Flour production from mango peel residue and use in pastry psroducts

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Abstract

This article discusses the formulation and development of flour made from mango peel, a byproduct that is usually discarded by the food industry. However, recent studies have shown that mango peel has a high fibre and antioxidant content. A bibliographic review was conducted on the nutritional benefits of this flour, and experimental tests were performed to evaluate its viability in pastry formulations. Laboratory analyses confirmed the absence of pathogens according to the parameters of the INEN 616 standard. Discriminant sensory tests were conducted with semi-trained panelists to evaluate acceptability and organoleptic characteristics in processed products. After optimizing formulations by adjusting ingredients and production processes, sponge cake with 30% wheat flour replaced by mango peel flour was the most accepted in terms of taste, texture, and appearance. Finally, standard recipes are proposed to Favor future applications and the sustainable use of by-products, as well as the reduction of food waste.

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Introduction

Ecuador's warm climate is ideal for cultivating various fruits and vegetables, especially mangoes. The province of Guayas leads the national mango production with approximately 7,700 hectares dedicated to this crop. Of that total, 6,500 hectares are oriented toward export, and the remaining 1,200 hectares are used for domestic consumption and industrialization (Loor Marquínez et al., 2023). The mango (Mangifera indica L.) is recognized as a high-quality exotic fruit that is in high demand among consumers and industries due to its excellent flavour, nutritional value, and versatility in producing various processed goods. In the Ecuadorian coastal region, different varieties of mango are cultivated, with Tommy Atkins being the predominant variety, representing around 57% of the total regional production. The Haden variety follows with 21%, and Kent is in third place with 14%. Keitt, Autaulfo, Edward, Van, and Splind Felds account for the remaining 8% of the regional crop (Atkins et al., 2014). Mango is one of the most widely consumed fruits worldwide, thanks to its pleasant taste and remarkable nutritional content. It is especially rich in vitamins and dietary fibre. Additionally, mangoes stand out for their significant antioxidant, polyphenol, and carotene content, which provides multiple health benefits. According to the Food and Agriculture Organization of the United Nations (FAO), mangoes were the third most exported tropical fruit globally in 2015, with Asia leading exports at 78.4%, followed by Africa at 8.5% and South America at 13.1% (María Eugenia García Álvarez & Hernández, 2017). In the food industry, mangoes are primarily used to produce processed goods such as gelatine, pulp, dehydrated products, and preserves, especially jams and jellies. Typically, the pulp is the main ingredient, and the peel is discarded (Guachamín, 2021). However, recent research has shown that, with appropriate treatment, the peel can be used as a food byproduct, increasing the nutritional value of products by partially replacing other flours in standard formulations that consumers accept.

In Ecuador, more than 50 varieties of mango have been cultivated, including the popular Tommy Atkins, Haden, Keitt, Ataulfo, and Edgar varieties, as well as native varieties such as Suking, Apple, Cinnamon, Camphor, and Knife. Mango is a highly nutritious fruit, offering an abundance of vitamins, minerals, and proteins (Duque & Gómez, 2010). However, the industrial processing of mango generates significant amounts of waste due to its composition. It is 79% pulp, 10% peel, and 11% seed. However, only 79% is used, and the remaining 21% is discarded. The peel is underused in the food industry due to a lack of knowledge about its nutritional and functional properties, despite its high antioxidant content, which helps reduce the risk of diseases such as cancer (Ajila & Prasada Rao, 2013).

The carbohydrate and dietary fibre content of mango peel is driving growing interest in its potential as a functional ingredient in dehydrated powders. These products enrich flours and constitute an attractive alternative for improving nutritional value (Álvarez-Parrilla, 2018). The food industry must respond to consumers' nutritional needs and mitigate environmental pollution by transforming waste into functional products that generate economic benefits for the sector (Wall-Medrano et al., 2015). This article addresses the production of flour from mango peel for use in pastries. It uses a combined quantitative and qualitative methodology that allows for optimal results that meet consumer expectations.

