Rabbit meat burgers with pitahaya peel powder: Functional, physicochemical and sensory analysis

Hamburguesas de carne de conejo con polvo de cáscara de pitahaya: Análisis funcional, fisicoquímico y sensorial

Hambúrgueres de carne de coelho com pó de casca de pitaiaiás: Análise funcional, físico-química e sensorial

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Abstract

Nowadays, it is necessary to seek alternative agroindustrial uses of fruit residues, as these are sources of bioactive compounds important for human nutrition. The objective of this study was to evaluate the effect of pitahaya peel powder on the functional, physicochemical, and sensory acceptability properties of rabbit meat burgers. Five formulations of rabbit burger meat with pitahaya peel powder (3, 5, 7, and 9 %) and a control formulation were established under a completely randomized experimental design with a factorial arrangement. In the processed products, functional properties (anthocyanin content, antioxidant activity (DPPH and ABTS) and total phenols), physicochemical properties (pigmentation of the ether extract, protein, fat, fiber, ash, moisture and total solids), textural and colorimetric characteristics (hardness, cohesiveness, adhesiveness, gumminess and color), microbiological properties (mesophilic aerobes, *Escherichia coli*, *Staphylococcus aureus* and Salmonella) and sensory attributes (flavor, aroma, color and texture) were determined. The treatment with the best physicochemical and functional properties was T4 (9 % ppp) whose values were: fat (2.48 %); fiber (3.86 %); a* (23.06); b* (3.47), anthocyanins (+++), DPPH (23.667 µmol trolox equivalent.g^{-1}), ABTS (30.353 µmol trolox equivalent.g^{-1}), total phenols (19.706 mg gallic acid equivalent.g^{-1}); pigmentation (0.113), hardness (4.552 N), adhesiveness (-0.855 N) and gumminess (2.128 N). All treatments met the physicochemical and microbiological requirements established in the Ecuadorian standard NTE INEN 1338.

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Resumen

En la actualidad es necesario buscar alternativas de aprovechamiento agroindustrial de los residuos frutícolas, debido a que estos son fuentes de compuestos bioactivos de importancia en la alimentación humana. El objetivo de este estudio fue evaluar el efecto del polvo de cáscara de pitahaya sobre las propiedades funcionales, fisicoquímicas y aceptabilidad sensorial de hamburguesas de carne de conejo. Se establecieron cinco formulaciones de carne de hamburguesas de conejo con polvo de cáscara de pitahaya (3, 5, 7 y 9 %) y una formulación control, bajo un diseño experimental completamente al azar con arreglo factorial. En los productos elaborados, se determinaron propiedades funcionales (contenido de antocianinas, actividad antioxidante (DPPH y ABTS) y fenoles totales), fisicoquímicas (pigmentación del extracto etéreo, proteína, grasa, fibra, cenizas, humedad y sólidos totales), características de textura y colorimetría (dureza, cohesividad, adhesividad, gomosidad y color), microbiológicas (aerobios mesófilos, *Escherichia coli, Staphylococcus aureus* y Salmonella) y los atributos sensoriales (sabor, aroma, color y textura). El tratamiento con mejores propiedades fisicoquímicas y funcionales fue el T4 (9 % ppp) cuyos valores fueron: grasa (2,48 %); fibra (3,86 %); a* (23,06); b* (3,47), antocianinas (+++), DPPH (23,667 μmol trolox equivalente.g^{-1}), ABTS (30,353 μmol trolox equivalente.g^{-1}), fenoles totales (19,706 mg ácido gálico equivalente.g^{-1}); pigmentación (0,113), dureza (4,552 N), adhesividad (-0,855 N) y gomosidad (2,128 N). Todos los tratamientos cumplieron con los requisitos fisicoquímicos y microbiológicos establecidos en la norma ecuatoriana NTE INEN 1338.

Palabras clave: análisis sensorial, carne, conejo, *Hylocereus undatus*, perfil de textura.

