Escuela Agrícola Panamericana, Zamorano

Food Science and Technology Department

Food Science and Technology Major

Graduation Research Project

Development of a "banana candy" using banana (*Musa paradisiaca*) peel flour as a fiber supply.

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Abstract

The reuse of agricultural by-products to enhance the nutritional value of food products is currently a growing trend being implemented by the industry. Bananas are considered the fourth most important food crop globally, with Ecuador ranked among the top producers. The peel, which is rich in fiber and antioxidants, accounts for 30% of the fruit. This project evaluated the addition of banana peel flour to a traditional Ecuadorian dessert called “banana candy” to increase its fiber content. The objectives were to assess the effect of this addition on the sensory, physical characteristics, and fiber content of the dessert. Affective sensory evaluation was conducted using an acceptance and preference test with 100 panelists, where color, smell, taste, sweetness, texture, and overall acceptance of four treatments with different levels of banana peel flour (0%, 5%, 7.7%, and 10%) were evaluated. A Randomized Complete Block Design (RCBD) was used, an ANOVA and a Duncan mean separation were applied to determine the treatment with the highest acceptance. Physicochemical analyses were performed on the control and the 5% banana peel flour treatment using an Independent Samples Design and a t-test. The results showed that the 5% banana peel flour treatment was the most accepted after the control, significantly increasing the fiber content, although it did not meet the levels required to be considered a source of fiber according to the RTCA.

Keywords: banana peel flour, banana candy, dietary fiber, nutritional value.

Resumen

La reutilización de subproductos agrícolas para agregar valor nutricional a productos alimenticios es una tendencia que la industria está poniendo en práctica en la actualidad y que va en aumento. El banano se considera el cuarto alimento más importante del mundo y Ecuador se posiciona entre los productores principales de este. Su cáscara, que es rica en fibra y antioxidantes, representa el 30% del fruto. En el proyecto se evaluó la adición de harina de cáscara de banano en un dulce tradicional de la región ecuatoriana, denominado "dulce de banano", para lograr un incremento en su contenido de fibra. Los objetivos fueron evaluar el efecto de esta adición en las características sensoriales, físicas y en el contenido de fibra del dulce. Se realizó una evaluación sensorial afectiva con una prueba de aceptación y preferencia, con 100 panelistas, se evaluó color, olor, sabor, dulzura, textura y aceptación general de cuatro tratamientos con diferentes niveles de harina de cáscara de banano (0, 5, 7.7 y 10%). Se utilizó un diseño BCA, un ANDEVA y una prueba Duncan, para determinar el tratamiento con mayor aceptación. Al control y al tratamiento con 5% de harina se les realizó análisis fisicoquímicos, se usó un Diseño de Muestras Independientes y una prueba t-student. Los resultados mostraron que, el tratamiento con 5% de harina de cáscara fue el más aceptado después del control, incrementando significativamente el contenido de fibra, aunque sin alcanzar los niveles requeridos para ser considerado una fuente de fibra, según el RTCA.

Palabras claves: dulce de banano, fibra dietética, harina de cáscara de banano, valor nutricional.

Introduction

Banana is the fourth most important food in the world, and Ecuador is positioned as the leading global exporter of this food, covering 29% of the international market (León Ajila et al., 2023). Thus, it is the main non-oil export sector of the country, representing 2% of the national GDP, making the sector a substantial economic base for Ecuador and, at the same time, a significant source of work and employment, especially in rural areas (León Ajila et al., 2023). In 2022, Ecuador exported approximately 376 million boxes of bananas (Asociación de Exportadores de Banano del Ecuador [AEBE], 2022). As of July 2023, Ecuador has been exporting more than 220 million boxes of bananas, showing a 6.40% increase compared to the previous year. For this purpose, the main market is the European Union with a participation of 30.20% to date (AEBE, 2023). It is necessary to highlight that, according to Burgos & Pupo Francisco (2016), 30% of all production destined for export is rejected due to low quality levels compared to competitors from other countries.

The banana (*Musa paradisiaca*) is a tropical perennial plant with an elongated shape between 8 and 13 cm in length, estimated to have an annual global production of 115 million tones (Food and Agriculture Organization of the United Nations [FAO], 2020). Nutritionally, the banana provides significant contributions based on macronutrients; for example, banana pulp has high potassium and carbohydrate content. However, the banana peel, which accounts for approximately 30% of the fruit (Gómez Montaño & Blasco, 2014) and contributes to 35% of waste (Hussain et al., 2020), is even better nutritionally than the pulp, presenting high content of carbohydrates (60.87%), protein (11.47%), and fiber (8.47%) (Ajijolakewu et al., 2021). According to studies by Girón Ortiz (2016), the banana peel also has more vitamins and potassium than the fruit's pulp, similarly states that other components in the peel, which makes it useful in industry, include antioxidants, pectins, natural dyes, carbohydrates, among others.

Dietary fiber is a nutrient derived from the edible parts of plants, including fruits (16.74-91.24%), composed of carbohydrates and their analogs, including those that are indigestible. There is scientific evidence that fiber can function in human metabolism for the prevention and treatment of chronic diseases such as diabetes and cancer (He et al., 2022). It can be used as an additive or a functional ingredient and is divided into digestible and indigestible types, offering additional benefits such as producing high levels of antioxidants and improving waste deposition (Hussain et al., 2020). Fiber can cause adverse effects such as flatulence, bloating, and abdominal discomfort when exceeding recommended levels (Soliman, 2019). On the other hand, some do not consume the necessary and recommended amounts of fiber due to a lack of knowledge about its nutritional properties and generational customs. The RTCA (2018) recommends consuming 25 g of fiber per day based on a 2000-calorie diet, and for a product to be considered high in fiber needs to contain 6 g of fiber per 100 g or 1.5 g per portion. Over time, the decrease in dietary fiber intake has led to negative changes in the gut microbiota, which has been linked to the rise in metabolic diseases such as obesity and type 2 diabetes (Fu et al., 2022). A research conducted by Tate & Lyle (2021) highlights a global deficiency in dietary fiber intake across multiple countries, with all falling below the recommended daily intake of 25-38 grams. Mexico (23.5 g/day) has the highest intake but still falls short, followed by Spain (22.7 g/day) and Chile (22.4 g/day). Countries like Germany, South Africa, and Australia have moderate intakes around 20-21 g/day, while nations such as France, China, and Italy show lower values between 18-19 g/day. The USA, Brazil, and Japan have the lowest fiber intakes, with Japan consuming only 14.5 g/day. This highlights a widespread gap in meeting recommended fiber levels crucial for maintaining health.

A serious problem in recent years has been waste management in the agro-food industry, especially in developing countries like Ecuador. Currently, around 14% of the food produced globally is estimated to be lost, and another 17% is wasted, leading to consequences such as food insecurity and increased costs (FAO, 2022). Additionally, not reusing these components generates unnecessary waste, resulting in the depletion of important natural resources. Waste generated from fruits and vegetables makes up approximately 6% of the overall food (Râpă et al., 2024). Revalorizing these wastes to convert them into by-products can mean a boost in different economies, mitigation of negative environmental effects, and contribution to health and nutrition (Hussain et al., 2020).

Thus, proper management of food waste and circularity are key points for governments and populations to integrate food systems into plans that result in the transformation of sustainable feeding techniques. For this reason, the food industry has been focusing on how to take advantage of these residues based on their nutritional and functional properties, which would also potentially contribute to various dimensions of the 2030 Agenda and the Sustainable Development Goals (FAO, 2022).

Banana candy is traditionally made in Ecuador, promoted through ancestral cuisine (El Universo, 2014). It is usually made from very ripe banana puree, sugar, and unsalted butter. Consumption of this is quite frequent in provinces like Manabí, Santa Elena, Guayas, and El Oro; supporting various micro and small enterprises (MiPymes) where industrial processes are not predominantly used, representing an opportunity to add value through the reuse of its own peel, offering a fiber contribution while boosting its commercialization and economy.

The purpose of the research was to develop a banana candy with added fiber through the fruit peel used in the form of flour to improve its nutritional contribution, therefore, the following objectives were proposed:

To evaluate the effect of adding banana peel flour on the sensory characteristics of banana candy.

To determine the effect of adding banana peel flour on the color and texture in the most accepted banana candy.

To assess the daily fiber contribution in the most accepted banana candy.

Materials and Methods

Location

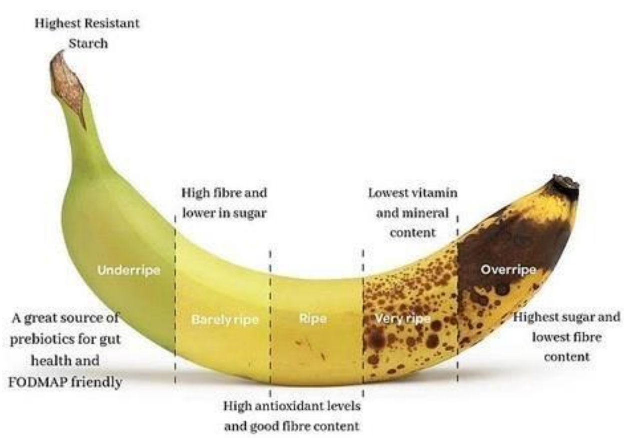
The study was conducted at the Zamorano Pan-American Agricultural School, located at kilometer 30 on the Tegucigalpa to Danlí highway, Valle del Yeguare, Municipality of San Antonio de Oriente, Francisco Morazán, Honduras. The development of the banana candy took place in the Food Innovation Plant. The microbiological analysis of the banana candy was performed in the Zamorano Microbiology Laboratory. Subsequently, the sensory evaluations were conducted in the Sensory Analysis Laboratory, and the physicochemical analysis were carried out in the Zamorano Food Analysis Laboratory.

Materials

The raw materials used for this project were: banana (*Musa paradisiaca* var. *Cavendish*) in a very ripe state (Figure 1) provided by the Zamorano horticultural plant, sugar (sucrose), banana peel collected from the "Doris Stone" student dining hall, and unsalted butter. Other essential inputs included sodium hypochlorite for disinfection and ascorbic acid to prevent browning of the product.

Figure 1

Different ripening stages of bananas.