Materials and Methods

A mixed methodology combining qualitative and quantitative approaches within an experimental and descriptive design was used. This strategy yielded accurate, detailed results regarding the use of mango peel and consumer acceptance

Data collection techniques: universe, sample, population and target group

The evaluation carried out by the inhabitants of Guayaquil provided crucial data on the acceptance and effectiveness of the product made from mango peel flour. This evaluation involved tabulating survey results to generate a comprehensive dataset. The sample size was determined using a finite formula, ensuring the reliability and validity of the results. Finite formula is shown in (1).

$$n = \frac{Z^2 * p * q * N}{e^2(N-1) + Z^2 * p * q} \qquad (1)$$

Where:
n = Sample size
N = Population size 2,644,891 inhabitants in the city of Guayaquil
Z = 95% confidence level
e = Margin of error (o.05%)
p = 50% probability of success (0.5)
q= 50% probability of failure (0.5)

According to the results obtained under the finite formula, a survey was carried out on 384 people for different parishes in the city of Guayaquil using technology such as Google forms.

Materials to produce flour and mango peel-based product.

Specialized materials such as convection oven, thermometers, mill, food processors and professional blender were used, along with basic ingredients such as eggs, wheat flour and milk, allows the efficient production of flour and mango peel-based products, this scientific approach not only maximizes the use of food resources, but also drives innovation in the food industry, promoting sustainable and nutritious alternatives for human consumption.

Survey of a specific group and evaluation of semi-trained panellists

The qualitative survey was presented as an essential tool for data collection. It was specifically designed for the residents of the Guayaquil canton. The objective of the survey was to identify the level of knowledge of the use and acceptance of mango flour in confectionery products made with this raw material. The tasting tests allowed for the identification of cause-and-effect relationships and the differentiation of options. For this purpose, a group of 10 semi-trained judges evaluated the characteristics of the product based on mango flour, including aroma, flavour, colour, and texture. The hypothesis test of one-tailed was used, depending on the case. The Student's T statistic was used for less than 30 data points, whose value is -1.729 for hypothesis tests of left tail and 1.729 for right tail.

Confidence Level Formula is shown in (2).

$$t = \frac{X - \mu}{s/\sqrt{n}} \quad (2)$$

Where:
t = Confidence Level
x = Sample Mean
μ = Population Mean
s = Known Standard Deviation
√n = Square Root of Sample Size

Pilot hedonic test

The pilot hedonic test was used to evaluate the level of liking or disliking a product. This test is essential in product development because it allows for determining consumers' preferences and their willingness to buy. The hedonic test was initially carried out with a pilot group of 30 individuals. Each participant selected the sample they liked the most. This was later developed to evaluate the acceptance of the product in the city of Guayaquil. One-factor analysis of variance (ANOVA) was also used to analyse the data obtained and verify that the best evaluated formulation was statistically accepted. Hypothesis tests were also applied using the Z statistic, since the sample size exceeded 30 participants. A critical value of -1.65 was used for left-tail hypothesis tests and 1.65 for right-tailed hypotheses, in order to evaluate the degree of acceptance of the formulation is as follows:

Confidence Level Formula is presented in (3):

(3)

$$Z = \frac{\overline{X} - \mu}{\sigma/\sqrt{n}}$$

Where:
z = Confidence Level
x = Sample Mean
μ = Population Mean
o = Known Standard Deviation
$\sqrt{n}$ = Square Root of Sample Size

Experimental design in the production of products based on mango peel flour

The experimental phase was conducted with the objective of producing mango flour for use in a final product. The initial step involved the separation of the pulp from the peel, followed by the removal of any meat residue to ensure optimal dehydration (Larios et al., 2019). It is essential to prepare and disinfect all equipment and materials prior to use. For instance, kitchen ovens used for dehydration, blenders or grinders for pulverization, and other such equipment must be maintained in a safe environment. This will ensure that the final product is suitable for human consumption when samples are sent for evaluation in laboratories.

A survey was carried out to collect preferences for the consumption of pastry products among the target population. Several options were offered, considering the results, and the three most popular preparations were selected for the experiments. Various formulations were tested using mango peel flour in percentages ranging from 30% to 70% of the total recipe. The base recipes were adapted to enhance the samples' familiarity and appeal. Additionally, efforts were made to differentiate them from traditional preparations to highlight their unique characteristics. A tasting test was conducted to gather feedback that informed adjustments to the production process. These adjustments were made to create improved options for final evaluation by the target group.