Resumo

Atualmente, faz-se necessário buscar usos agroindustriais alternativos dos resíduos de frutas, visto que estes são fontes de compostos bioativos importantes para a nutrição humana. O objetivo deste estudo foi avaliar o efeito do pó da casca de pitaiaiás nas propriedades de aceitabilidade funcional, físico-química e sensorial de hambúrgueres de carne de coelho. Cinco formulações de carne de hambúrguer de coelho com pó da casca de pitaiaiás (3, 5, 7 e 9 %) e uma formulação controle foram estabelecidas em delineamento experimental inteiramente casualizado com arranjo fatorial. Nos produtos processados, foram determinadas as propriedades funcionais (teor de antocianinas, atividade antioxidante (DPPH e ABTS) e fenóis totais), propriedades físico-químicas (pigmentação do extrato etéreo, proteína, gordura, fibra, cinzas, umidade e sólidos totais), características texturais e colorimétricas (dureza, coesividade, adesividade, gomosidade e cor), propriedades microbiológicas (aeróbios mesófilos, *Escherichia coli*, *Staphylococcus aureus* e Salmonella) e atributos sensoriais (sabor, aroma, cor e textura). O tratamento com melhores propriedades físico-químicas e funcionais foi o T4 (9 % ppp) cujos valores foram: gordura (2,48 %); fibra (3,86 %); a* (23,06); b* (3,47), antocianinas (+++), DPPH (23,667 μmol equivalente trolox.g^{-1}), ABTS (30,353 μmol equivalente trolox.g^{-1}), fenóis totais (19,706 mg equivalente ácido gálico.g^{-1}); pigmentação (0,113), dureza (4,552 N), adesividade (-0,855 N) e gomosidade (2,128 N). Todos os tratamentos atenderam aos requisitos físico-químicos e microbiológicos estabelecidos na norma equatoriana NTE INEN 1338.

Palavras-chave: Análise sensorial, carne, coelho, *Hylocereus undatus*, perfil de textura.

Introduction

Rabbit meat (*Oryctolagus cuniculus*) stands out for its unique nutritional compounds, being a lean meat, low in fat, rich in minerals, vitamins (especially B vitamins: B1, B2, B12) and proteins (Aquino-López *et al*., 2020). It differs from other meats in organoleptic aspects such as flavour, aroma and tenderness (Herrera-Stanziola *et al*., 2023). Rabbit meat is recommended for people with high protein requirements or a sensitive digestive system. In addition, it is highly versatile in the food industry for the production of various meat products (González Balmaceda *et al*., 2023).

Rabbit meat in products such as ham and sausages has been shown to generate a yield comparable to that of other species. Rabbit meat formulations with honey as an antioxidant have also been developed (López-Velasco *et al*., 2021), as well as sausages with chontaduro powder (*Bactris gasipaes*) and reformed corn starch extenders (Hleap-Zapata *et al*., 2014), achieving improvements in preservation and increased nutritional properties.

In Ecuador, 90 % of Manabí pitahaya is exported (Flores and García, 2016). Furthermore, only the edible part of the fruit, which represents about 55 % of its total weight, is used. This is used to make foods such as frozen pulp, concentrates, juices and jams, while the remaining 45 % is discarded in landfills, causing potential environmental pollution problems. Currently, it is used as fodder and in the extraction of natural pigments; however, alternatives for its use in the meat industry should be sought due to its high antioxidant content (Cervantes-Sánchez *et al*., 2017).

Pitahaya peel is a good source of bioactive compounds, such as phenolics, and also contains soluble and insoluble fibre, betalains and other volatile compounds (Lin *et al*., 2021). Currently, a variety of polyphenolic compounds have been described in the peel of red pitahaya fruits, including acids such as gallic, protocatechuic, vanillic, caffeic, syringic, p-coumaric acid, isorhamnetin triglycoside, and quercetin-3-O-rutinoside, among others (Tang *et al*., 2021).

