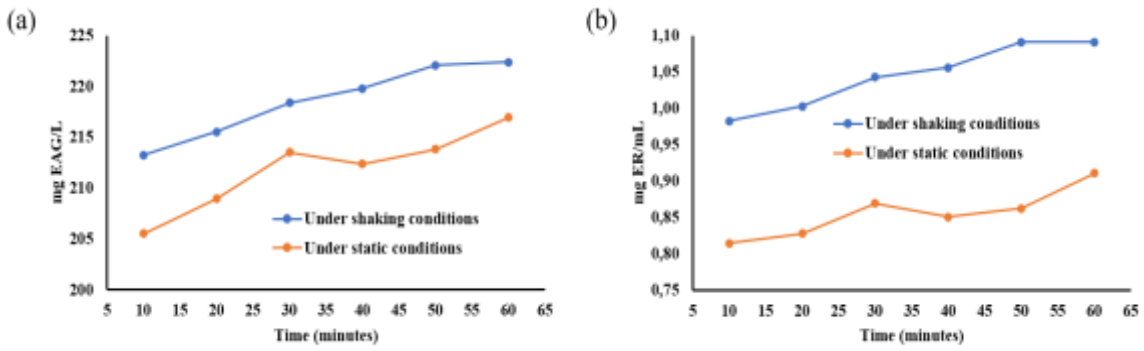


Source: The authors, 2025

Figure 2 presents a comparison between extraction processes under static and shaking conditions, conducted over a shorter timeframe (up to 60 minutes). It is evident that agitation (Figures 2a and 2b) accelerated the release of bioactive compounds, reaching a plateau at approximately 50 minutes with values of 222.09 mg GAE/L for phenolics and 1.09 mg RE/mL for flavonoids. In contrast, the process without agitation yielded lower concentrations within the same timeframe-specifically 213.80 mg GAE/L and 0.86 mg RE/mL. This difference demonstrates that agitation enhances extraction efficiency by increasing contact between the solvent and the plant matrix, thereby facilitating the diffusion of compounds into the liquid phase and reducing the time required to reach maximum concentration. These results align with findings reported by Firmino and Miranda (2015); in their evaluation of 25 green tea brands, they observed that infusion with mechanical agitation resulted in higher total polyphenol and flavonoid contents compared to infusion without agitation, further confirming that agitation improves the extraction efficiency of these bioactive compounds.

Figure 2

Comparison of the extraction of (a) phenolic compounds (mg GAE/L) and (b) flavonoid compounds (mg RE/mL) with and without agitation over the course of one hour.



