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Antioxidant activity and physicochemical properties of mango nectar with pitahaya

Actividad antioxidante y propiedades físico-químicas de un néctar de mango con pitahaya

Atividade antioxidante e propriedades físico-químicas de um néctar de manga com pitahaia

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Abstract

Currently, mixed fruit nectars are generating greater consumer interest due to their potential contribution of nutrients and exotic flavors. The objective of the study was to evaluate the antioxidant activity and the physicochemical properties of mango nectar (*Mangifera indica* L.) made with various levels of pitahaya (*Hylocereus undatus*). A completely randomized experimental design was used. The test consisted of the formulation of three treatments (10, 20, and 30 % pitahaya flesh (pf) and a control). Physicochemical, functional, microbiological, and sensory parameters were evaluated. Analysis of variance and Dunnett and Kruskal Wallis mean comparison test were applied at 5 % significance. The results showed that the levels of pitahaya flesh significantly influenced the response variables of pH, viscosity, soluble solids, density, turbidity, antioxidant activity, and total phenols, on the contrary, the colorimetry parameters (L, a, b) presented a $p > 0.05$. Regarding sensorial acceptability, a $p < 0.05$ was determined in the attributes of texture, consistency, and flavor, while color and smell were not significant ($p > 0.05$). The treatments under study met the physicochemical and microbiological requirements established in the NTE INEN 2337 standard. It was shown that the addition of 30 % of pf improved the content of total phenols in mango nectar up to 0.537 ± 0.00 mg Gallic Acid equivalent.mL^{-1}. The nectars had a yellow color with a greenish hue and bright luminosity. The treatment T3 was considered the best at the organoleptic level in texture, consistency, and flavor.

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Resumen

En la actualidad los néctares de frutas mixtos generan un mayor interés de consumo por su potencial aporte de nutrientes y sabores exóticos. El objetivo del estudio fue evaluar la actividad antioxidante y las propiedades fisicoquímicas de un néctar de mango (*Mangifera indica* L.) elaborado con varios niveles de pitahaya (*Hylocereus undatus*). Se empleó un diseño experimental completamente al azar, el ensayo consistió en la formulación de tres tratamientos (10, 20 y 30 % pulpa de pitahaya (pp) y un control). Se evaluaron parámetros fisicoquímicos, funcionales, microbiológicos y sensoriales. Se aplicó análisis de varianza y prueba de comparación de promedios Dunnett y Kruskal Wallis al 5 % de significancia. Los resultados demostraron que los niveles de pulpa de pitahaya influyeron significativamente en las variables de respuesta pH, viscosidad, sólidos solubles, densidad, turbidez, actividad antioxidante y fenoles totales, al contrario, los parámetros de colorimetría (L, a, b) presentaron un p>0,05. Respecto a la aceptabilidad sensorial, se determinó un p<0,05 en los atributos textura, consistencia y sabor, mientras que, color y olor fueron no significativos (p>0,05). Los tratamientos en estudio cumplieron con los requisitos fisicoquímicos y microbiológicos establecidos en la norma NTE INEN 2337. Se demostró que la adición de 30 % de pp mejoró el contenido de fenoles totales en el néctar de mango hasta un 0,537 ± 0,00 mg Ácido Gálico equivalente.mL^{-1}. Los néctares presentaron un color amarillo con matiz verdoso y luminosidad brillante. Se consideró al tratamiento T3 el mejor a nivel organoléptico en textura, consistencia y sabor.

Palabras clave: fenoles totales, *Hylocereus undatus*, *Mangifera indica*, néctar de fruta, sensorial.