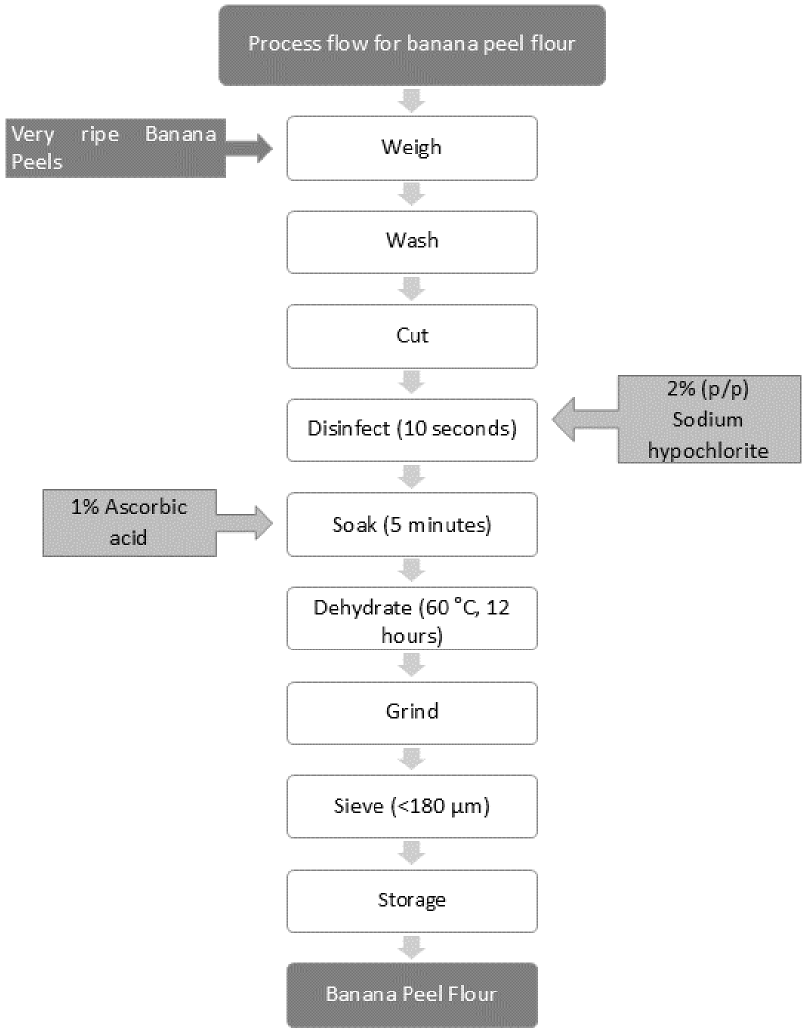
Note. Taken from Khalid (2021).

Process of Banana Flour Production

The banana peels were weighed, washed by immersion in a 3:1 ratio (water: peel) at 24 °C, and cut into 1 cm^2 pieces. They were disinfected with 5.25% sodium hypochlorite to achieve a 2% (w/w) solution, for 10 seconds and then rinsed with water. Subsequently, they were immersed in a 1% (w/w) ascorbic acid solution for 5 minutes, followed by rinsing and draining. They were then dehydrated using the Excalibur 9-Tray, series 4926T220FB equipment for 12 hours at 60 °C until a crunchy consistency was achieved for grinding. Finally, they were ground and sieved with a mesh until a particle size of <180 micrometers were obtained; in this instance, a 150-micrometer mesh was used. In that way, the flour was stored in airtight containers, previously disinfected glass jars (Figure 2). The process was carried out at low relative humidity (less than 50%) and without sun exposure to avoid physical changes (Anchundia et al., 2016).

Figure 2

Process flow for banana peel flour.



Note. Taken from Díaz Alejandro (2021). Adjusted by author.

Theoretical Formulation Determination

The formulation used in this project is based on a recipe provided by Leana Cedeño and consists of banana (*Musa paradisiaca* var. *Cavendish*), sugar (sucrose) and unsalted butter; this will be taken as the basis for conversion to a 30 g serving size, according to (RTCA, 2018) for the group of sugars, subgroup 5: honey, jellies, and jams.

According to Segura-Badilla et al (2022), fiber values that have been reported until now, are highly variable, ranging from 2.96% to more than 50%. With that, the following proximate composition of ripe Cavendish banana was used (Table 1), showing that the total dietary fiber content in banana peel flour was 50.84 ± 0.34. This study and the formulation of the banana candy allowed the formulation of each treatment with different fiber contents. It is important to mention that, although we worked with the "very ripe" stage, this "ripe" stage information will serve as a guide to carry out the theoretical estimation.

Table 1

Proximate composition of 100 g Cavendish banana peel flour in the mature state.

Parameter	Banana peel flour (ripe Cavendish) (g)
Moisture	11.20 ± 0.002
Ash	18.87 ± 0.003
Fat	5.96 ± 0.001
Protein	10.04 ± 0.009
Carbohidratos	54.01 ± 0.010
Crude fibre	11.09 ± 0.002
IDF	43.09 ± 0.340
SDF	7.75 ± 0.0001
TDF	50.84 ± 0.340

Note. IDF, insoluble dietary fibre; SDF, soluble dietary fibre; TDF, total dietary fibre. Taken from Ramli et al. (2010)

The first treatment did not contain the addition of banana peel flour, while the following three treatments contained the addition of banana peel flour dissolved in water in percentages of 3.5%, 8.7% and 10.7% (Table 2), to achieve products with source, excellent source and extra to excellent source of fiber within the established portion.

Table 2

Nutritional value of banana candy, per 30 g serving, according to RTCA 67.01.60.10 *(2018).*

	Serving size 30 g							
	Control		Treatment 1		Treatment 2		Treatment 3	
Composition	Total	%DV	Total	%DV	Total	%DV	Total	%DV
Energy (Kcal)	48.36	2	52.23	3	51.18	3	50.04	3
Total Fat (g)	0.51	1	0.48	1	0.57	1	0.64	1
Cholesterol (mg)	1.15	0	0.86	0	0.99	0	1.05	0
Sodium (mg)	0.35	0	0.32	0	0.32	0	0.32	0
Carbohydrates (g)	11.46	4	13.53	5	13.58	5	13.65	5

Composition	Serving size 30 g							
	Control		Treatment 1		Treatment 2		Treatment 3	
	Total	%DV	Total	%DV	Total	%DV	Total	%DV
Dietary Fiber (g)	0.61	2	1.28	5	1.67	7	2.04	8
Total Sugar (g)	8.98	18	10.59	21	10.28	21	9.99	20
Protein (g)	0.26	1	0.37	1	0.45	1	0.52	1
Vitamin A (mcg)	53.48	7	68.71	9	67.17	8	65.63	8
Calcium (mg)	1.36	0	1.17	0	1.16	0	1.13	0
Potassium (mg)	83.75	2	71.62	2	69.40	2	67.34	2

Note. %DV= Daily Value Percentage.

To determine the formulations, the percentages of banana peel flour addition were estimated by means of a nutritional assessment of the banana candy per serving (30g) (Table 2) according to the values established in the Table of Nutritional Composition of Central American Foods of (Instituto de Nutrición de Centro América y Panamá [INCAP], 2018) and the proximal characterization of banana peel flour by Ramli et al. (2010) (Table 1). With the objective of developing a product with the denomination of "fiber contribution", "fiber source 1" and "fiber source 2", obtaining the treatments shown in Table 3.

Table 3

Formulation of treatments, for banana candy with the addition of banana peel flour for one serving (30g).

Ingredients (%)	Treatments			
	Control (%)	Treatment 1 (%)	Treatment 2 (%)	Treatment 3 (%)
Banana	77.7	66.4	64.4	62.4
Sugar	20.5	27.2	26.4	25.7
Unsalted butter	1.8	1.3	1.5	1.6
BPF	0	5	7.7	10.2
TOTAL	100	100	100	100

Note. BPF= Banana Peel Flour

Traditional Banana Candy Production Process

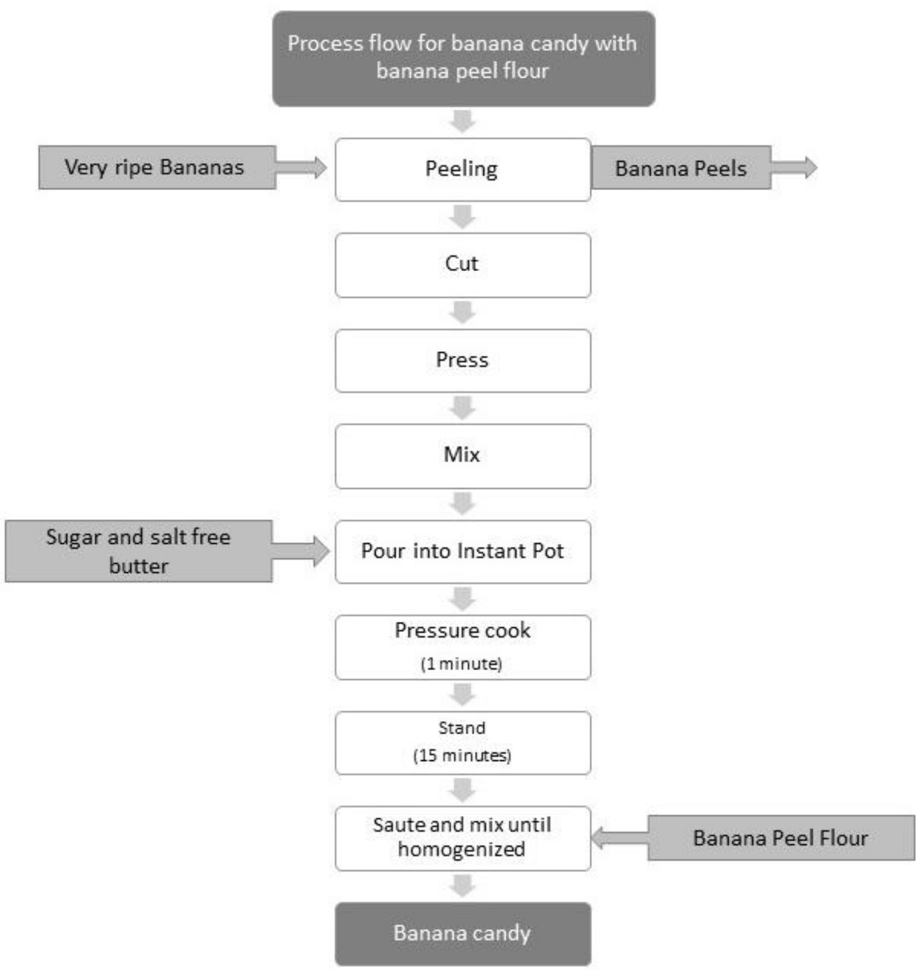
Very ripe bananas were peeled and cut into small pieces to be crushed or pressed. Sugar and unsalted butter were added. Then, they were transferred to an “Instant Pot” where 1 minute of pressure cooking was added, next the mixture was allowed to stand for 15 minutes and the "saute" mode was activated until the mixture caramelized and homogenized, at a temperature between 135 °C and 150 °C. Subsequently, the product was left to stand at a temperature of 4 °C for approximately 1 hour and 10 g balls were formed, thus, 3 balls would form the 30 g portion.

Production Process of Banana Candy with Added Banana Peel Flour

The same steps previously mentioned for the control banana candy were followed, but when activating the "saute" mode, the banana peel flour was added and mixed until a homogeneous product, without lumps was obtained. Finally, the mixture was left to stand until it cooled to 4 °C and 10 g balls were formed, thus, 3 balls would form the 30 g portion. The process flow as shown in Figure 3 was followed.

Figure 3

Process flow for banana candy with the addition of banana peel flour.



Microbiological Analysis

To ensure safety and the absence of pathogenic microorganisms, microbiological analysis was conducted on the banana candy. It is important to mention that banana peel flour (*Musa paradisiaca var. Cavendish*) did not undergo analysis due to the thermal process it underwent within de banana candy confection.