In this context, by-products from fruit processing industries are a rich source of antioxidant compounds with protective or preventive properties against human diseases (Echegaray *et al*., 2018). On the other hand, consumers of easy-to-prepare meat products demand hamburger meat with sensory, functional, nutritional, and healthy qualities for their consumption (Cantarero-Aparicio *et al*., 2022). In light of the above, this study evaluated the effect of pitahaya peel powder on the functional and physicochemical properties and sensory acceptability of rabbit meat burgers.

Materials and methods

Location of the trial

The experimental work was carried out at the Laboratorio de Procesos Agroindustriales, Facultad de Agrociencias, Universidad Técnica de Manabí, Chone, Ecuador.

Raw materials

Pitahaya fruit peel (*Hylocereus undatus*) was used, supplied by Hacienda El Okaso, located in the Rocafuerte district. The carcass of a New Zealand White rabbit was purchased in the rabbit production area located in the city of Santo Domingo de los T'sáchilas. The other ingredients (eggs, salt, cumin, pepper, garlic powder, breadcrumbs, sunflower oil) needed to make the hamburger patties were purchased at the GRAN AKÍ supermarket in the canton of Chone, province of Manabí, Ecuador.

Preparation of rabbit meat burgers

Before preparing the burgers, pitahaya (*Hylocereus undatus*) shell powder was obtained using the methodology proposed by Muñoz-Murillo *et al*. (2024).

The rabbit carcass was selected based on organoleptic parameters compatible with a quality product: bright pink colour, firm texture and characteristic smell, with no signs of decomposition. Standard cuts were then made, measuring approximately 7 cm wide by 9 cm long. The pieces were washed with drinking water to remove surface blood residues. Finally, the cuts were vacuum-packed in food-grade polyethylene bags and frozen at a temperature of -2 °C for 24 hours in order to preserve their physicochemical and microbiological stability prior to processing.

The rabbit meat was minced using an industrial mincer with 7 mm discs, then the meat was weighed and the respective repetitions were carried out, according to the hamburger formulation (table 1). Next, homogenisation was carried out, a process that consisted of mixing the ground meat with the other raw materials (egg, salt, cumin, pepper, garlic powder, breadcrumbs, sunflower oil, and pitahaya peel powder) until a homogeneous mixture was obtained.

The meat mixture was moulded using plastic hamburger patties, then packaged, sealing the meat patties in polyethylene bags. The prepared hamburgers were stored frozen (-2 °C) for 24 hours until laboratory analysis.

Table 1. Formulation of the treatments under study for rabbit meat burgers.

Raw materials (g)	T0 $_{0\ \%\ ppp}$	T1 $_{3\ \%\ ppp}$	T2 $_{5\ \%\ ppp}$	T3 $_{7\ \%\ ppp}$	T4 $_{9\ \%\ ppp}$
Egg	50.00	50.00	50.00	50.00	50.00
Salt	15.00	15.00	15.00	15.00	15.00
Cumin	2.00	2.00	2.00	2.00	2.00
Pepper	3.00	3.00	3.00	3.00	3.00
Garlic powder	2.00	2.00	2.00	2.00	2.00
Breadcrumbs	20.00	20.00	20.00	20.00	20.00
Sunflower oil	8.00	8.00	8.00	8.00	8.00
Rabbit meat	300.00	300.00	300.00	300.00	300.00
Pitahaya peel powder	-----	9.00	15.00	21.00	27.00
Total	**400.00**	**409.00**	**415.00**	**421.00**	**427.00**

ppp: pitahaya peel powder.

Functional and physicochemical analysis

In the different treatments of processed rabbit meat burgers, their anthocyanin content (acid/base qualitative test method), DPPH antioxidant activity (Haddouchi *et al*., 2014) and ABTS (Re *et al*., 1999) by spectrophotometric assay, total phenols (Sultana *et al*., 2009) by Folin-Ciocalteu spectrophotometric assay, ether extract pigmentation (spectrophotometric scanning assay), protein (NTE INEN-ISSO 937), fat (NTE INEN-ISSO 1443), fibre (AOAC 962.09), ash (NTE INEN 520), moisture (NTE INEN-ISSO 1442), total solids (NTE INEN-ISO 1442).