Resumo

Atualmente, os néctares mistos de fruta despertam um maior interesse por parte do consumidor devido ao seu potencial aporte de nutrientes e sabores exóticos. O objetivo do estudo foi avaliar a atividade antioxidante e as propriedades físico-químicas de um néctar de manga (*Mangifera indica* L.) elaborado com vários níveis de pitaya (*Hylocereus undatus*). O delineamento experimental foi o inteiramente casualizado; o ensaio consistiu na formulação de três tratamentos (10, 20 e 30 % de polpa de pitaia (pp) e uma testemunha). Foram avaliados parâmetros físico-químicos, funcionais, microbiológicos e sensoriais. Foi aplicada a análise de variância e o teste de comparação de médias de Dunnett e Kruskal Wallis, com um nível de significância de 5 %. Os resultados mostraram que os teores de polpa de pitaia influenciaram significativamente as variáveis resposta pH, viscosidade, sólidos solúveis, densidade, turbidez, atividade antioxidante e fenóis totais, ao contrário, os parâmetros colorimétricos (L, a, b) apresentaram p> 0,05; Quanto à aceitabilidade sensorial, determinou-se p<0,05 nos atributos textura, consistência e sabor, enquanto a cor e o cheiro não foram significativos (p>0,05). Os tratamentos em estudo cumpriram os requisitos físico-químicos e microbiológicos estabelecidos na norma NTE INEN 2337. Foi demonstrado que a adição de 30 % pp melhorou o teor de fenóis totais no néctar de manga até 0,537 ± 0,00 mg equivalente de Ácido Gálico. mL^{-1}. Os néctares apresentaram uma coloração amarela com tonalidade esverdeada e luminosidade intensa. O tratamento T3 foi considerado o melhor a nível organolético em termos de textura, consistência e sabor.

Palavras-chave: fenóis totais, *Hylocereus undatus*, *Mangifera indica*, néctar de frutas, sensorial.

Introduction

Ecuador has a large number of fruit specimens, some native to Ecuadorian biomes, and others introduced to the country. In general, most of the tropical and exotic fruits of the Ecuadorian territory are perishable in the short and long term, their consumption is local, and in turn, they present little industrialization and innovation in the food industry, which generates losses for farmers as they are undervalued and underutilized (Guevara *et al*., 2019; Valencia *et al*., 2021). Among the fruits that are underutilized at the industrial level, but of great importance in the domestic and export markets, are mangoes and pitahaya (Espinosa and Nájera, 2021).

Mango in Ecuador has an approximate production of 75,800 metric tons (Marcillo *et al*., 2021). Guayas is the province with the highest production, with an area of 7,700 hectares, of which only 6,500 are dedicated to export (Valdez *et al*., 2022). The most commonly grown varieties are: Tommy, Kent, Ataulfo, Haden, and Keitt (Quintana *et al*., 2021).

The mango fruit is a rich source of macronutrients (carbohydrates, proteins, amino acids, and organic acids) (Maldonado *et al*., 2019), micronutrients (vitamins and minerals) (Akin *et al*., 2020), phenolic acids (coumaric, ferulic, and hydroxybenzoic acid), polyphenols (quercetin, mangiferin, catechins, tannins, kaempferol, anthocyanins, gallic and ellagic acid), and carotenoids (α-, β- and γ-carotene) which are the most abundant (Veeranjaneya *et al*., 2021; Yahia *et al*., 2023). These compounds have antioxidant activity, contributing to the prevention of cancer, diabetes mellitus, cardiovascular diseases and inflammatory processes (Lauricella *et al*., 2017).

On the other hand, the pitahaya that is mainly produced in Ecuador is the *Hylocereus undatus* variety with white flesh and reddish skin (Díaz *et al*., 2024). In 2018, the province of Manabí managed to export 356.34 tons of this variety of pitahaya, with the Rocafuerte canton being a benchmark in production with 90 hectares of cultivation (Murillo *et al*., 2024).

From a nutritional point of view, this fruit is considered highly nutritious, due to its high water content (Jeronimo *et al*., 2017), carotenoids (α-carotene, β-carotene), total phenolics, antioxidant capacity, vitamin E, flavanones, dietary fiber and minerals (N, K, Fe, Mn, and Zn), pitahaya is known to have nutraceutical and therapeutic properties. Its consumption is also related to the reduction of cholesterol, antidiabetic, and digestive activity (Souza *et al*., 2023).

For the use of this type of fruit, there are various agro-industrial transformation alternatives, including the production of fruit nectars (Muñoz *et al*., 2023). This type of beverage plays an important role in human health because its consumption is associated with providing a significant contribution of essential nutrients (vitamins, bioactive compounds, and phytochemicals) that promote consumer health benefits, however, mixed fruit nectars are more appreciated compared to pure nectars (Climaco *et al*., 2019).