For all treatments, which fall within "Group 5" of foods (Confectionery Products), subgroup 5.2 (nougat, marzipan, traditional sweets, panela, and other products that primarily contain sugar and its dietary equivalents, excluding hard candies, acidulated powders, chewing gum, gummies, and marshmallows), according to RTCA (2018) standards (Table 4), specific microbiological analyses are recommended based on the composition of the product. For instance, *Staphylococcus aureus* testing is required for products containing milk; however, since banana candy does not include milk as an ingredient, this test was deemed unnecessary and was therefore omitted. In contrast, *Escherichia coli* testing was conducted prior to its use in the sensory analysis, indicated in the following table.

Table 4

Microbiological analysis Group 5 foods, Subgroup 5.2, according to RTCA 67.04.50 *(2018).*

5.2 Food Subgroup: nougat, marzipan, traditional sweets, panela, and other products that primarily contain sugar and its dietary equivalents. Hard candies, acidulated powders, chewing gum, gummies, and marshmallows are not subject to analysis.			
Parameter	Category	Food type	Allowed limit
Escherichia coli	N/A	B	<10 UFC/g

Note. B= comprises foods that by their nature, composition, process, handling, and target population, have a medium probability of causing harm to health. 10= Serious hazard, reduced risk. 8= Moderate hazard, no change in risk. N/A= Not applicable. CFU= Colony forming units.

According to the Manual of Practices of the Food Microbiology Laboratory of the Escuela Agrícola Panamericana Zamorano (Luna Jarrín, 2023), the following process was followed:

Escherichia coli Analysis: Although RTCA (2018) mentions that *Escherichia coli* does not apply in risk category, its analysis was performed because there was manual handling in the process of making banana candy.

This analysis was carried out by the plate casting method. A sample of 10 g of banana candy (per treatment) was used. For this, first, dilutions with phosphate buffer were made until concentrations of 10^-1, 10^-2 and 10^-3 were obtained. Each dilution was added in 1 mL together with 15 mL of Violet Red Bile Agar with MUG (VRBA-MUG). When the agars solidified, another 5 mL was added as a cover, again, it was allowed to solidify and subsequently, the plates were inverted and incubated at 35 °C for 24 hours and which were then analyzed, performing the calculations that solve the counting rules, where it was corroborated with the previously established parameters (100 CFU/10 g).

A total of four microbiological analysis were performed, since one analysis was performed per treatment.

Sensory Analysis

The sensory analysis was conducted in the Sensory Analysis Laboratory at Zamorano, where the panelists were students from different years and nationalities, totaling 100 panelists who tasted the four treatments, each presented in three repetitions. For the study, an affective analysis was performed using an acceptance test with a 9-point hedonic scale, where 9: like extremely; 5: neither like nor dislike; 1: dislike extremely. The evaluated attributes were color, odor, taste, sweetness, texture, and general acceptance. Similarly, a preference ranking test was conducted, where the panelists ranked the samples from 1 to 4, with 1 being the most preferred sample and 4 the least preferred.

Physicochemical Analysis

The physicochemical analysis conducted were color, texture, water activity, and dietary fiber. These were performed on the control banana candy and the treatment that showed the highest acceptance.

Color Analysis

The color test was performed using the Colorflex Hunter Lab* equipment and the Hunter Lab Universal software version V4.00. The analysis method used was AN 1018.00. In this method, the Lab* scale has the following meanings: the L* value represented lightness (brightness), ranging from 0 (black) to 100 (white). The a* and b* values are chromaticity coordinates, where positive a* values indicated a reddish deviation, negative a* specified a greenish tendency, positive b* designated a yellowish tendency, and negative b* indicated blue.

The following steps were followed: The equipment was calibrated using standard black, white, and green disks according to the software instructions. The samples were then ground and placed in the equipment to facilitate analysis, and color measurements were taken in three repetitions for each treatment.

Texture Analysis

The texture test was performed using the Brookfield CT3 texture analyzer. The analysis method used was ASTM E83, utilizing the TA7 'guillotine' probe, which simulated the bite of the incisors. The equipment was also calibrated with a speed of 1.00 mm/s and a target value of 25 mm. A 10 g portion of each banana candy sample was used as a reference, and the maximum force (hardness) and adhesiveness were measured, both in Newtons (N).

Water Activity Analysis (aw)

Water activity was determined using the AquaLab equipment, model 3TE. The official method AOAC 978.18 was used. The equipment was calibrated with the help of a 5.00 aw standard. The sample was ground beforehand to be placed in the equipment's meter.

Dietary Fiber Analysis

The dietary fiber test was conducted using the AOAC 985.29 analytical method. For each treatment, 1 gram of product was used as the sample. Three repetitions were performed per treatment.

This analysis was divided into three main phases:

Preparation (Gooch Crucibles and Sample): The crucibles were rinsed with 15 mL of acetone, dried for 30 minutes, and then heated in an oven at 105 °C for 2 hours. They were allowed to cool to 25 °C before adding 0.5 g of Celite. Subsequently, they were returned to the oven at 105 °C until a constant weight was achieved. Once ready, they were stored in a desiccator. Meanwhile, a representative portion of each sample was homogenized.

Enzymatic Digestion: A 1 g ± 0.005 g portion of each sample was weighed using a 600 mL Berzelius beaker. Then, 50 mL of phosphate buffer was added and mixed with a magnetic stirring bar. Additionally, 100 µL of α-amylase solution was added and mixed again. The beakers were fully covered with aluminum foil and incubated in a water bath at 95 °C for 15 minutes, starting the timing when the internal temperature of the beakers reached 95 °C. During this time, the beakers were stirred every 5 minutes. They were then removed from the water bath and allowed to cool to room temperature. The aluminum foil was removed, and 10 mL of 0.275 M NaOH (sodium hydroxide) was added, adjusting the pH of the solution to 7.5. Next, 100 µL of α-protease was added to the sample for incubation in a water bath at 60 °C for 30 minutes, then cooled to room temperature. Furthermore, 10 mL of 0.325 M HCl (hydrochloric acid) solution was incorporated, adjusting the pH to 4.0 - 4.6. Thirdly, 100 µL of α-amyloglucosidase was integrated and incubated at 60 °C for 30 minutes. Finally, for the enzymatic digestion, 280 mL of 95% ethanol preheated to 60 °C was added, the samples were removed from the water bath and allowed to cool to room temperature for approximately one hour.

Filtration: A Buchner flask, a rubber stopper, a Buchner funnel, and a vacuum pump with rubber tubing were used for vacuum filtration. The crucible was placed on top of the flask, which was then placed on the funnel. 15 mL of 78% ethanol was added to the crucible (with constant weight) containing Celite. The contents of the Berzelius beaker were then added, and the residue was washed with 78% ethanol, 95% ethanol, and acetone. The crucibles were subsequently placed in a convection oven at 105 °C overnight. The crucibles were then placed in a desiccator for one hour and weighed to calculate the residue weight.

Finally, the following equation was used to calculate the total dietary fiber, with corrections for fat, sugar, and humidity:

$$DF = \frac{\left[\frac{(R_1 + R_2 + R_3)}{3}\right] - P - A - B}{\left(\frac{M_1 + M_2 + M_3}{3}\right)} \times 100 \qquad [1]$$

Where:

DF= Dietary Fiber

R= Residue

P= Protein

A= Ash

B= Blank

M= Sample weight

It is important to note that, for this occasion, the protein, lipid, and ash values used in the formula were obtained theoretically.

Experimental Design & Statistical Analysis

For the experimental design in the sensory analysis results, a Randomized Complete Block Design (RCBD) was used. Each treatment was replicated three times, resulting 12 experimental units. For the physicochemical analysis, an Independent Sample Comparison design was used with a "T-student" test for 2 treatments (control and the most accepted one), with 3 replications each, for a total of 6 experimental units.

For the statistical analysis the four treatments were evaluated using the program “Statistical Analysis System” (SAS Online version). To evaluate the significance of the model, an analysis of variance (ANOVA) was conducted to determine if there were significant differences in the sensory characteristics of the four treatments. The Duncan's multiple range test method was used to determine which treatment was most acceptable to the panelists. Additionally, for the preference evaluation using a ranking test, the Kramer (Basker) rank sum test was applied. A correlation analysis was also performed. For the physicochemical analysis, a "T-student" test was applied.

Nutritional Labeling

A nutritional label was developed using the "Food Processor" software in the Human Nutrition Laboratory at Zamorano. The values presented are theoretical, based on the nutritional composition of the control banana candy and the most accepted treatment, except for the dietary fiber values, which were obtained from the chemical analysis conducted on both treatments.

Results and Discussion

Microbiological Analysis

Escherichia coli is a pathogen of high importance in the food industry, particularly the O157: H7 strain, which is one of the most significant contaminants in products such as meat, salads, milk, and unpasteurized foods (López-Pino et al., 2021).

The total *Escherichia coli* count across all four banana candy treatments showed a consistent trend, with results staying appropriately within acceptable limits (<10 UFC/ g) according to RTCA 67.04.50 (2018), as no colonies were detected in any of the dilutions of the treatments. This indicates that the sanitization process, handling, and temperature control during banana candy production were ideal, leading to optimal microbiological outcomes. As established by the World Health Organization (2018), thermal treatments are the primary option to ensure food safety, where it is required that food cooking reaches a temperature of 70 °C or higher. In this way, the obtained results allowed the sensory evaluation process to continue.

Sensory Analysis

As stated by Ruiz-Capillas & Herrero (2021), sensory analysis assesses a product or food by evaluating its characteristics through the senses of panelists. This method is crucial for innovation and application, as it helps ensure that the final product is accepted by consumers.

Table 5 shows the average results of the sensory analysis performed on the banana candy, with the attributes of color, odor, taste, sweetness, texture, and general acceptance. Significant statistical differences ($P<0.05$) were found between the control and the other 3 treatments, in the 6 parameters evaluated. The control treatment obtained the best punctuation in each of the attributes.

Color

According to Spence (2015b), color "is the single most important product-intrinsic sensory cue when it comes to setting people's expectations regarding the likely taste and flavour of food and drink".

Consumers tend to associate certain colors with specific flavors, which can affect their perception of taste. Also, the intensity of a food's color can have a dramatic impact on how consumers perceive its taste (Spence, 2015a).

It is noteworthy that there were significant differences (P< 0.05) between the control and the other treatments. No significant differences (P< 0.05) were found between Treatment 1 and Treatment 2, nor between Treatment 2 and Treatment 3. The panelists, according to the hedonic scale, rated the control with a 7: "I moderately like it," while Treatments 1, 2, and 3 were rated with a 6: "I slightly like it." Results showed that acceptance decreased as the banana peel flour content in the formulation increased. The higher acceptance of the control banana candy may be due to its color being less dark, with shades within the brown color range, whereas the other treatments had darker shades, which may have been perceived as black. The presence of a darker color in the treatments with banana peel flour can be attributed to the Maillard reaction occurred during the production of the banana peel flour (Carvalho & Conti-Silva, 2018), moreover it is rich in antioxidants such as polyphenols (Oguntoyinbo et al., 2020) which, when exposed to heat during processing, may oxidize and produce dark colors, as they are prone to undergo auto-oxidation in the presence of oxygen (Zhang et al., 2022). The panelists mentioned in the evaluation comments that the lighter color of the control banana candy made it “more pleasant”.