Determination of texture and colorimetric characteristics

In the different treatments under study, an instrumental analysis of texture profile was performed using a Texture Tester (Shimadzu Universal Tester EZTest EZ-LX). The parameters evaluated in the APT were: hardness (N), cohesiveness (dimensionless), adhesiveness (N) and gumminess (N). Colour analysis was evaluated using a Konica Minolta CR-410FF colourimeter with printer (CIELab scale). The parameters considered were: lightness (L*), saturation (a*) and hue (b*).

Microbiological analysis

The following microbiological parameters were evaluated: mesophilic aerobes CFU.g^{-1} (NTE INEN 1529-5), *Escherichia coli* CFU.g^{-1} (AOAC 991.14), *Staphylococcus aureus* CFU.g^{-1} (NTE INEN 1529-14) and *Salmonella* 1/25 g (NTE INEN 1529-15).

Sensory analysis

The rabbit meat hamburger treatments made with pitahaya peel powder were evaluated organoleptically through sensory analysis. Seventy untrained tasters participated in the analysis. The samples were cooked in sunflower oil at a temperature of 170 °C for 6 minutes (3 minutes per side), then left to cool for 30 minutes at 28 °C. The rabbit burger patties were then chopped up and given to the tasters in random order, along with a hedonic test of sensory acceptability on a 7-point scale (1 = I dislike it very much – 7 = I like it very much). The tasters immediately determined the degree of acceptance of the following sensory attributes: flavour, aroma, colour and texture of the processed product.

Experimental design and statistical analysis

A completely randomised experimental design with a factorial arrangement was used, with five treatments including a control and three replicates per treatment, giving a total of 15 experimental units. The factor under study was the concentrations of pitahaya peel powder (3, 5, 7 and 9 %).

Minitab 18 statistical processing software was used. Analysis of variance and Dunnett's test at 5 % significance and 95 % confidence were used for the functional and physicochemical profile data. Non-parametric analysis of variance and Kruskal Wallis test at 5 % significance and 95 % confidence were used for the sensory data. The results were presented as mean ± standard deviation.

Results and discussion

Functional and physicochemical profile analysis

The results of the analysis of variance and comparison of means according to Dunnett are detailed in table 2. The anthocyanin results were interpreted according to the following assessment: - (nil); + (moderate); ++ (notable) and +++ (total change).

The presence of anthocyanins in rabbit meat burgers was zero (-) in the control treatment; however, in T1 and T2 their presence was moderate (+), notable in T3 and a total change in T4. Similar results were presented by Muñoz-Murillo *et al*. (2025), who determined a notable presence of anthocyanins in chicken nuggets with 10 % red pitahaya peel powder, demonstrating that this agro-industrial residue is rich in functional compounds such as anthocyanins. On the other hand, Rocchetti *et al*. (2022) determined that adding encapsulated elderberry extract to beef burgers caused several metabolomic changes, probably due to the abundance of different compounds such as anthocyanins. The antioxidant activity results (DPPH and ABTS) obtained were higher in T4 (23.667 ± 0.18 µmol trolox equivalent.g^{-1} - 30.353 ± 0.04 µmol trolox equivalent.g^{-1}), exceeding those published by Mancini *et al*. (2020), who obtained values for ABTS between 1.38 and 1.03 mmol trolox eq.kg^{-1}, while for DPPH their averages ranged from 0.07 to 0.960 trolox eq.kg^{-1} in rabbit hamburger meat cooked with garlic powder.

In terms of total phenol content, T4 showed the best results. Plastina Cardoso *et al*. (2023) reported 0.26 ± 0.05 mg EAG.kg^{-1}

Table 2. Functional and physicochemical profile of rabbit meat burgers made with pitahaya peel powder.