Results and Discussion

The results obtained were derived from the implementation of several qualitative and quantitative aspects, encompassing experimentation and survey administration.

Flour experimentation

The ingredients used in the preparation of the flour were selected based on criteria that prioritized quality and freshness. To ensure the safety and quality of the final product, the fresh mangoes were meticulously disinfected using a combination of water and a specialized disinfectant solution designed for use on fruits. Additionally, a thorough cleaning and disinfection process involving vinegar was implemented for the equipment utilized in the dehydration and storage of the mango peel. To prevent contamination, please refer to the accompanying diagram, which illustrates the selection of ingredients and the streamlined process for producing mango flour.

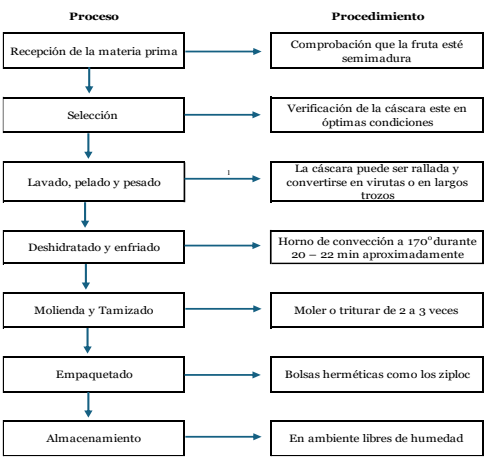


Fig. 1. Flow chart of mango peel flour production.

Mango peel flour, a product of an artisanal process, must be stored in a dry environment and protected from sunlight to ensure its quality is maintained. Its shelf life is approximately two to three days from the time of production, if it has undergone the proper dehydration, packaging, and storage procedures. The yield of flour from 100 grams of dehydrated husk is approximately 25 to 30 grams, contingent upon the moisture content of the husk.

Product experimentation

The results of the study on consumer preferences for pastry products indicate that the most outstanding products were selected for further analysis. A group of semi-experts was convened to sample the prepared biscuits, biscuits, and pastry cream. The cake made with mango flour was found to have a 42.96% acceptance rate. The present study will focus on the elaboration of a cake using mango peel rejects and its transformation into flour. To this end, three variations were carried out. The first involved the elaboration of a sponge cake using wheat flour and mango peel flour, together with specific ingredients for pastry. These variations were designated "code 219 samples" and were subdivided into three categories: A, B, and C. The objective of this study is to ascertain the optimal percentage of each ingredient in the samples to obtain accurate results in the tasting by the semi-experts. The procedure will commence with a demonstration of each sample.

Sample code 219 A: In the first test, 22.5% wheat flour, 2.5% mango peel flour was used, using base ingredients from the pastry such as sugar, eggs, margarine, mixing these ingredients and obtaining a homogeneous mixture by incorporating the mixture in a mold of 10 cm diameter with wax paper and introducing it in the oven at 180°C for 25 minutes, resulting in a product with a pleasant texture and A natural cake aroma.

Sample code 219 B: In this second test, the amount of mango peel flour was increased to 7.5%, wheat flour by 17.5%, adding the same percentages of the base ingredients of the cake mentioned above, and introducing the mixture in a 10 cm diameter mold with wax paper, it is baked in the oven at 180° C for 20-25 minutes, In this way, a soft aroma and pleasant texture were obtained.

Sample code 219 C: In the same way, the percentage of mango peel flour increased to 12.5% and wheat flour to 12.5%, and with this formula a hard and heavy product with a strong taste and smell of the peel was obtained.

Table 1. Table of percentages of the preparation of the cake with substitution of mango peel flour.

Sample 219			
Description	**To**	**B**	**C**
Wheat flour	22,5%	17,5%	12,5%
Marva	22,5%	22,5%	22,5%
Sugar	24%	24%	24%
Egg	25%	25%	25%
Cornstarch	2.5%	2.5%	2.5%
Salt	0.01%	0.01%	0.01%
Mango Peel Flour	2,5%	7,5%	12,5%
Total	100%	100%	100%

Table 1 shows the different variations derived from the use of the samples, where the use of mango peel flour is contrasted with other commonly used conventional ingredients.