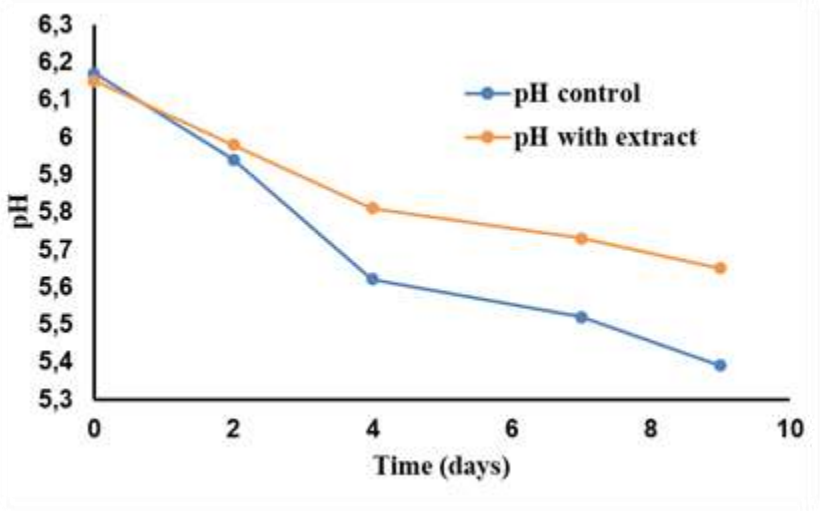
Source: The authors, 2025

3.3 Application of the extract in hamburgers

The parameters evaluated in this study were pH and color. In the preliminary test, the formulation containing 3.00% (w/w) extract showed the least pH variation during storage, with a ΔpH of 0.505 from day 0 to day 9, whereas the control sample showed a variation of 0.78 over the same period, demonstrating greater stability for this parameter according to statistical analysis. Regarding color, statistical analysis indicated that the a* parameter - associated with the intensity of the red color characteristic of meat - showed a significant difference only at the end of the 9-day refrigerated storage period ($p \leq 0.05$) for both the control group and the extract - treated group. Furthermore, there were no significant differences between the control and extract treatments regarding the colorimetric parameters evaluated (L*, a*, b*, C*, and h*) during storage ($p > 0.05$), indicating that the addition of the extract did not cause detectable changes in the color of the burgers compared to the control formulation. The other colorimetric parameters also showed no significant differences between treatments during the evaluated period. In the definitive test (Figure 3 and Table 1), a progressive decrease in pH was observed in both groups, though it was slower in the burgers containing the extract, highlighting an antioxidant effect associated with the presence of phenolic compounds and flavonoids from ora-pro-nóbis. These compounds act as electron donors, neutralizing free radicals and delaying the oxidative process. (Rosa & Pintro, 2022).

Figure 3

The pH behavior of control and treated burgers in the definitive test.



Source: The authors, 2025

Regarding color (Table 1), the L* parameter did not show a significant reduction during storage. In the control, a slight gradual increase was observed, indicating a subtle lightening of the patties, whereas in the samples containing extracts, the values remained similar over time. The a* component showed a marked reduction in both formulations, reflecting the loss of the meat's characteristic red hue. This change was observed only at the end of the 9-day storage period; no differences were detected up to day 7 of refrigerated storage in either formulation. The b* and C* values also decreased, indicating lower color intensity, while h*

increased, evidencing a shift toward more yellowish tones. However, for the b* parameter, there were no statistically significant differences among the time points evaluated. In both samples, no statistical differences were found between time points-despite numerical variations - possibly due to the high variability of the data, as evidenced by the standard deviations. Statistical analysis indicated a time effect, with differences observed between days 0 and 9 for a* and C* (Tukey's test), whereas no differences were observed between treatments. Thus, the results indicate that the addition of the extract did not cause detectable changes in color parameters compared to the control.

Table 1

Color test results for the refrigerated hamburgers.

	Component L*				
Treatment	day 0	day 2	day 4	day 7	day 9
Control (without extract)	40.41^{A} ± 0.37	46.98^{A} ± 0.40	45.70^{A} ± 1.71	48.89^{A} ± 4.59	51.27^{A} ± 4.99
With 3.00% of extract	45.20^{A} ± 3.10	44.97^{A} ± 3.74	47.40^{A} ± 0.21	44.58^{A} ± 2.35	43.08^{A} ± 2.08
	Component a*				
Treatment	day 0	day 2	day 4	day 7	day 9
Control (without extract)	15.59^{A} ± 0.63	11.95^{AB} ± 0.40	12.18^{AB} ± 0.43	12.90^{AB} ± 0.16	10.98^{B} ± 1.58
With 3.00% of extract	13.74^{A} ± 0.24	9.97^{AB} ± 0.16	13.64^{AB} ± 2.56	14.37^{AB} ± 3.15	8.84^{B} ± 2.46
	Component b*				
Treatment	day 0	day 2	day 4	day 7	day 9
Control (without extract)	14.38^{A} ± 1.97	13.70^{A} ± 0.95	14.16^{A} ± 0.57	15.02^{A} ± 1.05	12.82^{A} ± 1.79
With 3.00% of extract	13.11^{A} ± 0.08	13.12^{A} ± 1.00	14.21^{A} ± 0.86	12.12^{A} ± 1.95	11.95^{A} ± 0.52
	Component C*				
Treatment	day 0	day 2	day 4	day 7	day 9
Control (without extract)	21.23^{A} ± 1.80	18.18^{AB} ± 0.98	18.66^{AB} ± 0.12	19.80^{AB} ± 0.89	16.96^{B} ± 0.33