Spence (2015b), supported within his studies that black is often seen as unappetizing in food due to its association with spoilage, burning, or decay. Cultural and psychological factors play a role, as lighter and brighter colors are generally linked to freshness and quality, while darker colors, especially black, may suggest something undesirable or overly intense in flavor. In the same way, Phillips (2023), indicated that color black can be named as “Off – coloring” which refers to a color that conflicts with the consumer’s beliefs about what a given food should look like, and that usually consumers avoid them because they tend to associate them with mold.

Odor

As noted by Billesbølle et al. (2023) "Our sense of smell enables us to navigate a vast space of chemically diverse odour molecules". In this way, food flavors are distinctive mainly because of their aromatic volatiles, and while simply being exposed to these odors can create preferences, within the context of food, these odors are always combined with tastes that are already perceived as either pleasant or unpleasant (Prescott, 2024).

There were significant differences (P< 0.05) between the control and the other treatments, with the first one presenting an evaluation of 7: "I like it moderately". Between Treatments 1 and 2 there were no significant differences (P< 0.05) of acceptance with a score of approximately 7. On the contrary, Treatment 3 showed significant differences with all the other treatments, with a score of 6: "I like it slightly".

These scores may be explained by the idea suggested by Dewi et al. (2023), the aroma of banana peel flour could have been influenced by the level of maturity of the banana, namely the longer the harvest, the stronger the distinctive aroma of bananas. "Amyl acetate, amyl butyrate, and acetaldehyde contribute to the banana aroma found only in fully ripe bananas" (Elvinna & Sadek, 2024). Thus, it is assumed that in the control banana candy (without banana peel flour), the aroma was not as intense, which was more pleasing to the panelists. Also, there is a possibility that banana peel flour tends to have an earthy, vegetal aroma since it was demonstrated in a study of Juárez Ojeda (2022), that the phenolic compounds responsible for this spectrum of aromas that are contained in the peel, when dehydrated were increased. What may have been less appealing to the panelists. According to the study of Eshak (2016), of adding banana peel flour to bread, panelists gave lower scores as the bread treatments contained more banana peel flour, as the very nature of the volatile compounds present in banana peel flour can introduce less pleasant compounds or mask more desirable aromas in bread as the amount of this flour increases. Additionally, the drying and grinding process of the banana peels can alter their aromatic profile, potentially resulting in a less appealing smell compared to bread made solely with wheat flour.

Taste

Taste can be defined as the perception of the basic taste sensations (sweet, salty, sour, bitter, and umami). These basic flavors arise from the chemical components of food, which can be organic or inorganic in nature (Gutiérrez Domínguez & Ramírez Godínez, 2021).

It was observed that the control and Treatment 1 did not present significant differences ($P>0.05$), indicating that both treatments were equally accepted statistically. Additionally, Treatment 1 showed no significant differences compared to Treatment 2, and Treatment 2 exhibited no significant differences compared to Treatment 3. This suggests that the treatments fall within the categories of "Moderately Like" and "Slightly Like." Thus, significant differences are only observed between the control and Treatment 3, with the control having the highest acceptance and Treatment 3 the lowest acceptance.

These results can be attributed to the possibility that banana peel flour may enhance the flavor of the product, creating a similarity to the banana flavor that the candy aims to deliver. According to studies of Ahmed et al. (2021), the addition of banana peel flour to a cake also resulted in no significant differences in flavor between the control and its treatments, thereby following a consistent trend in the evaluation of this attribute, as have shown similar acceptance levels in sensory evaluations.

As shown in Table 5, it can be observed that as the banana peel flour content in the banana candy increased, acceptance decreased. This behavior can also be observed in the odor and taste.

Table 5

Results of sensory analysis of color, odor, and taste; of banana candy with the addition of banana peel flour (BPF).

Treatment	Color	Odor	Taste
	Media ± SD	Media ± SD	Media ± SD
Control (0% BPF)	7.04 ± 1.64^{A}	7.23 ± 1.35^{A}	7.42 ± 1.42^{A}
Treatment 1 (5% BPF)	6.44 ± 1.54^{B}	6.74 ± 1.53^{B}	6.37 ± 1.86^{AB}
Treatment 2 (7.7 BPF)	6.25 ± 1.79^{BC}	6.54 ± 1.66^{B}	6.27 ± 1.86^{BC}
Treatment 3 (10.2 BPF)	5.95 ± 1.87^{C}	6.24 ± 1.75^{C}	5.54 ± 2.00^{C}
CV%	22.52	15.42	59.25

Note. SD= Standard Deviation. CV%= Coefficient of variation. Letter from A-C: different capital letters in each column indicate significant differences between the treatments evaluated (P< 0.05). 9-point hedonic scale: 1: "dislike extremely", 5: "neither like or dislike", 6: "like slightly", 7: "like moderately" and 9: "like extremely".

Sweetness

Sweetness can be defined as "the generally pleasurable sensation that occurs when sugars or other sweet substances activate specialized receptor proteins found in certain taste bud cells" (Trumbo et al., 2021). It's crucial to recognize that any strategies for reducing sugar are likely to need to account for individual variations in sweetness preferences. Over time, people have been classified as "sweet likers" or "sweet dislikers" based on their hedonic reactions to increasing sweetness in sugar solutions, which can introduce considerable variability into study outcomes (Wang et al., 2019).

Table 6 shows the results of the sweetness evaluation of banana candys across different treatments. The control, which received a rating of 7: "Moderately like," showed significant differences compared to the other treatments. Meanwhile, Treatments 1 and 2 did not revealed significant differences, both receiving a rating of 6: "Slightly like." Finally, Treatment 3 demonstrated significant differences from the previous treatments, receiving a rating of 5: "Neither like nor dislike."

Panelists did not provide additional comments on the sweetness of the product. However, statistically, it was evident that as the amount of banana peel flour increased, the sweetness of the product was affected. The addition of banana peel flour may dilute the overall sweetness due to its higher fiber content. The natural sugars in the banana candy are likely to be less prominent as the fibrous components from the banana peel flour compete with the sugars, reducing their intensity, as the quantities of banana and butter were reduced to accommodate the addition of banana peel flour. In contrast, a study by Elvinna & Sadek (2024) found that adding banana peel flour to a pudding resulted in a more pleasant sweetness compared to the control treatment.

Texture

According to Nishinari et al. (2024), the role of texture attribute in food is highly important. This attribute is as crucial as flavor. Also, it is noted that texture plays a significant role more in solid foods than in liquid foods. Texture affects mouthfeel and is essential in defining the identity and consistency of a product.

The control was the one that obtained the greatest acceptance within category 7: “I like it moderately”, showing significant differences in relation to the other 3 treatments. On the other hand, there were no significant differences between Treatments 2 and 3, falling into category 6: “I like it slightly”.

The panelists mentioned that the texture of the last two treatments were more “pasty” in texture compared to the others. This is since the consistency of the candy is naturally “chewier” or “gummy” and firm, and by adding flour, such as banana peel flour, it is more difficult to obtain a texture like the one mentioned above. As well as Carvalho & Conti-Silva (2018), mention that, by adding banana peel flour to cereal bars, the product ceased to present the characteristic texture of a cereal bar, which is considered crunchy and chewy.

The inclusion of banana peel flour in the banana candy affected the texture primarily due to its high fiber content, which altered the product's structural integrity. The flour introduced a coarser and denser texture, deviating from the smooth and chewy consistency that is typically preferred in such confections. The additional fiber from the banana peel flour could absorb more moisture, making the candy feel drier and less cohesive, which contributed to the “pasty” or less appealing mouthfeel noted by the panelists.

General Acceptance

For general acceptance, it is observed in Table 7 that the control presented significant differences ($P<0.05$), being the most accepted, with a score of 8: "Like very much”. This result was due to the other 5 evaluated attributes were also more favorably received in the control treatment. On the other hand, there were no significant differences ($P<0.05$) between Treatment 1 and Treatment 2, both receiving a score of 6: "I slightly like it," despite the increase in the addition of banana peel flour. Finally, Treatment 3 was the least accepted compared to the others, as it received a score of 5: "I neither like nor dislike it," being the least favored in the evaluation of the other 5 attributes as well. These results were consistent with a study by Segura-Badilla et al. (2022), where the addition of 5% banana peel flour in pasta did not affect the overall acceptance of the product, making it the most accepted treatment after the control.

The attributes of sweetness, texture, and overall acceptance also observed a similar behavior as the rest of evaluated characteristics. According to the study of Carvalho & Conti-Silva (2018), the acceptance of products containing banana peel flour is generally good but varies depending on the proportion of banana peel flour used in the formulation. As the amount of banana peel flour increased, changes in the product's sensory characteristics were observed, such as a darker color and a stronger banana aroma, which could influence taste perception.

However, despite these changes potentially being positive in some aspects, acceptability decreased when excessive amounts of banana peel flour were used. This was because higher amounts of banana peel flour were reported to result in a more bitter taste and reduced banana flavor intensity, which could be less appealing to consumers. Additionally, texture and other sensory characteristics were negatively affected, contributing to lower overall acceptability of the final product.

Table 6

Results of sensory analysis of sweetness, texture, and general acceptance; of banana candy with the addition of banana peel flour (BPF).

Treatment	Sweetness	Texture	General Acceptance
	Media ± SD	Media ± SD	Media ± SD
Control (0% BPF)	7.43 ± 1.31^{A}	7.15 ± 1.63^{A}	7.56 ± 1.23^{A}
Treatment 1 (5% BPF)	6.45 ± 1.74^{B}	6.55 ± 1.70^{B}	6.63 ± 1.39^{B}
Treatment 2 (7.7% BPF)	6.35 ± 1.82^{B}	6.06 ± 2.09^{C}	6.50 ± 1.63^{B}
Treatment 3 (10.2% BPF)	5.85 ± 1.88^{C}	6.01 ± 2.04^{C}	5.87 ± 1.76^{C}
CV%	21.03	23.38	17.01

Note. SD= Standard Deviation. CV%= Coefficient of variation. Letter from A-C: different capital letters in each column indicate significant differences between the treatments evaluated (P < 0.05). 9-point hedonic scale: 1: "dislike extremely", 5: "neither like or dislike", 6: "like slightly", 7: "like moderately" and 9: "like extremely".

Correlation Analysis

In Table 7, the results of each attribute with respect to overall acceptance, where significant correlations (<0.0001), are evident. These indicated that the sweetness attribute was the only one that presented a high positive correlation, being ≥0.70, which means that this attribute had a quite significant and strong influence on the panelist's ratings of the overall acceptance of the presented treatments. On the other hand, the attributes of color, aroma, and texture showed medium positive correlations, as they fell between 0.50 and 0.69. Finally, the flavor attribute was the only one that presented a low positive correlation, as it was <0.5, which means that the relationship this attribute had with the overall acceptance of the treatments was weak and probably not a determining factor on its own when developing this new product.

Table 7

Results of correlation test of banana candy with the addition of banana peel flour.