In this context, this study aimed to evaluate the antioxidant activity and physicochemical properties of mango nectar (*Mangifera indica* L) made with various levels of pitahaya (*Hylocereus undatus*).

Materials and methods

Location of the research

The experimental development was carried out in the Fruits and Vegetables Laboratory of the Faculty of Agricultural Sciences, Chone Extension, Technical University of Manabí.

The analysis of the physicochemical, functional and microbiological parameters of mango nectar with pitahaya was carried out in the Biochemistry, Bromatology and Microbiology Laboratories of the Faculty of Agrosciences, Technical University of Manabí.

Preparation of mango nectar with pitahaya

For the process of making the fruit nectar, mangoes of the Haden variety and pitahaya (reddish skin/white flesh) were selected, which, like the sucrose, were obtained from the Akí supermarket in the Chone canton. The water used was trademarked by MANAGUA S.A. The stabilizer carboxymethylcellulose (CMC) was obtained from the microenterprise "Químicos Maquinsa" located in the Portoviejo canton, province of Manabí.

Mango and pitahaya in good condition were received and selected, without the presence of fungi, bruises, and mechanical damage. Subsequently, a wash was carried out with a solution of sodium hypochlorite (20 ppm). Subsequently, the fruits were peeled using a stainless steel knife. The peel and seed were removed from the mango, while only the skin was removed from the pitahaya. Then, the respective pulping and refining of the fruits were carried out separately through the use of an industrial blender. In the case of the mango, it was refined for six (6) minutes, while, the pitahaya flesh was refined for three (3) minutes, then they were sieved to avoid the presence of seeds and fibers.

Next, the raw materials and ingredients detailed in Table 1 were mixed. The inputs were weighed on an analytical balance (SARTORIUS brand), and then water and mango pulp were added to a stainless steel pot. Subsequently, at a temperature of 40 °C and under constant agitation, the stabilizer mixed with sugar was added until it was completely dissolved. Then, the concentrations of pitahaya flesh were added according to each experimental treatment (Table 1), it is worth mentioning that the flesh was diluted in a 2:1.5 ratio (pitahaya flesh/water).

Table 1. Raw material and inputs for the formulation of mango nectar.

Raw materials and inputs	Treatments							
	$T0_{0\ \%\ pf}$		$T1_{10\ \%\ pf}$		$T2_{20\ \%\ pf}$		$T3_{30\ \%\ pf}$	
	%	g	%	g	%	g	%	g
Mango pulp	36.0	1800	36.0	1800	36.0	1800	36.0	1800
Water	54.0	2700	54.0	2700	54.0	2700	54.0	2700
Sucrose	9.8	490	9.8	490	9.8	490	9.8	490
Stabilizer	0.2	10	0.2	10	0.2	10	0.2	10
Total	100	5000	100	5000	100	5000	100	5000
Diluted pitahaya flesh	0	0	10	500	20	1000	30	1500

pf: pitahaya flesh.

Once the different formulations were made, the mango nectar was pasteurized at a temperature of 70 °C for 30 minutes in order to avoid the presence and proliferation of pathogenic microorganisms. An industrial thermometer was used for temperature measurement. The beverages were allowed to cool down to 55 °C, then packaged in glass bottles with a capacity of 300 mL, previously sterilized and stored in refrigeration (8 °C).

Physicochemical properties of nectar

The respective physicochemical quality analyses were carried out in the treatments under study in accordance with the provisions of the NTE INEN 2337 standard. The analyses evaluated were; pH by the method (NTE INEN-ISO 1842), viscosity by the instrumental method (rotational viscometer), soluble solids by the test method (NTE INEN 380), density (NTE INEN 1078), turbidity by the instrumental method (turbidity meter) and color (CIELab) by the instrumental test method (colorimeter).

Antioxidant activity of nectar

The antioxidant activity of mango nectars was determined by the ABTS (Re *et al*., 1999) and DPPH (Haddouchi *et al*., 2014) methods with some modifications.