Parameters	T0 0 % ppp $\bar{X}$ ± SD	T1 3 % ppp $\bar{X}$ ± SD	T2 5 % ppp $\bar{X}$ ± SD	T3 7 % ppp $\bar{X}$ ± SD	T4 9 % ppp $\bar{X}$ ± SD	Sig. Dunnett
Anthocyanins	-	+	+	++	+++	---
DPPH (µmol Trolox)	8.496 ± 0.26ᴬ	12.772 ± 0.08	14.187 ± 0.06	18.688 ± 0.14	23.667 ± 0.18	0.000
ABTS (µmol Trolox)	15.196 ± 0.02ᴬ	17.061 ± 0.02	21.082 ± 0.01	28.341 ± 0.08	30.353 ± 0.04	0.000
Phenols (mg gallic acid)	14.425 ± 0.09ᴬ	16.502 ± 0.12	16.693 ± 0.07	19.982 ± 0.04	19.706 ± 0.05	0.000
Pigmentation	0.032 ± 0.00ᴬ	0.055 ± 0.00	0.076 ± 0.00	0.097 ± 0.00	0.113 ± 0.00	0.000
Protein (%)	20.59 ± 0.06ᴬ	19.56 ± 0.19	19.11 ± 0.07	18.70 ± 0.07	17.88 ± 0.50	0.000
Fat (%)	2.13 ± 0.13ᴬ	2.33 ± 0.25ᴬ	2.30 ± 0.06ᴬ	2.44 ± 0.21ᴬ	2.48 ± 0.20ᴬ	0.247
Fibre (%)	1.08 ± 0.02ᴬ	1.61 ± 0.16	2.05 ± 0.06	2.31 ± 0.04	3.86 ± 0.07	0.000
Ash (%)	1.99 ± 0.00ᴬ	2.27 ± 0.01	2.43 ± 0.03	2.65 ± 0.05	3.19 ± 0.04	0.000
Moisture (%)	73.27 ± 0.33ᴬ	72.68 ± 0.25	71.40 ± 0.01	70.36 ± 0.11	67.75 ± 0.13	0.000
Total solids (%)	26.72 ± 0.33ᴬ	27.31 ± 0.25	28.58 ± 0.01	29.63 ± 0.11	32.23 ± 0.13	0.000

ppp: pitahaya shell powder. Means not labelled with the letter A are significantly different from the mean of the control level.

of phenolic compounds in hamburger meat with Goji berry extract. With regard to the pigmentation of the ethereal extract in the control treatment, a lower presence (0.032 ± 0.00) was observed due to the pigment oxymyoglobin, which particularly generates an attractive red colour characteristic of meat (Valenzuela and Pérez, 2016). Pigmentation was higher in T4 due to the anthocyanins present in the pitahaya peel powder. Plant pigments and natural compounds improve colour and reduce lipid oxidation in meat-based foods.

The protein content in the processed rabbit meat burgers was lower in the treatments with ppp. This is because the protein content is low, as stated by Siriwan *et al*. (2022), who in their research determined a 6.15 % protein content in pitahaya (*Hylocereus undatus*) peel powder. Therefore, as the concentration of PPP in the formula increases, protein levels decrease considerably. However, the experimental products were within the permissible protein limit (minimum 10 %) established in the Ecuadorian standard NTE INEN 1338 (2012).

The fat values were similar among the rabbit meat burger formulations, falling within 2%, which makes the meat product an important lean food in the human diet. Mancini *et al*. (2017) demonstrated that adding ginger powder increased the PUFAω3 fatty acid compounds in rabbit meat burgers in both raw and cooked samples, unlike in this study, where the values remained the same within the same range when using pitahaya peel powder.

The significant fibre content in the meat product was due to its presence in the pitahaya peel, which, according to Siriwan *et al*. (2022), contains around 65.2 % fibre, meaning that its consumption could promote the proper functioning of the digestive system in the human body.

With regard to ash content, pitahaya peel powder had a significant influence on rabbit meat burgers, i.e. the higher the amount of pitahaya peel powder in the formula, the greater the slight increase in the ash levels of the meat product, which may benefit consumers by providing them with a food product that is a potential source of minerals.