Table 2. Laboratory results on the evaluation of wheat flour from Tommy Atkins mango peel.

Wheat flour	Parameters	Method	Results	Unit
	Total Aerobes*	AOAC 986.33	1x104	UFC/G
	Coliforms. Total*	AOAC 991.14	1 X 101	UFC/G
	E. Coli*	AOAC 991.14	Absence	Absence/Presence

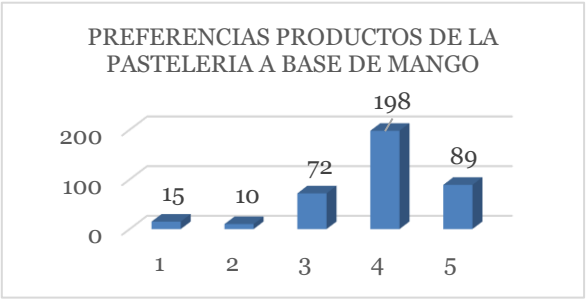
	Salmonella*	Aoac ri 041101	Absence	Absence/Presence
Nte616	Yeasts & Molds*	Aoac 100401	1 X 102	UFC/G
	Humidity	Ntn Inen 518	0.12	Percentage (%)
	Ash	AOAC 942.05	0.079	Percentage (%)
	Protein	AOAC 995.04	0.089	UFC/G
	Sugars	---	0.095	Percentage (%)
	Acids	Aoac 967.21	0.05	Percentage (%)

The samples were sent to the laboratory for physicochemical and microbiological analysis under NTE616, considering bacteria such as E. coli and salmonella, passing both tests indicating safety for human consumption, the physicochemical results showing percentages within the limits allowed by current regulations, in addition, an article external to the standard is included, without qualified parameters, considered a relevant data due to the nature of the fruit and the research.

Survey Results

The surveys were administered via the Google Forms platform and disseminated among the inhabitants of Guayaquil, within the designated territorial limitations established for the study using mango peels. Therefore, it is posited that the formulation of a proposal cantered on mango peel flour has the potential to encourage its consumption as a nutritionally beneficial alternative.

Below are the most relevant questions and figures that represent their results from the survey.



How much would you like to test a pastry by-product using a mango as a base?

Fig. 2 shows the answers to the question: How much would you like to try a pastry by-product using a mango as a base?, For the 384 people surveyed in the city of Guayaquil, the same one that through the Likert scale, represents in the population that would like to consume a by-product from mango, finding a classification of 51.56%; followed by 23.17%; which represent to a greater extent a favourable opinion to the creation of something new, therefore, it can be seen that it is aimed at a common interest.

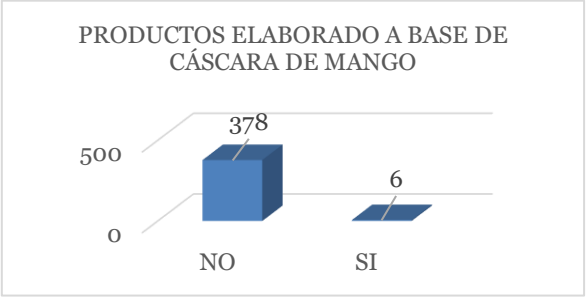


Fig. 3. Do you know any products made from mango peel?

Fig. 3 determines the products made from mango peels, showing the answers to the question: Do you know of any products made from mango peels?; of the 384 people surveyed in the city of Guayaquil, in this

representation it is evident that 98.44% of the population does not have knowledge about products made with mango within the canton of Guayaquil, these data are useful to consolidate the initiative of the development of a product based on mango peel, and with this it could be encouraged to consume a wasted by-product such as the peel.

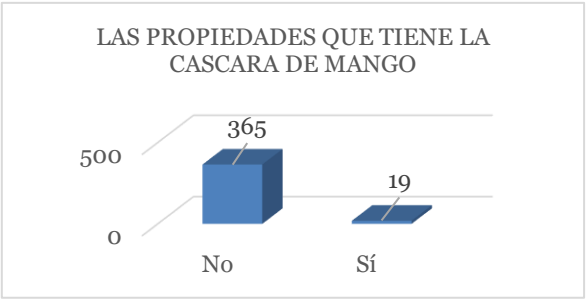


Fig. 4. Do you know the properties of the mango peel?