For the ABTS assay, a working solution with an absorbance between 0.8 and 1 to 734 nm was prepared by dissolving the $ABTS^{+}$ radical stored with methanol for 16 hours, until the established values were achieved. Then, 1 mL of sample and control (extract dilution medium) and 1 mL of the prepared radical were added to a test tube. It was shaken with the help of a vortex and allowed to react for 1 hour. After the established time, absorbance was measured at 734 nm, using a spectrophotometer (Evolution ™ 201/220 UV-Vis Thermo Scienfitic ™, Waltham, Ma, USA). Antioxidant activity was expressed in µmol Trolox equivalent g^{-1}.

The DPPH reagent was prepared by dissolving 2 mg in 50 mL of methanol. The solution was homogenized and allowed to react in the dark for 24 hours. The working solution was obtained by mixing 2.5 mL of the DPPH reagent with 15 mL of methanol and then performing an absorbance reading in the spectrophotometer at a wavelength of 517 nm, obtaining an absorbance of 0.750 ± 0.005. An aliquot of extract (1 mL) was allowed to react at different concentrations with 1 mL of the DPPH solution for 30 minutes in the dark, then the absorbance reading was performed on the spectrophotometer at a wavelength of 517 nm. The antioxidant activity was expressed in µmol Trolox equivalent.g^{-1}.

Total phenols of nectar

The determination of the total phenolic content of the nectar was carried out following the spectrophotometric/Folin Ciocalteu method, proposed by Sultana *et al.* (2009) with some modifications, 200 uL of the sample or standards was taken, then 1.5 mL of distilled water was added and 100 uL of Folin-Ciocalteu reagent (phosphomolybdic acid + phosphotungstic acid) was added, subsequently, it was left to stand for five (5) minutes, and 200 uL of 20 % $^{m}/_{v}$ sodium carbonate was added to the resulting solution. The solution was allowed to stand for one (1) hour at room temperature in the dark, and then the absorbance reading was taken using a UV-vis spectrophotometer (Evolution™ 201/220 UV-Vis Thermo Scienfitic™, Waltham, Ma, USA) at 760 nm. The phenol content was expressed as mg gallic acid equivalent g^{-1}.

Microbiological quality of nectar

To ensure the safety of fruit nectars, the following analyses were carried out according to the NTE INEN 2337 reference standard for fruit nectars; coliforms and fecal coliforms by the test method (NTE INEN 1529-7), mesophilic aerobes according to the standard (NTE INEN 1529-5), molds and yeasts (NTE INEN 1529-1).

Sensory analysis of nectar

To determine the sensory acceptability of the nectars made, 90 semi-trained tasters participated, who were provided with a hedonic test with a scale of seven (7) points (with 1 being the lowest acceptance and 7 being the highest). The samples of each treatment were served in transparent, coded cups and in a random order, the tasters in terms of quality evaluated the response attributes: color, texture, smell, consistency, and flavor.

Experimental design and statistical analysis

A completely randomized experimental design with a factorial arrangement (unidirectional) was used, and the factors under study corresponded to the concentrations of pitahaya flesh (10, 20, and 30 %). Four (4) treatments were formulated in the study including a control. Three (3) replicates were established per treatment, obtaining a total of 12 experimental units, which are detailed in table 2.

Table 2. Treatments under study.

Treatments	Codes	% pitahaya flesh	Replicates
1	T_0	0	3
2	T_1	10	3
3	T_2	20	3
4	T_3	30	3

The statistical analysis was performed using Minitab 18 software. For the physicochemical, functional, and microbiological data of the nectar produced, an analysis of variance and a Dunnett mean comparison test were performed. Regarding the sensory profile data, non-parametric analysis of variance and Kruskal Wallis test were used. For both cases, the values were processed with 5 % significance and 95 % confidence. Results were expressed as mean ± standard deviation.

Results and discussion

Physicochemical properties of mango nectar with various levels of pitahaya

According to the analysis of variance, it is observed in table 3 that the variables under study: pH, viscosity, soluble solids, density, and turbidity presented statistical significance ($p<0.05$). On the other hand, the parameters of CIELab (L, a, and b) did not present significant differences ($p>0.05$), which indicated that the color of the beverages produced was considered similar between the treatments, presenting a luminosity close to bright, and a yellow-slightly greenish color.

The pH results in mango fruit nectars with various levels of pitahaya were significant compared to the control formulation (100 % mango). It was observed that the treatment T0 presented a lower pH (3.43 ± 0.01) and the highest value was T3 (3.92 ± 0.00).