The moisture content was higher in T0, while lower results were found in T4. The moisture content in meat products is important because this physicochemical quality parameter is the ideal medium for the proliferation and activation of pathogenic microorganisms. Studies such as that by Castro *et al*. (2020) reported a moisture content of 78.6 % in hamburger meat. The total solids results obtained in this study refer to those presented by García *et al*. (2012) with maximum averages of 38.82 ± 2.01 % total solids in hamburger meat with legume flour.

Texture profile and colorimetry

Table 3 details the results of the analysis of variance and Dunnett's comparison of means test for the texture profile and colorimetry variables.

Table 3. Texture and colorimetry profile (CIELab) in rabbit meat burgers made with pitahaya peel powder.

Parameters		T0 0 % ppp $\bar{X}$ ± SD	T1 3 % ppp $\bar{X}$ ± SD	T2 5 % ppp $\bar{X}$ ± SD	T3 7 % ppp $\bar{X}$ ± SD	T4 9 % ppp $\bar{X}$ ± SD	Sig. Dunnett
Hardness (N)		1.805 ± 0.03ᴬ	1.844 ± 0.23ᴬ	2.549 ± 0.43	2.501 ± 0.33ᴬ	4.552 ± 0.28	0.000
Cohesiveness		0.0511 ± 0.00ᴬ	0.199 ± 0.34ᴬ	0.547 ± 0.02ᴬ	0.543 ± 0.07ᴬ	0.465 ± 0.05ᴬ	0.112
Adhesiveness (N)		-0.223 ± 0.05ᴬ	-0.429 ± 0.04	-0.504 ± 0.05	-0.616 ± 0.08	-0.855 ± 0.14	0.000
Gumminess (N)		0.924 ± 0.01ᴬ	0.416 ± 0.72ᴬ	1.407 ± 0.30ᴬ	1.375 ± 0.36ᴬ	2.128 ± 0.39	0.007
	L*	53.43 ± 0.61ᴬ	48.92 ± 0.10	46.73 ± 3.68	39.39 ± 0.47	35.22 ± 1.19	0.000
CIELab	a*	2.43 ± 0.01ᴬ	14.23 ± 0.51	19.04 ± 0.20	20.76 ± 0.93	23.06 ± 0.48	0.000
	b*	12.85 ± 0.03ᴬ	7.15 ± 0.98	4.98 ± 1.14	3.23 ± 0.83	3.47 ± 1.92	0.000

ppp: pitahaya shell powder. Means not labelled with the letter A are significantly different from the mean of the control level.

The hardness of the rabbit meat hamburger was lower for the control treatment T0: 1.805 ± 0.03 N, while the treatment with the highest hardness was T4: 4.552 ± 0.28 N. These results demonstrated that the higher the concentration of pitahaya peel powder in the product, the higher the hardness values. Lima da Silva *et al*. (2023) reported a hardness of 23.1 ± 10.3 N in hamburger meat with sweet passion fruit peel. On the other hand, Parafati *et al*. (2019) demonstrated that by directly adding or encapsulating prickly pear fruit extract in the formulation of beef hamburger meat, the hardness of the meat product would increase significantly from 10.55 ± 1.46 to 15.76 ± 5.66 N. The addition of by-products to meat products can improve their texture.

The adhesiveness of rabbit meat burgers was higher in treatments with pitahaya peel powder. In contrast, Muñoz-Murillo *et al*. (2025) reported lower adhesiveness of -0.01 ± 1.10 N in chicken nuggets with 4, 7 and 10 % pitahaya peel powder, indicating that pitahaya by-products can increase or decrease adhesiveness depending on the meat product.

The gumminess was higher in treatments with percentages greater than 5 % pitahaya peel powder. These results are similar to those obtained by Muñoz-Murillo *et al*. (2025), who obtained 3.90 ± 0.29 N in chicken nuggets with 4 % pitahaya peel powder. Gumminess can be influenced by the fibre content present in pitahaya peel powder, as stated by Rocha Saraiva *et al*. (2019), who demonstrated in their study that when fat was partially replaced by brewer's waste (malt bagasse – high in fibre) in hamburger meat, the gumminess of the meat product increased considerably.