With the question: Do you know the properties of mango peels? and with the number of 384 people surveyed, it can be seen in Fig. 4 that the lack of knowledge about the benefits of mango peels has a total of 95.05% of the entire population surveyed.

With the following question, it was possible to choose the decisive product for this research; Made from mango peel flour and demonstrate a product rich in vitamins and with nutritional properties.

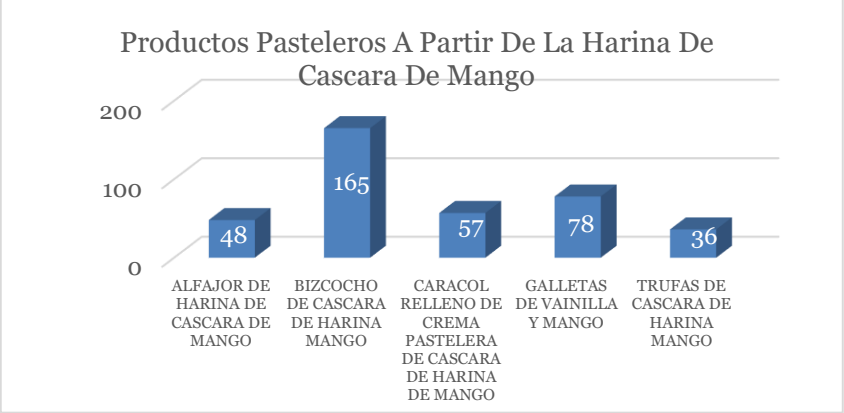


Fig. 5. Pastry products from mango peel flour

With the survey of the question: Pastry products from mango peel flour, from the same number of people surveyed in the city of Guayaquil, it is possible to represent Fig. 5, and the graph that the participating population considers that the main preparation to use is a cake with 42.96%, followed by vanilla cookies with mango with 20.31%, and in third position a snail with a pastry cream filling of the product with 14.84%, these are the products with the most selection and that will go to the experimentation stage.

Sensory Analysis Results (Semi-Trained Test)

The semi-trained panellists assessed the degree of satisfaction with the product using a discriminating sensory analysis, using a 7-point hedonic scale, ranging from "I like it a lot" to "I really dislike it". A minimum score of 2 was established as a criterion in each attribute evaluated, the study was carried out in Guayaquil, where these panellists were specifically surveyed in relation to preparations made with mango peel flour.

The result is presented in statistical tables that reflect the data provided by the experts in the tasting, with a focus on the tests carried out with the cake made with this flour, since the cookies and pastry cream obtained a lower acceptance by the semi-trained panellists.

The results obtained are detailed below:

The proportional percentages of mango peel flour used in samples A, B and C for the preparation of the cake are shown, these percentages reflect the varied amounts used in the previous samples as part of the evaluation process.

- Bizcocho A is made of 2.5% Mango Peel flour.
- Bizcocho B is made of 7.5% Mango Peel flour.
- Bizcocho C is made of 12.5% Mango Peel flour.

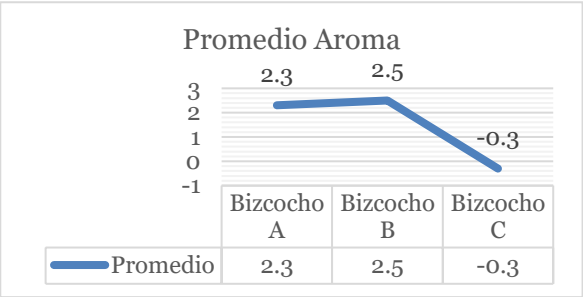


Fig. 6. Average Sponge Cake Aroma

In Fig. 6, the comparison of the 3 samples was obtained, where the characteristics of the "Aroma" were evaluated, in which it can be seen how the best average was attributed to sample "B", followed by sample "A", with preparation "C" being outside the average required to be accepted in the test performed.