	Taste	Odor	Color	Texture	Sweetness
General Acceptance	0.41215	0.52835	0.64206	0.68308	0.76370
	<.0001	<.0001	<.0001	<.0001	<.0001

Sensory Test of Ordering Preference

Table 8 shows the results of the sensory test of preference by ordering, where 1 is the most preferred and 4 is the least preferred. The Basker and Kramer test, as defined by Lawlees and Heymann in 1998, was used. This allowed to detect which of the four treatments presented to the panelists was the most preferred, in descending order, and if there were differences with respect to the critical value, which in this case was 46.9, since the test was done with 100 total panelists and four treatments.

It is interpreted according to the results that the control was the most preferred treatment by the panelists because it presents the lowest sum category, which meant that it was voted as the number one, more times. On the other hand, it was evident that between Treatments 1, 2 and 3, there were no differences in preference, confirming that panelists did not show a marked preference for the previously mentioned four treatments.

Table 8

Results of sensory test of ordering preference of banana candy with the addition of banana peel flour.

Sample	Sample	Control	Treatment 1	Treatment 2	Treatment 3
	Sum category	154	263	274	309
Control	154	0	-109	-120	-155
Treatment 1	263	109	0	-11	-46
Treatment 2	274	120	11	0	-35
Treatment 3	309	155	46	35	0

Note. Control (0% banana peel flour). Treatment 1 (5 % banana peel flour). Treatment 2 (7.7 % banana peel flour). Treatment 3 (10.2 % banana peel flour). Critical value 46.9.

Physicochemical Analyses

Treatment 1 with 5% addition of banana peel flour was selected to continue with the physicochemical analyses because, among the three treatments with addition, it was the most accepted. Although it did not show significant differences in this aspect compared to Treatment 2, Treatment 2 was not considered to continue with the analysis because, in attributes such as color, taste, and texture, this treatment had significant grade C differences that matched the results of Treatment 3.

The physical analysis performed on the banana candy were color and texture; and the chemical analysis performed were water activity and dietary fiber.

Color

Color, being the first noticeable characteristic in food, significantly influences consumer preferences. Although as a physical property, it reflects the chemical composition of food and serves as an indirect indicator of overall food quality (Giusti et al., 2024). This analysis was conducted using the Hunter colorimeter with the L,a,b scale, a system grounded in the Opponent-Color Theory, which aligns with the color receptors in the human eye.

According to Table 9, the L scale results indicated that both the control and Treatment 1 fell within the low luminosity range, meaning darker colors. However, there were significant differences between them ($P<0.05$), showing that the color of Treatment 1 was darker than that of the control. Similarly, a scale also revealed significant differences ($P<0.05$), where both the control and Treatment 1 showed a tendency towards red rather than green, with this tendency being more pronounced in the control. Finally, the b scale once again showed significant differences between treatments, highlighting a tendency towards yellow, which was more prominent in the control which is due to the Maillard browning and caramelization (Ayoub et al., 2022). This results where similar to the results by Shafi et al. (2022), Where, upon adding banana peel flour to cookies, the treatments with the addition showed lower values closer to 0 compared to the control, which exhibited the highest values on the L,a,b scale; since there was an introduction of darker color of fibers caused by the addition of the banana peel flour, according to phytochemical compounds owned by banana peels (Ayoub et al., 2022). In this way, these results could be related and validated with the sensory color evaluation results, as the panelists mentioned that the treatments with banana peel flour appeared darker than the control.

Table 9

Results of scale color L, a, b analysis of banana candy with addition of banana peel flour (BPF).

Treatment	L*	a*	b*
	Media ± SD	Media ± SD	Media ± SD
Control (0% BPF)	22.28 ± 1.39	10.24 ± 0.51	12. 62 ± 2.44
Treatment 1 (5% BPF)	11.00 ± 1.59	4. 04 ± 0.61	6. 32 ± 0.51
CV%	20.7320	1.68	4.13
P	0.0008	0.0002	0.0119

Note. BPF= banana peel flour. L= Luminosity. A: red- green. B: yellow- blue. SD= Standard Deviation. CV%= Coefficient of variation.

Texture

Humans are highly sensitive to the microstructure and material properties of food, perceiving its mechanical, geometrical, surface, and body attributes through touch, sight, and sound from the first bite to swallowing, which encompasses the concept of texture (Rosenthal & Chen, 2024).

In this analysis, two rheological properties were evaluated: hardness and adhesiveness. Table 10 presents the hardness results, which the International Organization for Standardization (2009) defines as the mechanical textural attribute relating to the force required to achieve a given deformation. Significant differences ($P<0.05$) were observed between the control treatment and Treatment 1, with the control showing a hardness of 7.2187 N, compared to 3.7050 N for Treatment 1. According to a study by Elvinna & Sadek (2024), adding 6% banana peel flour to a pudding resulted in significant differences between the addition treatment and the control, with the control exhibiting greater hardness, like the findings in this study. Following this, adhesiveness was evaluated, which refers to the strength of the bonds between a product and surrounding surfaces and defined as the force needed to remove material that sticks to the mouth or another surface (ISO, 2009). Significant differences ($P<0.05$) were also observed, where the control showed higher adhesiveness (2.55 N.s.), compared to Treatment 1 (0.89 N. s). This may be attributed to the fact that, according to Cheng et al. (2024), banana peel flour possesses water absorption properties due to its starch content (31.90-33.50%), which can vary depending on its degree of ripeness. This characteristic may help retain moisture and prevent products from exhibiting sticky or adhesive textures.

Table 10

Results of texture analysis of banana candy with addition of banana peel flour (BPF).

Treatment	Hardness (N)	Adhesiveness (N.s)
	Media ± SD	Media ± SD
Control (0% BPF)	7.22 ± 2.27	2.55 ± 0.51
Treatment 1 (5% BPF)	3.71 ± 0.37	0.89 ± 0.20
CV%	41.50	42.05
P	0.0572	0.0061

Note. SD= Standard Deviation. CV%= Coefficient of variation.

Water Activity (aw)

As water activity refers to the amount of water available in a product, it is a crucial concept for discussing the critical limits surrounding microorganisms. Consequently, it is considered a concept more closely related to the chemical, physical, and microbiological properties of a food item, rather than just its moisture content (Barbosa-Cánovas et al., 2020). According to Ergun et al. (2010) “Water is important during the manufacturing of confections, is an important factor in governing texture, and is often the limiting parameter during storage that controls shelf life”.

In Table 11, the results of the water activity analysis are presented, showing significant differences ($P<0.05$) between the control treatment and Treatment 1. According to a review by Ismail et al. (2024), banana peel flour is recognized for its quality attribute of increased water absorption capacity due to its starch and fiber content, which makes it highly absorbent and imparts these properties to the product with its addition. In contrast, the control, which primarily consists of banana and sugar, has sugar that limits the availability of water in the final product due to the caramelization process. A study by Palachum et al. (2023), mentions that the water activity of soft candy products generally ranges from 0.45 to 0.75, which results in a positive outcome for both treatments regarding the shelf life and preservation of the evaluated products.

Table 11

Results of water activity analysis of banana candy with addition of banana peel flour (BPF).

Treatment	Water Activity
	Media ± SD
Control (0% BPF)	0.55 ± 0.01
Treatment 1 (5% BPF)	0.64 ± 0.02
CV%	4.99
P	0.0024

Note. SD= Standard Deviation. CV%= Coefficient of variation.

Dietary Fiber

According to Eshak (2016), banana peel wastes from industrial processes represent about 40% of fresh bananas and by being rich in fiber, proteins, essential amino acids, polyunsaturated fatty acids, potassium, and phenolic compounds. Currently, there is a focus on promoting the use of these to provide significant nutritional contributions to foods by transforming them into flour. In addition to that Klosterbuer et al. (2011), mentions that “clinical studies suggest fiber can exert a wide range of benefits in areas such as bowel function, gut health, immunity, blood glucose control, and serum lipid levels”.

In Table 12, the results for dietary fiber in the control and Treatment 1 are presented, showing significant differences ($P<0.05$). The control treatment yielded a dietary fiber content of 2.04%. However, the treatment with 5% BPF exhibited a significantly higher dietary fiber content compared to the control, although it had a coefficient of variation of 6.3488 %, indicating greater variability among the repetitions performed for this treatment. In this way, the treatment contained more fiber than the control, because the treatment included a 5% addition of banana peel flour, which, as shown in Table 1, had an approximate total dietary fiber content of 50.84%. Segura-Badilla et al. (2022) state that, according to various studies, the optimal amount to achieve a balance between contribution and acceptability of a product with added banana peel flour is between 5% and 10%. Similarly, the results obtained in this experiment are compared with the study by (Sayem et al., 2024), where banana peel flour was added at 5%, 10%, and 15% concentrations in the preparation of cookies for fiber enrichment, which showed significant differences to its control.

Table 12

Results of dietary fiber analysis of banana candy with addition of banana peel flour (BPF).

Treatment	Dietary Fiber (%)
	Media ± SD
Control	2.04 ± 0.12
Treatment 1	3.33 ± 0.34
CV%	11.18
P	0.0159

Note. SD= Standard Deviation. CV%= Coefficient of variation.

The results in Table 13 show the amount of dietary fiber contained in a 30 g serving of banana candy, as suggested by the RTCA (2018), which was the serving size used throughout the experiment. According to the RTCA (2018), for a product to be considered a source of fiber, it must contain at least 1.5 g of fiber per serving. When comparing the results obtained for the control and Treatment 1 (0.6108 g and 0.9983 g, respectively) with this criterion, it was evident that neither treatment met the established requirement. However, a significant increase in dietary fiber content was observed with the addition of 5% banana peel flour to the product. Consequently, the control treatment provided 2% of the daily value (DV) of fiber in a 30 g serving, while Treatment 1 delivered 4%, effectively doubling the fiber contribution to the daily value.

Table 13

Results of dietary fiber analysis of banana candy with addition of banana peel flour (BPF), per 30 g serving, according to RTCA 67.01.60.10 *(2018).*

Treatment	Dietary Fiber (g)	DV%
	Media ± SD	
Control (0% BPF)	0.61 ± 0.04	2
Treatment 1 (5% BPF)	1.00 ± 0.10	4
CV%	11.18	
P	0.0159	

Note. SD= Standard Deviation. DV%= Daily value. CV%= Coefficient of variation.

Nutritional Labeling

In Figure 4, nutritional labeling of banana candy with 0% and 5% addition of banana peel flour (BPF), in 30 g serving size is presented. As reported by López-Ramírez & Celis-Rozo (2024) , the nutritional labeling of foods represents an essential component within the informational framework of the food industry, complying with current regulations. This process involves the application of written, printed, or graphic information on food packaging or containers to provide consumers with detailed data about the general and specific characteristics of the product. This practice not only serves a crucial informational function but also helps consumers make informed decisions.

Comparing the nutritional profiles of the control banana candy (0% addition of banana peel flour) and the banana candy with 5% BPF, both products exhibited similar limitations. Neither met the criteria to be a significant source of fiber (<1.5 g) or potassium, and both contained more than 0.5 grams of added sugars per serving. However, it is important to note that the daily value of fiber increased by 2% from one treatment to the other. Additionally, both varieties were free from total fat, saturated fats, trans fats, cholesterol, and sodium. This indicated that while neither product provided substantial amounts of fiber or potassium, they both offered some nutritional benefits and can be considered for inclusion in a balanced diet due to their lack of harmful fats and cholesterol.