According to the CIELab scale, the treatment with the best brightness (L*) characteristic was T0 (0 % ppp), while T4 had the best saturation (a*) and tone (b*) close to reddish-yellow due to the 9 % ppp concentration. García-Vásquez *et al*. (2020) determined values of L* (48.54 ± 0.83), a* (1.70 ± 0.25) and b* (8.30 ± 0.57) for rabbit burgers infused with *Chenopodium*.

Microbiological analysis

The microbiological quality results for all treatments under study are within the requirements of standard NTE INEN 1338 (2012) for meat products (table 4).

Table 4. Microbiological analysis of rabbit meat burgers made with pitahaya peel powder.

Microorganisms	T0 $_{0\ \%\ ppp}$	T1 $_{3\ \%\ ppp}$	T2 $_{5\ \%\ ppp}$	T3 $_{7\ \%\ ppp}$	T4 $_{9\ \%\ ppp}$
Mesophilic aerobes	$1.0x10^6$	$1.0x10^6$	$1.0x10^6$	$1.0x10^6$	$1.0x10^6$
Escherichia coli	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$
Staphylococcus aureus	$1.0x10^3$	$1.0x10^3$	$1.0x10^3$	$1.0x10^3$	$1.0x10^3$
Salmonella	Ausencia	Ausencia	Ausencia	Ausencia	Ausencia

ppp: pitahaya shell powder. CFU: Colony-forming units.

Sensory analysis

The treatments under study did not show statistical significance among themselves for the variables of taste, aroma, colour and texture (table 5), i.e. statistically all treatments are considered similar in the organoleptic attributes evaluated by untrained tasters. The sensory analysis results established an organoleptic acceptance rating of 5.00 points for all treatments in terms of flavour, aroma, colour and texture in rabbit meat burgers made with pitahaya peel powder, indicating a low level of acceptability for the meat product. In contrast, studies such as that by Mohamed Mokhtar and Sallah Eldeep (2020) identified that adding 0.01 % mango peel flour to beef burgers resulted in the most acceptable sensory acceptance of the meat product by tasters.

Table 5. Sensory acceptability of rabbit meat burgers.

Sensory attributes	T0 $_{0\ \%\ ppp}$ $\bar{X}$ ± DE	T1 $_{3\ \%\ ppp}$ $\bar{X}$ ± DE	T2 $_{5\ \%\ ppp}$ $\bar{X}$ ± DE	T3 $_{7\ \%\ ppp}$ $\bar{X}$ ± DE	T4 $_{9\ \%ppp}$ $\bar{X}$ ± DE	Sig.
Flavour	5.13 ± 1.84	5.30 ± 1.73	5.17 ± 2.06	5.13 ± 1.79	5.27 ± 1.87	0.8928^{ns}
Aroma	5.17 ± 1.41	5.13 ± 1.58	5.06 ± 1.72	5.11 ± 1.51	5.30 ± 1.50	0.9491^{ns}
Colour	5.23 ± 1.56	5.34 ± 1.34	5.39 ± 1.43	4.81 ± 1.58	5.14 ± 1.51	0.1609^{ns}
Texture	5.23 ± 1.64	5.29 ± 1.51	5.61 ± 1.42	5.19 ± 1.69	5.20 ± 1.77	0.4200^{ns}

ppp: pitahaya shell powder. ns: not significant

Conclusions

A significant increase in functional and nutritional compounds was demonstrated in rabbit meat burgers enriched with pitahaya peel powder, generating a viable alternative for the use of agro-industrial waste and the nutritional improvement of meat products.

Treatment T4 showed the best results in terms of colorimetry (a* and b*) and texture profile in the variables of hardness, adhesiveness, and chewiness. The treatments were microbiologically acceptable, complying with Ecuadorian technical standard NTE INEN 1338.

Untrained tasters expressed a low degree of acceptance in terms of sensory response attributes. Therefore, it is important to conduct further studies to improve the sensory perception of tasters in the processed product.

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