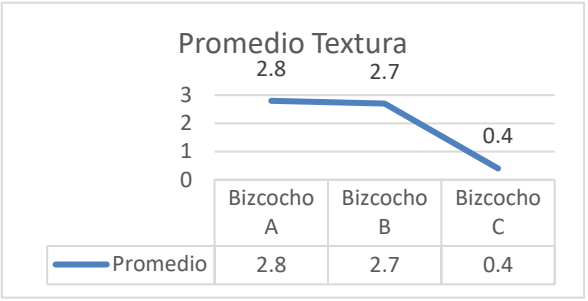


Fig. 7. Average Sponge Texture

Fig. 7 evaluates the distinction between the 3 samples, focusing on the attribute "flavour", it is observed that the first formulation obtains the best average of the three samples evaluated; the second formulation presents a difference of only one tenth in the average; in contrast, the third formulation shows the lowest average, with 0.4 points.

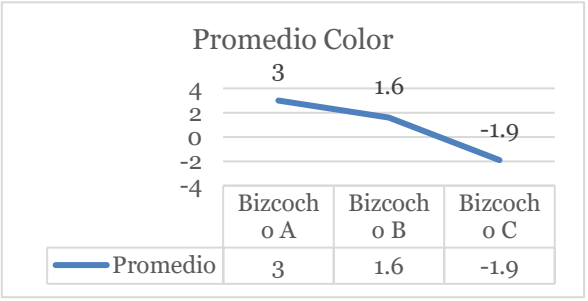


Fig. 8. Average Sponge Cake flavour

As can be seen in Fig. 8, the difference that exists in the "Flavour" attribute is shown, where the formulation "A" and "B" reach an average of 2, however, in this table it can be seen that the formulation "C" does not reach a score higher than 1.

Table 3. Analysis of the attributes of the cake.

Aroma					
Product	**Average**	**Stand Dev.**	**Statistic z**	**Value "t"**	**Result**
Sponge cake A	2,3	0,48	$t=\frac{2,30-2}{0,48\sqrt{10}}$	0,2	H0 Accepted
Sponge cake B	2,5	0,53	$t=\frac{2,5-2}{0,53\sqrt{10}}$	1,67	H0 Accepted
Sponge cake C	-0,3	0,67	$t=\frac{-0,03-2}{0,67\sqrt{10}}$	-0,95	H0 Accepted
Texture					
Product	**Average**	**Stand Dev.**	**Statistic z**	**Value "t"**	**Result**
Sponge cake A	2,8	0,42	$t=\frac{2,8-2}{0,48\sqrt{10}}$	0,6	H0 Accepted
Sponge cake B	2,7	0,48	$t=\frac{2,7-2}{0,48\sqrt{10}}$	0,46	H0 Accepted
Sponge cake C	0,4	0,52	$t=\frac{0,4-2}{0,52\sqrt{10}}$	-0,97	H0 Accepted
Colour					
Product	**Average**	**Stand Dev.**	**Statigrapher z**	**Value "t"**	**Result**
Sponge cake A	2,3	0,00	$t=\frac{2,30-2}{0,48\sqrt{10}}$	0	H0 Accepted
Sponge cake B	2,5	0,52	$t=\frac{2,5-2}{0,52\sqrt{10}}$	-0,24	H0 Accepted
Sponge cake C	-0,3	0,74	$t=\frac{-0,03-2}{0,74\sqrt{10}}$	-1,67	H0 Rejected
Taste					
Product	**Average**	**Stand Dev.**	**Statigrapher z**	**Value "t"**	**Result**
Sponge cake A	2,9	0,32	$t=\frac{2,9-2}{0,32\sqrt{10}}$	0,89	H0 Accepted
Sponge cake B	2	0,47	$t=\frac{2-2}{0,47\sqrt{10}}$	1,49	H0 Accepted
Sponge cake C	0,6	0,70	$t=\frac{0,6-2}{0,70\sqrt{10}}$	-0,63	H0 Accepted

As demonstrated in Table 3, an analysis of variance was conducted, resulting in the conclusion that the formulations of the cake prepared with different mango peel flour formulations exhibited significant differences between the preparations. Consequently, the formulation that is furthest from the rejection zone is deemed to be the most suitable.