Figure 4

Nutritional labeling of banana candy with 0% and 5% addition of banana peel flour (BPF), in 30 g serving size.

CONTROL (0% BPF)

Nutrition Facts

servings per container	
Serving size	**(30g)**
Amount per serving	
Calories	**50**
	% Daily Value*
Total Fat 0.5g	**1%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 0mg	**0%**
Total Carbohydrate 11g	**4%**
Dietary Fiber 0.6g	**2%**
Total Sugars 9g	
Includes 6g Added Sugars	**12%**
Protein 0.2g	**1%**
Vitamin D 0mcg	0%
Calcium 1mg	0%
Iron 0mg	0%
Potassium 84mg	2%

*The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

TREATMENT 1 (5% BPF)

Nutrition Facts

servings per container	
Serving size	**(30g)**
Amount per serving	
Calories	**50**
	% Daily Value*
Total Fat 0g	**0%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 0mg	**0%**
Total Carbohydrate 14g	**5%**
Dietary Fiber 1g	**4%**
Total Sugars 11g	
Includes 8g Added Sugars	**16%**
Protein 0.3g	**1%**
Vitamin D 0mcg	0%
Calcium 1mg	0%
Iron 0mg	0%
Potassium 72mg	2%

*The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Conclusions

The treatment without the addition of banana peel flour (control) was the most accepted and preferred. However, the treatment with 5% addition was the most accepted after the control. This suggests that the addition of the flour alters the sensory characteristics in a way that may not be favorable for all consumers.

The addition of 5% of banana peel flour increased the fiber content in the banana candy in 2% regarding to the daily value, while improving its nutritional worth. However, this increase also affected the texture by reducing its hardness and adhesiveness, making it less pleasant compared to the control.

In terms of fiber content, although there was an improvement, the final product still does not meet the requirements to be considered a high-fiber source according to the standards established by the RTCA (2018). However, it can be considered a food with a contribution to the recommended daily intake of dietary fiber.

Recommendations

Conduct a proximal characterization of banana peel flour for the specific development of each product, as studies have shown that the dietary fiber content is highly variable.

For the formulation, include blending with other ingredients, such as gums, to compensate for variations in texture and ascorbic acid for variations in color.

To apply a pretreatment of the banana peel flour to improve its absorption in banana candy to enhance its integration into the mixture, to obtain a smoother and more consistent final product.

Additionally, explore the addition of banana peel flour to other food matrices to assess its versatility and benefits. For example, it could be incorporated into baked goods like muffins, cookies, snack bars.

Lastly, market studies should be conducted to evaluate consumer acceptance in a real-world setting, particularly focusing on the Ecuadorian region.

References

Ahmed, Z., El-Sharnouby, G., & EL-Waseif, M. (2021). Use of Banana Peel As A By-Product to Increase The Nutritive Value of The Cake. *Journal of Food and Dairy Sciences*, *12*(4), 87–97. https://doi.org/10.21608/jfds.2021.167053

Ajijolakewu, K. A., Ayoola, A. S., Agbabiaka, T. O., Zakariyah, F. R., Ahmed, N. R., Oyedele, O. J., & Sani, A. (2021). A review of the ethnomedicinal, antimicrobial, and phytochemical properties of Musa paradisiaca (plantain). *Bulletin of the National Research Centre*, *45*(1). https://doi.org/10.1186/s42269-021-00549-3

Anchundia, K., Santacruz, S., & Coloma, J. (2016). Caracterización física de películas comestibles a base de cáscara de plátano (Musa Paradisiaca). *Revista Chilena De Nutrición*, *43*(4), 9. https://doi.org/10.4067/S0717-75182016000400009

Asociación de Exportadores de Banano del Ecuador. (2022). *Anuario Estadístico*. https://d1fdloi71mui9q.cloudfront.net/OoEMbR7lTnKeLnVK5Qnm_Anuario%20Estadistico%20AEBE%20-%202022.pdf.

Asociación de Exportadores de Banano del Ecuador. (2023). *Anuario Estadístico*. https://ugc.production.linktr.ee/b5b6296e-8dd0-4ec2-98b5-47b89885bf09_Reporte-Agosto-AEBE.pdf

Ayoub, W. S., Zahoor, I., Dar, A. H., Anjum, N., Pandiselvam, R., Farooq, S., Rusu, A. V., Rocha, J. M., Trif, M., & Jeevarathinam, G. (2022). Effect of incorporation of wheat bran, rice bran and banana peel powder on the mesostructure and physicochemical characteristics of biscuits. *Frontiers in Nutrition*, *9*, 1016717. https://doi.org/10.3389/fnut.2022.1016717

Barbosa-Cánovas, G. V., Fontana, A. J., Schmidt, S. J., & Labuza, T. P. (2020). Water Activity in Foods. Advance online publication. https://doi.org/10.1002/9781118765982

Billesbølle, C. B., March, C. A. de, van der Velden, W. J. C., Ma, N., Tewari, J., Del Torrent, C. L., Li, L., Faust, B., Vaidehi, N., Matsunami, H., & Manglik, A. (2023). Structural basis of odorant recognition by a human odorant receptor. *Nature*, *615*(7953), 742–749. https://doi.org/10.1038/s41586-023-05798-y

Burgos, J. E., & Pupo Francisco, J. M. (2016). Metodología para medir la innovación en las empresas agroindustriales obligadas a llevar contabilidad en la provincia del Oro – República del Ecuador. *Eumed*(ISSN: 1696-8352).

Carvalho, V. S., & Conti-Silva, A. C. (2018). Cereal bars produced with banana peel flour: Evaluation of acceptability and sensory profile. *Journal of the Science of Food and Agriculture*, *98*(1), 134–139. https://doi.org/10.1002/jsfa.8447

Cheng, Y., Huang, P., Chan, Y., Chiang, P., Lu, W., Hsieh, C., Liang, Z., Yan, B., Wang, C. R., & Li, P. (2024). Investigate the composition and physicochemical properties attributes of banana starch and flour during ripening. *Carbohydrate Polymer Technologies and Applications*, *7*, 100446. https://doi.org/10.1016/j.carpta.2024.100446

Dewi, N. W. E. P., Rai, I. N., Mayadewi, N. N. A., & Efendi, D. (2023). Characteristics qualities of banana peel flour on three balinese banana cultivars (Musa spp.) with different fruit maturity levels. *Open Access Research Journal of Biology and Pharmacy*, *7*(1), 1–9. https://doi.org/10.53022/oarjbp.2023.7.1.0086

Díaz Alejandro, A. M. (2021). *Elaboración y caracterización fisicomecánica de una película biodegradable utilizando harina de cáscara de plátano (Musa paradisiaca L.)* [Proyecto Especial de Graduación]. Escuela Agrícola Panamericana, Zamorano, Honduras. https://bdigital.zamorano.edu/server/api/core/bitstreams/9106d7c1-c7e5-462a-b21e-de9caca0b56a/content

El Universo. (2014). *El dulce de guineo es tradición en la Península de Santa Elena*. https://www.eluniverso.com/vida-estilo/2014/10/13/nota/4098831/dulce-guineo-es-tradicion-peninsula/

Elvinna, & Sadek, N. F. (2024). Utilization of banana peel as functional ingredient in pudding: physicochemical and sensory aspects. *IOP Conference Series: Earth and Environmental Science*, *1324*(1), 12117. https://doi.org/10.1088/1755-1315/1324/1/012117

Ergun, R., Lietha, R., & Hartel, R. W. (2010). Moisture and shelf life in sugar confections. *Critical Reviews in Food Science and Nutrition*, *50*(2), 162–192. https://doi.org/10.1080/10408390802248833

Eshak, N. S. (2016). Sensory evaluation and nutritional value of balady flat bread supplemented with banana peels as a natural source of dietary fiber. *Annals of Agricultural Sciences*, *61*(2), 229–235. https://doi.org/10.1016/j.aoas.2016.07.002

Food and Agriculture Organization of the United Nations. (2020). *Banana facts and figures*. https://www.fao.org/economic/est/est-commodities/oilcrops/bananas/bananafacts/en/

Food and Agriculture Organization of the United Nations. (2022). *Food waste management and circular economy in mediterranean cities [*Webinar Outcomes]. https://openknowledge.fao.org/server/api/core/bitstreams/0f2afcbf-c9ef-4dc8-bcd7-e2773421926b/content

Fu, J., Zheng, Y., Gao, Y., & Xu, W. (2022). Dietary Fiber Intake and Gut Microbiota in Human Health. *Microorganisms*, *10*(12). https://doi.org/10.3390/microorganisms10122507

Girón Ortiz, J. A. (2016). *Elaboración y valoración bromatológica de galletas funcionales a base de cáscara de plátano verde (Musa paradisiaca) enriquecidas con semillas de zambo (Cucurbita ficifolia) y endulzadas con stevia [*Undergraduate], Riobamba, Ecuador. http://dspace.espoch.edu.ec/bitstream/123456789/5040/1/56T00641%20UDCTFC.pdf

Giusti, M. M., Gordillo, B., & González-Miret, M. L. (2024). *Color Analysis* (Nielsen's Food Analysis.). *Food Science Text Series*. Springer, Cham. https://doi.org/10.1007/978-3-031-50643-7_31

Gómez Montaño, F. J., & Blasco, G. (2014). Propiedades funcionales del plátano (Musa sp). *Revista Médica UV*, *14. 22-26*. https://www.researchgate.net/publication/348975625_Propiedades_funcionales_del_platano_Musa_sp

Gutiérrez Domínguez, J. F., & Ramírez Godínez, J. (2021). *Sabores básicos.* Universidad Autónoma del Estado de Hidalgo. https://repository.uaeh.edu.mx/bitstream/bitstream/handle/123456789/19903/sabores-basicos.pdf?sequence=1&isAllowed=y

He, Y., Wang, B., Wen, L., Wang, F., Yu, H., Chen, D., Su, X., & Zhang, C. (2022). Effects of dietary fiber on human health. *Food Science and Human Wellness*, *11*(1), 1–10. https://doi.org/10.1016/j.fshw.2021.07.001

Hussain, S., Jõudu, I., & Bhat, R. (2020). Dietary Fiber from Underutilized Plant Resources—A Positive Approach for Valorization of Fruit and Vegetable Wastes. *Sustainability*, *12*(13), 5401. https://doi.org/10.3390/su12135401

Instituto de Nutrición de Centro América y Panamá. (2018). *Tabla de composición de alimentos de Centroamérica* (Tercera edición). Instituto de Nutrición de Centro América y Panamá, INCAP.

