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Abstract -- The objective of this research was to evaluate the effect of the addition of mango by-product powders on the physicochemical, biochemical and sensory characteristics of cookies.

Peels and seeds of creole mango from the Puebla Mixtec region were processed to obtain fine powders, from which the physicochemical and functional characteristics, total dietary fiber content, phenol content, and antioxidant activity were determined. A control cookie (F0) and three formulations incorporating 10% (F1), 13% (F2), 17% (F3) of peel powder mixed with 23% of mango seed powder were prepared. The formulations were tested for physicochemical, biochemical [1] and sensory characteristics.

The incorporation of mango peel and mango seed powders in cookies at 13% and 23% substitution level, respectively, was organoleptically acceptable. The moisture, protein, fat, crude fiber, ash, carbohydrate contents of the cookie formulations were significantly higher (p=0.00) compared to the control formulation. A significant increase in total dietary fiber content, total phenols and DPPH radical inhibition was found. Therefore, the use of creole mango peel and seed powders can play an important role in improving the nutritional value of cookies by taking advantage of their nutritional properties, antioxidant and dietary fiber content.

Keywords: *mango by-product; cookies: fiber: antioxidants.*

Abstract -- The objective of this research was to evaluate the effect of the addition of powders obtained from mango by-products on the physicochemical, biochemical and sensory characteristics of cookies.

Peels and seeds of mango criollo from the Mixteca Poblana were processed to obtain fine powders, for which the physicochemical and functional characteristics, total dietary fiber content, phenolic content and antioxidant activity were determined. A control cookie (F0) and three formulations were prepared incorporating 10% (F1), 13% (F2), 17% (F3) of peel powder mixed with 23% of mango seed powder. The physicochemical, biochemical [1] and sensory characteristics of the formulations were determined.

The incorporation of mango peel and seed powders in cookies at a substitution level of 13% and 23%, respectively, was organoleptically acceptable. The moisture, protein, fat, crude fiber, ash, carbohydrate content of the biscuit formulations were significantly higher (p=0.00) compared to the control formulation. A significant increase in the content of total dietary fiber, total phenolics and inhibition of the DPPH radical was found. Therefore, the use of mango criollo peel and seed powders can play an important role in improving the nutritional value of cookies by taking advantage of their nutritional properties, antioxidant content and dietary fiber.

Key words : mango by-product; cookies: fiber: antioxidants.

INTRODUCTION

Bioactive compounds such as phenols, carotenoids, and dietary fibers have received increasing attention due to their antioxidant, anticarcinogenic, antimutagenic, and other health-promoting properties [2]. A diet rich in these compounds imparts health benefits [3, 4] such as reduction of cholesterol, intestinal regulation, glycemic control, weight control, decreased risk of certain types of cancer, among others.

Cookies are easily acquired and transported foods, the fact that they are eaten anywhere and at any time [5] makes them very versatile products of "mass consumption" [6], which, in addition to their high demand and low production cost, are a food that can satisfy hunger [7, 8]. Due to their ease of preparation and fortification, they have been considered as a good vehicle to provide the population with a food proposal of high nutritional value [9, 8, 10, 11, 5], since their nutritional content increases according to the raw material used, so wheat flour combined with soybean, corn germ and legumes, roots, fruits and vegetables have been used [12, 13, 6]. It has been shown that by-products from the fruit and vegetable processing industry, such as pineapple [15] and banana [16] peels [15], have a high nutritional content [16].
are a rich source of dietary fiber, minerals and bioactive compounds [14, 7] that have been incorporated into cookie formulations making them foods that can promote health benefits.

Mango is mainly composed of peel and pulp with 82.97%, the stone represents between 7-8%, and of the latter, 15% corresponds to the seed [15]. Depending on the variety, the peel and seed contain a higher content of dietary fiber and a number of bioactive compounds associated with it, such as polyphenols phenolic acids, alkyl(en)ilresorcinols, dietary fiber, terpenoids as well as antioxidant minerals such as potassium, copper, zinc, manganese, iron [2, 17, 18, 19]. Ajila *et al.* [7], Ashoush & Gadallah [8], Alazb *et al.* [19], Aslam *et al*. [20] have reported the improvement of the nutritional properties of bakery products, by including in their formulations mango by-products in the form of flour, due to the above it is considered that powders obtained from peel and seed of Criollo mango (*Mangifera indica L.*) from the region of Acatlán, Puebla, when incorporated in cookie formulations, provide antioxidants and dietary fiber, thus increasing its nutritional and functional value, without affecting its sensory characteristics.