Table4. Complementary analysis of the sponge cake formulations

	Smell	**Texture**	**Color**	**Taste**
Sponge cake A	Something close ZR	Something close ZR	Something close ZR	Further away from the ZR
Sponge cake B	Further away from the ZR	Closer to the ZR	Further away from the ZR	Something close ZR
Sponge cake C	Closer to the ZR	Further away from the ZR	In the rejection zone	Closer to the ZR

In Table 4, it was concluded that formulation "B" will be taken to a second sensory analysis, this being the pilot hedonic test because statistical analysis results are obtained that indicate attributes further away rejection zone, being the optimal of the three formulations presented; in the same way, the "B" cake will be modified taking into account the observations provided by the group of semi-trained panellists, and a new formulation will be made that will be presented to the target market.

- Red: Rejection zone
- Blue: Moves farther away from the rejection zone
- Yellow: Something is moving away from the rejection zone
- Orange: Closer to the reject zone

Result of the Pilot Hedonic Test

The hedonic analysis cantered on the level of liking exhibited by the samples, as evaluated by the initial jury. The preparations were modified in accordance with the observations made by the evaluators, with adjustments to percentages and enhancements to the organoleptic properties achieved through the incorporation of mango peel flour. The obtained data indicates a high level of liking across all samples evaluated, signifying a positive acceptance within the target population for this gastronomic innovation. Similarly, the results obtained for the sponge cake are presented, as it was the preparation that garnered the most acceptance.

Table 5. Table of data on the hedonic test carried out on the target population.

9-point hedonic test	Samples:	Sample 219				
	Aspects	Appearance	Colour	Smell	Taste	Texture
I dislike it Extremely		0	0	0	0	0
I dislike it a lot		0	0	0	0	0
I dislike it moderately		0	0	0	0	0
I dislike it little		0	0	0	0	0
I don't like it/ I don't dislike it		5	2	2	4	4
Like Little		6	4	1	1	1
Like Moderately		10	7	9	3	6
I like it a lot		3	10	9	9	12
Like Extremely		6	7	9	13	7
Total, of responses		30	30	30	30	30

Table 5 presents the data of the pilot hedonic test carried out in the target group of the city of Guayaquil, 30 tests were carried out with people from this population to evaluate the level of liking of the products that passed the first analysis, the same attributes previously evaluated were considered and the appearance of the product was added as an additional characteristic. Subsequently, a unilateral hypothesis test was carried out to determine that the product is within the established acceptance range.

Fig. 9. Hedonic test biscuit

As illustrated in Fig. 9, the sponge cake sample was subjected to analysis. The flavour attribute demonstrated a notably favorable reception in comparison to the other properties. Additionally, it was observed that the attributes such as texture, aroma, and color received a median level of approval. The appearance attribute, however, received a comparatively lower score. It is noteworthy that the cake exhibited superior quality in terms of flavour, yet its appearance did not meet the respondents' expectations, as it was only moderately agreeable to them.

Attribute Results

These analyses determined that formulations obtained a minimum rating of 3, after the tasting of the 30 people, all the formulas entered the acceptance range, however, the analyzed attributes that are closer and farther away from the rejection zone will be better reflected in the Tables from 6 to 10.

Product	Statistic z	"z" value	Result
Sample 219	$z=\frac{1,97-3}{1,35\sqrt{30}}$	0	H0 Accepted

Table 6. Statistical analysis of the appearance attribute

In this case, as can be seen in Table 6, according to the appearance analysis, sample 219 is closer to the rejection zone.

Table 7. Statistical analysis of the color attribute

Product	Statistic z	"z" value	Result
Sample 219	$z=\frac{2,53-3}{1,19\sqrt{30}}$	0,08	H0 Accepted

Now we proceeded to carry out a statistical analysis of the color attribute, which we can see in table 7, that the color of the cake has an acceptance of 0.08, demonstrating that it is relevant for the consumer.

Table 8. Statistical analysis of the Aroma attribute

Product	Statistic z	"z" value	Result
Sample 219	$z=\frac{2,73-3}{1,14\sqrt{30}}$	0,12	H0 Accepted

In Table 8, the aroma attribute is assessed, we can see that sample 219 is more distant from the rejection zone. Thus, indicating that the proposal of the mango flour cake obtained better acceptance in the analysis of this attribute.