International Organization for Standardization. (2009). *Sensory analysis. Vocabulary: ISO 5492:2009+A1:2017.* British Standart Institute. https://www.en-standard.eu/bs-en-iso-5492-2009-a1-2017-sensory-analysis-vocabulary/?srsltid=AfmBOoqQExRqzgwFk4pjkLOIcS3LR45NhjrTH89Dazn8qTYTUSCCm3bq

Ismail, S., Dubey, P. K., Mishra, A. A., & Ashka, F. (2024). Valorisation of banana peel and mango peel as functional ingredients in baked products: a review. *International Journal of Food Science & Technology*, *59*(9), 5938–5950. https://doi.org/10.1111/ijfs.17395

Juárez Ojeda, C. E. (2022). *Harina de banano (Cavendish): Efecto del secado convectivo en los compuestos fenólicos y la capacidad antioxidante* [Tesis de Pregrado]. Universidad Nacional de Frontera, Sullana, Perú. https://repositorio.unf.edu.pe/bitstreams/f03d9d0a-5194-45d6-83e0-c9c346e8e501/download

Khalid, S. (2021). Nutrients availability with stages of banana ripening. https://www.researchgate.net/figure/Nutrients-availability-with-stages-of-banana-ripening_fig1_352793672

Klosterbuer, A., Roughead, Z. F., & Slavin, J. (2011). Benefits of dietary fiber in clinical nutrition. *Nutrition in Clinical Practice : Official Publication of the American Society for Parenteral and Enteral Nutrition*, *26*(5), 625–635. https://doi.org/10.1177/0884533611416126

León Ajila, J. P., Espinosa Aguilar, M. A., Carvajal Romero, H. R., & Quezada Campoverde, J. (2023). Análisis de la producción y comercialización de banano en la provincia de El Oro en el periodo 2018-2022. *Ciencia Latina Revista Científica Multidisciplinar*, *7*(1), 7494–7507. https://doi.org/10.37811/cl_rcm.v7i1.4981

López-Pino, J. I., Valenzuela-Melendres, M., Camou, J. P., González-Ríos, H., Ayala-Zavala, F., & Peña-Ramos, A. (2021). Predicción de la resistencia térmica de Escherichia coli O157:H7 en carne molida de res en función de la temperatura y las concentraciones de carvacrol y grasa. *Biotecnia*, *23*(2), 47–54. https://doi.org/10.18633/biotecnia.v23i2.1372

López-Ramírez, M. P., & Celis-Rozo, E. E. (2024). Evolución del Etiquetado Nutricional y Frontal: Hitos históricos en Colombia y el mundo. *Revista Colombiana De Investigaciones Agroindustriales*, *11*(2), 1–31. https://doi.org/10.23850/24220582.5994

Luna Jarrín, L. E. (2023). *Manual de prácticas Laboratorio de microbiología de alimentos.* Escuela Agrícola Panamericana, Zamorano.

Nishinari, K., Peyron, M.-A., Yang, N., Gao, Z., Zhang, K., Fang, Y., Zhao, M., Yao, X., Hu, B., Han, L., Mleko, S., Tomczyńska-Mleko, M., Nagano, T., Nitta, Y., Zhang, Y., Singh, N., Suk Meng, A. G., Pongsawatmanit, R., Gamonpilas, C., . . . Su, L. (2024). The role of texture in the palatability and food oral processing. *Food Hydrocolloids*, *147*, 109095. https://doi.org/10.1016/j.foodhyd.2023.109095

Oguntoyinbo, O., Olumurewa, J., & Omoba, O. (2020). Chemical Composition, Dietary fiber and Antioxidant Activity of Fermented Ripe Banana Peel Flour. *Journal of Food Stability*, *3*(2), 27–42. https://doi.org/10.36400/J.Food.Stab.3.2.2020-0034

Palachum, W., Klangbud, W. K., & Chisti, Y. (2023). Novel nutritionally-enriched gummy jelly infused with nipa palm vinegar powder and nipa palm syrup as functional food ingredients. *Heliyon*, *9*(11), e21873. https://doi.org/10.1016/j.heliyon.2023.e21873

Pan American Health Organization. (2016). *Nutrient Profile Model*. https://iris.paho.org/bitstream/handle/10665.2/18621/9789275118733_eng.pdf?sequence=9&isAllowed=y

Phillips, K. (2023). *Effect Color Has on Food Perception, Flavor and Quality.* HunterLab. https://www.hunterlab.com/blog/effect-color-has-on-food-perception-flavor-and-quality/

Prescott, J. (2024). Development of Food Preferences, 1–24. https://doi.org/10.1007/978-3-319-75388-1_24-3

Ramli, S., Ismail, N., Alkarkhi, A. F. M., & Easa, A. M. (2010). The use of principal component and cluster analysis to differentiate banana peel flours based on their starch and dietary fibre components. *Tropical Life Sciences Research*, *21*(1), 91–100.

Râpă, M., Darie-Niță, R. N., & Coman, G. (2024). Valorization of Fruit and Vegetable Waste into Sustainable and Value-Added Materials. *Waste*, *2*(3), 258–278. https://doi.org/10.3390/waste2030015

RTCA 67.01.60.10, Reglamento Técnico Centroamericano. Etiquetado nutricional de productos alimenticios preenvasados para consumo humano para la población a partir de 3 años de edad., 2018. https://faolex.fao.org/docs/pdf/sica180091anx.pdf

RTCA 67.04.50, Reglamento Técnico Centroamericano. Alimentos. Criterios microbiológicos para la inocuidad de los alimentos., 2018. https://arsa.gob.hn/wp-content/uploads/2022/02/402-2018.pdf

Rosenthal, A., & Chen, J. (2024). Food Texturology: Measurement and Perception of Food Textural Properties. Advance online publication. https://doi.org/10.1007/978-3-031-41900-3

Ruiz-Capillas, C., & Herrero, A. M. (2021). Sensory Analysis and Consumer Research in New Product Development. *Foods (Basel, Switzerland)*, *10*(3). https://doi.org/10.3390/foods10030582

Sayem, A., Talukder, S., Akter, S. S., Alam, M., Rana, M. R., & Alam, M. M. (2024). Utilization of fruits and vegetables wastes for the dietary fiber enrichment of biscuits and its quality attributes. *Journal of Agriculture and Food Research*, *15*, 101077. https://doi.org/10.1016/j.jafr.2024.101077

Segura-Badilla, O., Kammar-García, A., Mosso-Vázquez, J., Ávila-Sosa Sánchez, R., Ochoa-Velasco, C., Hernández-Carranza, P., & Navarro-Cruz, A. R. (2022). Potential use of banana peel (Musa cavendish) as ingredient for pasta and bakery products. *Heliyon*, *8*(10), e11044. https://doi.org/10.1016/j.heliyon.2022.e11044

Shafi, A., Ahmad, F., & Mohammad, Z. H. (2022). Effect of the Addition of Banana Peel Flour on the Shelf Life and Antioxidant Properties of Cookies. *ACS Food Science & Technology*, *2*(8), 1355–1363. https://doi.org/10.1021/acsfoodscitech.2c00159

Soliman, G. A. (2019). Dietary Fiber, Atherosclerosis, and Cardiovascular Disease. *Nutrients*, *11*(5). https://doi.org/10.3390/nu11051155

Spence, C. (2015a). Multisensory flavor perception. *Cell*, *161*(1), 24–35. https://doi.org/10.1016/j.cell.2015.03.007

Spence, C. (2015b). On the psychological impact of food colour. *Flavour*, *4*(1). https://doi.org/10.1186/s13411-015-0031-3

Tate, & Lyle. (2021). *How and why to increase daily fibre intake*. https://www.tateandlyle.com/fibre-gap

Trumbo, P. R., Appleton, K. M., Graaf, K. de, Hayes, J. E., Baer, D. J., Beauchamp, G. K., Dwyer, J. T., Fernstrom, J. D., Klurfeld, D. M., Mattes, R. D., & Wise, P. M. (2021). Perspective: Measuring Sweetness in Foods, Beverages, and Diets: Toward Understanding the Role of Sweetness in Health. *Advances in Nutrition (Bethesda, Md.)*, *12*(2), 343–354. https://doi.org/10.1093/advances/nmaa151

Wang, Q. J., Mielby, L. A., Junge, J. Y., Bertelsen, A. S., Kidmose, U., Spence, C., & Byrne, D. V. (2019). The Role of Intrinsic and Extrinsic Sensory Factors in Sweetness Perception of Food and Beverages: A Review. *Foods (Basel, Switzerland)*, *8*(6). https://doi.org/10.3390/foods8060211

World Health Organization. (2018). *E. coli*. https://www.who.int/es/news-room/fact-sheets/detail/e-coli#:~:text=E.%20coli%20productora%20de%20toxina%20Shiga%20se%20destruye%20cociendo%20los,70%20%C2%B0C%20o%20m%C3%A1s.

Zhang, H., Wang, M., & Xiao, J. (2022). Stability of polyphenols in food processing. *Advances in Food and Nutrition Research*, *102*, 1–45. https://doi.org/10.1016/bs.afnr.2022.04.006

Appendices

Appendix A

Basker and Kramer Test Table "Critical value of differences between category sum".

Número de panelistas	Número de productos								
	2	3	4	5	6	7	8	9	10
20	8.8	14.8	21.0	27.3	33.7	40.3	47	53.7	60.6
21	9.0	15.2	21.5	28.0	34.6	41.3	48.1	55.1	62.1
22	9.2	15.5	22.0	28.6	35.4	42.3	49.2	56.4	63.5
23	9.4	15.9	22.5	29.3	36.2	43.2	50.3	57.6	65.0
24	9.6	16.2	23.0	29.3	36.9	44.1	51.4	58.9	66.4
25	9.8	16.6	23.5	29.9	37.7	45.0	52.5	60.1	67.7
26	10.0	16.9	23.9	30.5	38.4	45.9	53.5	61.3	69.1
27	10.2	17.2	24.4	31.1	39.2	46.8	54.6	62.4	70.4
28	10.4	17.5	24.8	31.7	39.9	47.7	55.6	63.6	71.7
29	10.6	17.8	25.3	32.3	40.6	48.5	56.5	64.7	72.9
30	10.7	18.2	25.7	32.8	41.3	49.3	57.5	65.8	74.2
31	10.9	18.5	26.1	33.4	42.0	50.2	59.4	66.9	75.4
32	11.1	18.7	26.5	34.0	42.6	51.0	60.3	60.3	76.6
33	11.3	19.0	26.9	35.0	43.3	51.7	61.2	69.0	77.8
34	11.4	19.3	27.3	35.6	44.0	52.5	62.1	70.1	79.0
35	11.6	19.6	27.7	36.1	44.6	53.3	63	71.1	80.1
36	11.8	19.9	28.1	36.6	45.2	54.0	63.9	72.1	81.3
37	11.9	20.2	28.5	37.1	45.9	54.8	64.7	73.1	82.4
38	12.1	20.4	28.9	37.6	46.5	55.5	67.2	74.1	83.5
39	12.2	20.7	29.3	38.1	47.1	56.3	65.6	75.0	84.6
40	12.4	21.0	29.7	38.6	47.7	57.0	66.4	76.0	85.7
41	12.6	21.2	30.0	39.1	48.3	57.7	67.2	76.9	86.7
42	12.7	21.5	30.4	39.5	48.9	58.4	68	77.9	87.8
43	12.9	21.7	30.8	40.0	49.4	59.1	68.8	78.8	88.8
44	13.0	22.0	31.1	40.5	50.0	59.8	69.6	79.7	89.9
45	13.1	22.2	31.5	40.9	50.6	60.4	70.4	80.6	90.9
46	13.3	22.5	31.8	41.4	51.1	61.1	71.2	81.5	91.9
47	13.4	22.7	32.2	41.8	51.7	61.8	72	82.4	92.1
48	13.6	23.0	32.5	42.3	52.2	62.4	72.7	83.2	93.8
49	13.7	23.2	32.8	42.7	52.8	63.1	73.5	84.1	94.8
50	13.9	23.4	33.2	43.1	53.3	63.7	74.2	85.0	95.8
55	14.5	24.6	34.8	45.2	55.9	66.8	77.9	89.1	100.5
60	15.2	25.7	36.3	47.3	58.4	69.8	81.3	93.1	104.9
65	15.8	26.7	37.8	49.2	60.8	72.6	84.6	96.9	109.2
70	16.4	27.7	39.2	51.0	63.1	75.4	87.8	100.5	113.3
80	17.5	29.6	42.0	54.6	67.4	80.6	93.9	107.5	121.2
90	18.6	31.4	44.5	57.9	71.5	85.5	99.6	114.0	128.5
100	19.6	33.1	46.9	61.0	75.4	90.1	105	120.1	135.5
110	20.6	34.8	49.2	64.0	79.1	94.5	110.1	126.0	142.1
120	21.5	36.3	51.4	66.8	82.6	98.7	115	131.6	148.4

Ref: Lawlees HT, Heymann H. Sensory evaluation of food. Principles and practices. Kluwer Academic/Plenum Publishers. New York, London, Dordrecht, Boston, 1998.