With 3.00% of extract	18.98^{A} ± 0.12	16.49^{AB} ± 0.91	19.52^{AB} ± 2.11	18.80^{AB} ± 3.66	14.91^{B} ± 1.87

	Component h*				
Treatment	day 0	day 2	day 4	day 7	day 9
Control (without extract)	42.58^{A} ± 2.77	48.86^{A} ± 1.02	49.24^{A} ± 2.05	49.28^{A} ± 1.66	49.33^{A} ± 8.00
With 3.00% extract	43.64^{A} ± 0.66	52.70^{A} ± 1.65	46.38^{A} ± 3.66	40.32^{A} ± 1.67	53.89^{A} ± 6.50

Note: Means followed by different uppercase letters in the same row differ statistically among storage periods (days) according to Tukey's test ($p<0.05$).
Source: Authors, 2025.

3.4 Sensory analysis

The sensory analysis results presented in Table 2 reinforce the extract's applicability. An acceptance test was conducted, revealing that the mean scores for color and odor were similar across groups - differing by only 0.3 points per attribute - with the highest color score observed in the control sample and the highest odor score in the extract-added burger; however, these differences were not statistically significant ($p > 0.05$). Since the mean scores exceeded 6 on the hedonic scale, both products were deemed acceptable by the panelists. These findings indicate that adding the extract did not compromise the product's visual and olfactory acceptance - a crucial factor for commercial-scale application. Similar results were reported by Lee et al. (2014), who observed higher overall acceptance in burgers containing lemon balm extract. Furthermore, the data align with the literature review by Alves et al. (2024), which indicates that meat products containing natural antioxidants are generally well-accepted or do not differ sensorially from those without such additives. It must be noted, however, that at high concentrations, these compounds can cause undesirable changes in sensory properties, as previously reported by de Araújo et al. (2022) and Rosa and Pintro (2022). Similarly, de Alencar et al. (2022) found that burgers containing grape-skin flour at levels above 1.50% did not achieve good sensory acceptance.

Table 2

Mean scores from the sensory test with statistical analysis.

	Group	
Attributes	With extract	Without extract
Color	7.1^{a}	7.4^{a}
Smell	7.3^{a}	7.0^{a}

Note: Means followed by the same letter do not differ from each other according t-test ($p > 0.05$).
Source: Authors, 2025

4. Conclusion

The ora-pro-nóbis (*Pereskia Aculeata Mill.*) proved to be a promising source of bioactive compounds, exhibiting significant levels of total phenolic compounds and flavonoids, which are associated with proven antioxidant potential. The 90:10 (v/v) hydroethanolic solution, combined with agitation, demonstrated greater extraction efficiency within a short timeframe.

Incorporating the extract into artisanal beef burgers contributed to greater pH stability during storage without compromising color parameters or sensory acceptance.

From a sensory perspective, the treated burgers maintained good acceptance, with mean scores above six on the hedonic scale for color and odor, demonstrating the feasibility of using the extract as a natural preservative in meat products.

The ora-pro-nóbis extract demonstrated efficiency and viability as a natural antioxidant, representing a promising alternative to synthetic preservatives and antioxidants for preserving quality and extending the shelf life of artisanal meat products.

Author contributions: Luiz Fernando Dias: Investigation (conducting experiments), Writing – original draft.

Ana Carolina da Silva: Methodology, Writing – review and editing (final review).

Evandro Roberto Alves: Methodology, Writing – review and editing (final review).

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