It was determined that, as pitahaya levels increase, the pH values rise significantly, this could be due to the organic acids (malic and citric) present in the pitahaya (Wu *et al*., 2020).

However, all treatments were within the range allowed by the NTE INEN 2337 (2008) standard, which establishes a pH of less than 4.5 for fruit nectars.

A viscosity of 386.7 ± 5.91 cP was obtained for the control formulation. It was observed that the addition of 10 % pf increased the viscosity of mango nectar (453 ± 14.21 cP), on the contrary, it decreased by 30 % (304.2 ± 6.06 cP) in the processed product. Uranga *et al*. (2022) reported a viscosity of 174.7±8.1 mPa·s in nectar made with mango of the Ataulfo variety. According to Elbandy *et al*. (2014) for consumers, viscosity is an important property in the nectars of all fruits.

The soluble solids for the treatments T0, T1, and T2 were similar, with no statistical significance between them, the values ranged from 10.10 ± 0.17 – 10.26 ± 0.15 %, while the formulation T3 presented a higher value (11.83 ± 0.37 %). According to the NTE INEN 2337 (2008) standard, mango fruit nectar must have a minimum soluble solids value of 2.75%, in this research all formulations complied with the requirements of the reference standard.

Dunnett's test showed that the density results for T0 and T1 were not significantly different (1.039 ± 0.00 – 1.039 ± 0.00 $g.mL^{-1}$), on the other hand, T2 and T3 presented statistical significance compared to the control, with T3 being the treatment with the highest density 1.047 ± 0.00 $g.mL^{-1}$. According to Macías *et al*. (2022), the density can vary around the components and dissolved substances that are present in the nectar, whether these are fruits, stabilizers, amino acids, enzymes, and salts.

Fruit nectars with various levels of pitahaya presented a significantly different turbidity compared to the control treatment, when adding 10 % of pitahaya flesh, the turbidity decreased to 4176 ± 195 NTU, while with 30 % it presented the highest turbidity with a value of 6696 ± 355 NTU. According to Muñoz *et al*. (2023), the interaction between different raw materials can increase or decrease turbidity in fruit nectar, because combining them may or may not generate a greater presence of suspended solids.

Antioxidant activity and phenol content in mango nectar with various levels of pitahaya

Table 4 shows that the analysis of variance (ANOVA) determined statistical significance ($p<0.05$) in all functional profile variables.

Table 3. Physicochemical parameters in mango nectars with various levels of pitahaya.

Physicochemical parameters		Experimental treatments				Sig. Dunnett
		T0 $_{0\ \%\ pF}$	T1 $_{10\ \%\ pf}$	T2 $_{20\ \%\ pf}$	T3 $_{30\ \%\ pf}$	
pH		3.43±0.01 ^{A}	3.65±0.01	3.80±0.00	3.92±0.00	0.000
Viscosity $_{(cP)}$		386.7±5.91^A	453.9±14.21	334.8±3.38	304.2±6.06	0.000
S. S $_{(\%)}$		10.10±0.17 ^{A}	10.03±0.00 ^{A}	10.26±0.15^A	11.83±0.37	0.000
Density ($g.mL^{-1}$)		1.039±0.00^A	1.039±0.00 ^{A}	1.041±0.00	1.047±0.00	0.000
Turbidity $_{(NTU)}$		4780±137 ^{A}	4176±195	6054±175	6696±355	0.000
CIELab	L	39.97±4.43^A	36.07±3.25 ^{A}	41.69±5.20^A	37.77±3.13^A	0.409
	a	-1.09±0.55 ^{A}	-0.94±0.89 ^{A}	-0.48±1.19 ^{A}	-0.05±0.51 ^{A}	0.459
	b	2.34±1.37 ^{A}	2.42±0.90 ^{A}	1.65±1.63 ^{A}	4.17±0.11 ^{A}	0.129

Means not labeled with the letter A are significantly different from the mean of the control level. **S.S:** Soluble solids. **pf:** pitahaya flesh.

Table 4. Functional profile parameters in fruit nectars.