Appendix B

Acceptance test sensory evaluation and order of preference ballot.

Boleta de Evaluación Sensorial

Prueba de aceptación de un dulce de banano con harina de cáscara de banano (*Musa paradisiaca*) como fuente de fibra.

Edad: _____________

Nacionalidad: ______________________________ Fecha: ____________

Instrucciones: Frente a usted se encuentran cuatro muestras de dulce de banano. Por favor, pruebe cada una de las muestras presentadas, en orden de izquierda a derecha. Antes y después de probar cada muestra debe comer un pedazo de galleta soda y tomar agua con la finalidad de limpiar su paladar. Posteriormente, indique el grado agrado o desagrado de cada uno de los atributos presentados, guiándose con *cuadro No. 1*. Anote los resultados percibidos en el *cuadro No.2* apuntando el código de cada una de las muestras.

Cuadro #1. Escala hedónica de 9 puntos

1	2	3	4	5	6	7	8	9
Me disgusta extremadamente	Me disgusta mucho	Me disgusta moderadamente	Me disgusta ligeramente	Ni me gusta ni me disgusta	Me gusta ligeramente	Me gusta moderadamente	Me gusta mucho	Me gusta extremadamente

Cuadro #2. Evaluación de aceptación.

# Muestra	Color	Olor	Sabor	Sabor dulce	Textura	Aceptación general

Comentarios:

____

____

A continuación, enumere las muestras en orden de preferencia escribiendo el número de la muestra, siendo 1 la muestra más preferida y 4 la menos preferida.

Orden de Preferencia

Más preferida 1. ____________

2. ____________

3. ____________

Menos preferida 4. ____________

Justifique su preferencia:

____

GRACIAS POR SU PARTICIPACIÓN.

Appendix C

Nutritional composition of banana candy control treatment (0% of banana peel flour), in 30 g of portion.

	30 g of banana candy				
Control TRT (0% BPF)	Banana	Sugar	Unsalted Butter	BPF	Total
Energy (Kcal)	20.76	23.75	3.85	0.00	48.36
Total fat (g)	0.08	0.00	0.44	0.00	0.51
Cholesterol (mg)	0.00	0.00	1.15	0.00	1.15
Sodium (mg)	0.23	0.06	0.06	0.00	0.35
Carbohydrates (g)	5.33	6.14	0.00	0.00	11.46
Dietary fiber (g)	0.61	0.00	0.00	0.00	0.61
Total sugars (g)	2.85	6.13	0.00	0.00	8.98
Protein (g)	0.25	0.00	0.00	0.00	0.26
Vitamin A (mcg)	0.70	49.10	3.67	0.00	53.48
Calcium (mg)	1.17	0.06	0.13	0.00	1.36
Potassium (mg)	83.50	0.12	0.13	0.00	83.75
Ash (g)	0.19	0.01	0.00	0.00	0.20

Appendix D

Nutritional composition of banana candy Treatment 1 (5% of banana peel flour), in 30 g of portion.

	30 g of banana candy				
TRT 1 (5% BPF)	Banana	Sugar	Unsalted Butter	BPF	Total
Energy (Kcal)	17.74	31.63	2.86	0.00	52.23
Total fat (g)	0.07	0.00	0.32	0.09	0.48
Cholesterol (mg)	0.00	0.00	0.86	0.00	0.86
Sodium (mg)	0.20	0.08	0.04	0.00	0.32
Carbohydrates (g)	4.55	8.17	0.00	0.81	13.53
Dietary fiber (g)	0.52	0.00	0.00	0.76	1.28
Total sugars (g)	2.44	8.16	0.00	0.36	10.95
Protein (g)	0.22	0.00	0.00	0.15	0.37
Vitamin A (mcg)	0.60	65.38	2.73	0.00	68.71
Calcium (mg)	1.00	0.08	0.10	0.00	1.17
Potassium (mg)	71.36	0.16	0.10	0.00	71.62
Ash (g)	0.16	0.02	0.00	0.28	0.46

Appendix E

Nutritional composition of banana candy Treatment 2 (7.7% of banana peel flour), in 30 g of portion.

	30 g of banana candy				
TRT 3 (10.2% BPF)	Banana	Sugar	Unsalted Butter	BPF	Total
Energy (Kcal)	16.67	29.85	3.51	0.00	50.04
Total fat (g)	0.06	0.00	0.40	0.18	0.64
Cholesterol (mg)	0.00	0.00	1.05	0.00	1.05
Sodium (mg)	0.19	0.08	0.05	0.00	0.32
Carbohydrates (g)	4.28	7.71	0.00	1.65	13.65
Dietary fiber (g)	0.49	0.00	0.00	1.56	2.04
Total sugars (g)	2.29	7.70	0.00	0.73	10.73
Protein (g)	0.20	0.00	0.00	0.31	0.52
Vitamin A (mcg)	0.56	61.71	3.35	0.00	65.63
Calcium (mg)	0.94	0.08	0.12	0.00	1.13
Potassium (mg)	67.07	0.15	0.12	0.00	67.34
Ash (g)	0.15	0.02	0.00	0.58	0.75

Appendix F

Nutritional composition of banana candy Treatment 3 (10.2% of banana peel flour), in 30 g of portion.

	30 g of banana candy				
TRT 3 (10.2% BPF)	Banana	Sugar	Unsalted Butter	BPF	Total
Energy (Kcal)	16.67	29.85	3.51	0.00	50.04
Total fat (g)	0.06	0.00	0.40	0.18	0.64
Cholesterol (mg)	0.00	0.00	1.05	0.00	1.05
Sodium (mg)	0.19	0.08	0.05	0.00	0.32
Carbohydrates (g)	4.28	7.71	0.00	1.65	13.65
Dietary fiber (g)	0.49	0.00	0.00	1.56	2.04
Total sugars (g)	2.29	7.70	0.00	0.73	10.73
Protein (g)	0.20	0.00	0.00	0.31	0.52
Vitamin A (mcg)	0.56	61.71	3.35	0.00	65.63
Calcium (mg)	0.94	0.08	0.12	0.00	1.13
Potassium (mg)	67.07	0.15	0.12	0.00	67.34
Ash (g)	0.15	0.02	0.00	0.58	0.75

Appendix G

Theoretical nutritional labeling of banana candy with 7.7% addition of banana peel flour, in 30 g serving size.

Nutrition Facts

servings per container	
Serving size	**(30g)**
Amount per serving	
Calories	**50**
	% Daily Value*
Total Fat 0.5g	**1%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 0mg	**0%**
Total Carbohydrate 14g	**5%**
Dietary Fiber 1g	**4%**
Total Sugars 11g	
Includes 8g Added Sugars	**16%**
Protein 0.4g	**1%**
Vitamin D 0mcg	0%
Calcium 1mg	0%
Iron 0mg	0%
Potassium 69mg	2%

*The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Appendix H

Theoretical nutritional labeling of banana candy with 10.2% addition of banana peel flour, in 30 g serving size.

Nutrition Facts

servings per container

Serving size	**(30g)**
Amount per serving	
Calories	**50**
	% Daily Value*
Total Fat 0.5g	**1%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 0mg	**0%**
Total Carbohydrate 14g	**5%**
Dietary Fiber 2g	**7%**
Total Sugars 11g	
Includes 8g Added Sugars	**16%**
Protein 0.5g	**1%**
Vitamin D 0mcg	0%
Calcium 1mg	0%
Iron 0mg	0%
Potassium 67mg	2%

*The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Appendix I

Nutrient Profile of banana candy with 0 % addition of banana peel flour, according to (Pan American Health Organization [PAHO], 2016).

	Quantity	%DV	Nutrient Profile	Excess	% Excess
Kcal	48.36	2.40	-	-	-
Added sugars (g)	6.13	2.00	1.20	4.90	407.00
Sodium (mg)	0.35	0.00	48.36	No Excess (0.35: 48.36)	-
Total Fat (g)	0.51	0.80	1.60	-1.10	-68.40

Note. %DV= Daily Value Percentage.

Appendix J

Nutrient Profile of banana candy with 5 % addition of banana peel flour, according to (PAHO, 2016).

	Quantity	%DV	Nutrient Profile	Excess	% Excess
Kcal	52.23	2.60	-	-	-
Added sugars (g)	8.16	2.70	1.30	6.90	524.90
Sodium (mg)	0.20	0.00	52.23	No Excess (0.20: 52.23)	-
Total Fat (g)	0.48	0.70	1.70	-1.30	-72.40

Note. %DV= Daily Value Percentage.

Appendix K

Nutrient Profile of banana candy with 7.7 % addition of banana peel flour, according to (PAHO, 2016).

	Quantity	%DV	Nutrient Profile	Excess	% Excess
Kcal	51.18	2.60	-	-	-
Added sugars (g)	7.92	2.60	1.30	6.60	519.00
Sodium (mg)	0.32	0.00	51.18	No Excess (0.32: 51.18)	-
Total Fat (g)	0.57	0.90	1.70	-1.10	-66.60

Note. %DV= Daily Value Percentage.

Appendix L

Nutrient Profile of banana candy with 10.2 % addition of banana peel flour, according to (PAHO, 2016)

	Quantity	%DV	Nutrient Profile	Excess	% Excess
Kcal	50.04	2.50	-	-	-
Added sugars (g)	7.70	2.60	1.30	6.40	515.50
Sodium (mg)	0.32	0.00	50.04	No Excess (0.32: 50.04)	-
Total Fat (g)	0.64	1.00	1.70	-1.00	-61.60

Note. %DV= Daily Value Percentage.