Table 9. Statistical analysis of the flavour attribute

Product	Statistic z	"z" value	Result
Sample 219	$z=\frac{2,86-3}{1,91\sqrt{30}}$	0,08	H0 Accepted

In Table 9, the flavour attribute was evaluated, and it was concluded that sample 219 showed a significant preference, standing out for being further away from the rejection zone compared to other samples of sponge cake evaluated.

Table 10. Statistical analysis of the texture attribute

Product	Statistic z	"z" value	Result
Sample 219	$z=\frac{2,56-3}{1,27\sqrt{30}}$	0,08	H0 Accepted

In Table 10, sample 219 denotes a score of 0.08, which shows that it is far from the rejection zone, concluding that the preparation of the cake is widely accepted

Discussion

The analysis of the results obtained in this research demonstrates the viability of using mango peel as a raw material to produce flour and its application in pastry products. The findings indicate that the acceptance of the processed product, particularly the sponge cake with a 30% substitution of wheat flour for mango peel flour, suggests that this agro-industrial by-product can be used in the formulation of value-added foods. This alternative also promotes a healthier and more sustainable option. However, survey data reflect a high level of ignorance about the nutritional properties of mango peel, with 98.44% of respondents stating that they have no information about its benefits. This lack of knowledge represents an opportunity for the food industry and academic research. Through dissemination and marketing strategies, the consumption of products enriched with this alternative flour can be encouraged. Furthermore, the development of these products can contribute to reducing food waste, aligning with the principles of a circular economy and sustainability. The integration of by-products within the food industry has the potential to catalyze a reevaluation of agricultural waste. This reevaluation could, in turn, promote a paradigm shift towards a more efficient and less polluting production model from a nutritional perspective. Mango peel flour has been demonstrated to contain dietary fiber, antioxidants, and other bioactive compounds that have the potential to enhance consumers' health. Its high fiber content could contribute to the improvement of intestinal transit and the reduction of the glycemic index in baked goods, rendering it an intriguing alternative for the formulation of products aimed at consumers with specific nutritional needs.

The microbiological analyses carried out under the INEN 616 standard confirmed that the product complies with the safety parameters, ensuring its suitability for human consumption. This lends further credence to its potential application in the food industry as a functional ingredient.

In terms of sensory analysis, hedonic evaluation, and discriminant test, the cake with a 30% substitution of wheat flour for mango peel flour obtained the highest acceptance compared to formulations with higher substitution. The attributes of texture, aroma, and flavour were pivotal in the evaluation of the semi-trained panellists , highlighting that a higher percentage of substitution negatively The product's acceptability is influenced by alterations in texture and sensory profile. These findings indicate that, while mango peel flour possesses potential as an alternative ingredient, its utilization must be meticulously balanced to avert alterations that might compromise the consumer experience. The outcomes of the pilot hedonic test

demonstrated that the selected formulation was well-received by the target population. However, avenues for enhancement were identified, particularly with regard to appearance and texture. This underscores the necessity to perpetually adjust the formulation to optimize consumer perception. Furthermore, it would be prudent to undertake larger-scale studies with diverse demographic groups to assess the product's acceptance in a broader market and ascertain its commercial viability at an industrial level.

Conclusion

The experimentation phase began with the product chosen by the target population, "the sponge cake" based on mango peel flour; With this, formulations with different percentages of mango peel flour were tested, until an adequate balance in their ingredients was found, for their elaboration three samples were made substituting with 25, 30, and 50% of the flour in each preparation, samples that were later subjected to a discriminatory test by semi-trained people to select which percentage generated greater acceptability in them.

After submitting the sample to the pilot hedonic test which passed the first selection, it was possible to statistically verify that it was approved, and through an analysis of attributes the organoleptic liking of the same was exemplified, determining that the cake has a score of 60% with respect to taste, smell and texture.

The analysis carried out denoted that the flour is suitable for consumption, as it is free of pathogens such as salmonella or E. coli. The INEN 616 standard was used to generate a referential comparison of the parameters that a flour should have, considering that its production process, resulting in acceptable parameters such as: ash, moisture, yeasts and molds, among others.

It is determined that the results obtained confirm the technical and sensory viability of the cake made with mango peel flour, evidencing its potential as an innovative and sustainable product in the food industry. This study not only validates the use of agro-industrial by-products in food formulations but also promotes waste recovery strategies. aligned with a more sustainable and efficient production model.

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