Functional parameters	Experimental treatments				Sig. Dunnett
	T0 $_{0\ \%\ pf}$	T1 $_{10\ \%\ pf}$	T2 $_{20\ \%\ pf}$	T3 $_{30\ \%\ pf}$	
A.A ABTS (μmol Trolox equivalent. mL^{-1})	5.109±0.01 ^{A}	4.802±0.20	4.728±0.10	4.604±0.08	0.005
A.A DPPH (μmol Trolox equivalent. mL^{-1})	5.135±0.12 ^{A}	4.066±0.27	4.255±0.12	4.318±0.09	0.000
Total phenols (mg Gallic Acid equivalent. mL^{-1})	0.456±0.00 ^{A}	0.509±0.00	0.514±0.01	0.537±0.00	0.000

Means not labeled with the letter A are significantly different from the mean of the control level. **A.A:** Antioxidant activity. **pf:** pitahaya flesh.

Dunnett's test for antioxidant activity parameters (ABTS/DPPH) determined statistical significance between T1, T2, and T3 compared to the control treatment. In both cases, the 100 % mango nectar presented the highest value in antioxidant activity (5.109 ± 0.01 – 5.135 ± 0.12 μmol Trolox equivalent.mL^{-1}), on the contrary, those nectars with pitahaya flesh presented the lowest results, in ABTS (4.802 ± 0.20 – 4.604 ± 0.08 μmol Trolox equivalent.mL^{-1}), and DPPH (4.066 ± 0.27 – 4.318 ± 0.09 μmol Trolox equivalent.mL^{-1}). Barakat *et al*. (2017) reported antioxidant activity values between 39 - 13.32 μmol TE g^{-1} in mango nectar sweetened with Stevia. This corroborated that mango beverages are rich in this functional compound of importance in the health of consumers.

In total phenols, mango nectar treatments with various levels of pitahaya were significantly different compared to the control treatment. It was evidenced that, as the concentrations of the factor under study (pf) increased, the values of total phenols increased considerably in mango nectar, which could be due to the presence of a higher content of these functional compounds in the pitahaya flesh. According to Díaz *et al*. (2024), pitahaya can provide between 45.40 – 40.38 mg GEA.100 mL^{-1} of total phenols. The 100 % mango nectar had the lowest total phenol value with 0.456 ± 0.00 mg Gallic Acid equivalent.mL^{-1}, on the contrary, the T3 formulation had a higher content (0.537 ± 0.00 mg Gallic Acid equivalent.mL^{-1}). Dyab and Abo-Taleb (2024) reported 17.48 ± 0.15 – 18.49 ± 0.19 mg.100 g^{-1} GAE in total phenolic compounds for mango nectar supplemented with basil by-product, which indicates that by adding raw materials that have functional properties in mango nectar, its phenolic content can be improved.

Microbiological quality of mango nectars

Table 5 shows the results of microbiological quality present in nectars made with mango fruits with various levels of pitahaya. The absence of coliforms and fecal coliforms was evidenced in all experimental treatments. Regarding the pathogen molds and yeasts, a count of 3.83 x 10 – 9.00 x 10 CFU.mL^{-1} was presented.

As for the presence of mesophilic aerobes, values between 5.75 x 10 3.93 x 101 CFU.mL^{-1} were determined. However, all mango nectar formulations with various levels of pitahaya were within the permissible limits established by the Ecuadorian technical standard NTE INEN 2337 (2008), which made it possible to guarantee a safe product for the consumer.

Sensory acceptability in fruit nectars

Table 6 shows the results of non-parametric analysis of variance for sensory profile variables. It was determined that the color and smell attributes did not present statistical significance between treatments (p>0.05). According to the ANOVA, the attributes that did show significant differences were the parameters texture, consistency, and flavor.

According to the results, the formulation with the greatest acceptance in texture was T3 with an average of 4.37 ± 1.42 and a hedonic scale rating of neither like it – nor dislike it. Other research, such as that of Calandrini *et al*. (2020), has shown that when mixing pitahaya and passion fruit, an acceptability in texture of 6.14 points and a degree of acceptance of I like little can be obtained, so it is advisable to make combinations with lower percentages of fruits, as long as they comply with the current regulations of each country.

According to the results obtained in this work, all the formulations developed presented an acceptability of neither like nor dislike in the consistency attribute, however, T3 with a score of 4.74 ± 1.34 was considered the best treatment for organoleptic acceptance. Obregón *et al*. (2019), determined an acceptability in consistency of 2.08 for a mixed nectar of *aguaymanto, camu camu,* and pitahaya with 5% soluble fiber, demonstrating that fructooligosaccharides (FOS) do not produce negative effects on the sensory acceptance of beverages. According to Villafán *et al*. (2024), the pitahaya fruit has FOS up to 86.49 ± 13.50 g.kg^{-1} depending on the variety and the condition of the fruit, however, the presence of this natural compound may have influenced the perception of the tasters about the consistency in the mango nectar, however, it did not negatively affect the acceptance of the product.

Table 5. Microbiological parameters in mango nectars.

Microbiological parameters	Experimental treatments				Sig. Dunnett
	T0 $_{0\ \%\ pf}$	T1 $_{10\ \%\ pf}$	T2 $_{20\ \%\ pf}$	T3 $_{30\ \%\ pf}$	
Coliforms (CFU.mL^{-1})	0 x 10	0 x 10	0 x 10	0 x 10	Sd
Fecal coliforms(CFU.mL^{-1})	0 x 10	0 x 10	0 x 10	0 x 10	Sd
Molds and yeasts (CFU.mL^{-1})	3.83 x 10 ^{A}	5.00 x 10	6.96 x 10	9.00 x 10	0.000
Mesophilic aerobes (CFU.mL^{-1})	5.75 x 10 ^{A}	7.50 x 10 ^{A}	6.78 x $10^{1\ A}$	3.93 x $10^{1\ A}$	0.665

Means not labeled with the letter A are significantly different from the mean of the control level. Nd: No difference. **pf:** pitahaya flesh.

Table 6. Sensory acceptability in mango nectars.

Sensory parameters	Experimental treatments				Sig. K.W.
	T0 0 % pf	T1 10 % pf	T2 20 % pf	T3 30 % pf	
Color	4.43±1.29 a	4.28±1.12 a	4.21±1.19 a	4.32±1.38 a	0.4645
Texture	4.28±1.25 ab	4.03±1.13 a	3.99±1.26 a	4.37±1.42 b	0.0495
Smell	4.13±1.34 a	4.09±1.11 a	4.03±1.28 a	4.12±1.31 a	0.9692
Consistency	4.58±1.37 bc	4.29±1.08 a	4.38±1.13 ab	4.74±1.34 c	0.0053
Flavor	4.33±1.20 b	3.86±1.16 a	3.88±1.36 a	4.36±1.45 b	0.0020

Means with a common letter are not significantly different (e>0.05). **pf:** pitahaya flesh.

For the flavor attribute, the treatments T1 and T2 with a score of 3.86 ± 1.16 – 3.88 ± 1.36 were the formulations with the lowest acceptance, on the contrary, with the highest sensory acceptability was the treatment T3, which presented an average approval of 4.36 ± 1.45, which indicates that a concentration of 30 % of pitahaya flesh generated greater acceptability, similar to the score of 100 % mango nectar (4.33 ± 1.20). Studies conducted by Rivera *et al*. (2023), determined 8.58 points in flavor for nectar with 12 % mango, 30 % tomato, and 2 % ground chia, values above that obtained in this research. It is highlighted that the combination of fruits, by-products, cereals, and vegetables can improve the panelists' perception of flavor because they become more attractive beverages for the consumer.

Conclusions

Mango nectar with various levels of pitahaya met the physicochemical and microbiological requirements established in the NTE INEN 2337 reference standard for fruit nectars.

It was evidenced that pitahaya concentrations can improve the density and viscosity of beverages.

At the colorimetry level, all the formulations presented a yellow color, with a tendency to a greenish hue, and luminosity close to bright.

It was determined that the addition of several levels of pitahaya flesh did not increase the content of antioxidant activity in the mango nectar, on the contrary, they did generate a greater presence of total phenols in the beverage. However, all formulations are potentially beneficial to the consumer due to the presence of functional compounds.

The untrained tasters determined a higher degree of sensory acceptability in mango nectar with 30 % pitahaya flesh, which corroborated that combinations of this type of fruit can be more attractive, due to their exotic flavors, consistency, and texture desired by the consumer.

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