In the region of Acatlán, Puebla, the amount of fruit from Criollo mango trees that are not harvested each year are considered waste fruit, and for small regional producers they represent economic losses because they cannot be marketed or processed due to the lack of processing companies for this fruit in the region. The purpose of this project was to evaluate the effect of the addition of powders obtained from Criollo mango by-products on the physicochemical, biochemical and sensory characteristics of cookies, as an alternative to give added value to Criollo mango by-products from the Mixtec region, considering them as a potential source of antioxidants and dietary fiber in cookie preparations.

DEVELOPMENT

The present work was carried out in the Food Industries Workshop, as well as in the Basic Multifunctional Laboratory of the Food Industries Engineering Career of the Tecnológico Nacional de México Campus Acatlán de Osorio.

Raw material procurement

Mangoes of the Criollo variety were harvested in the communities of Tianguistengo, Xayacatlán de Bravo and Las Adelfas located in the region of Acatlán, Puebla, between April and May 2022. The mangoes were selected at optimum maturity and washed with potable water to remove traces of soil and insects. Subsequently, they were manually pulped to separate seed and peel, and the first two were washed with potable water to eliminate the remains of pulp. Using a knife, the seeds were separated from the kernels. Both the husks and the seeds were subjected to blanching (98°C and 1 minute) and then immersed in citric acid solutions (5% w/v) to prevent browning due to enzymatic action and then in sodium bisulfite solution (1% w/v) to prevent the proliferation of fungi and yeasts; finally, they were dried with absorbent paper to eliminate excess water.

Obtaining mango peel and seed powders Mango peels and ***seeds*** were separately subjected to the action of hot air at a temperature 60 °C for 24 hours in a tray dehydrator (Aresma, model 100).

Once dehydrated, they were ground with the aid an electric grain mill and finally passed through a No. 35 sieve to a particle size of 500 microns. Both the husk and seed powders were packed in hermetically sealed polyethylene bags, duly labeled with the date of preparation, and stored at room temperature until their physicochemical and functional properties were determined and their use in the preparation of cookies was determined.

Physicochemical and functional properties of mango by-product powders.

The mango peel and seed powders were analyzed for proximate composition using official AOAC methods [1, 21, 22, 9, 23], total protein content was determined by the Kjendhal method (950.36), crude fiber (950.37), ash (930.22), fat (935.38) and moisture, using the rapid thermobalance method (NMX-F-428-1982) [24]. Carbohydrate content was calculated by difference [21, 22]. All analyses were performed in triplicate.

The functional properties of Creole mango peel and seed powders included water absorption capacity (WAC) and oil absorption capacity (OAC) described by Chaparro-Acuña *et al.* [25] and Menon *et al.* [26], respectively. A 1 g sample previously defatted with chloroform was taken and mixed with 10 mL of distilled water or soybean oil in a vortex shaker model MX-S, for 30 seconds. The sample remained at rest at room temperature (25 ± 2°C) for 30 minutes; it was then centrifuged at 3000 rpm for 30 minutes, the supernatant was immediately removed and the sediment was weighed. Water holding capacity was expressed as mL of water absorbed per gram of powder and lipid absorption was expressed as grams of oil absorbed per gram of powder.

Determination of total dietary fiber

Total dietary fiber, soluble and insoluble, was obtained by the enzymatic-gravimetric method [1], developed by Asp *et al.* [27] and modified by Parra & Meza [21], using alpha-amylase, pancreatin and pepsin, Sigma Aldrich® brand.

Obtaining sample extracts

Extracts were prepared from 1 g of sample, macerated with 25 mL of ethanol and shaken for 30 min at 5000 rpm [23]. The supernatant was filtered using Whatman No.1 filter paper and centrifuged at 2000 rpm for 20 minutes and immediately used for the determination of total phenolic compounds and antioxidant capacity (DPPH).

Total phenol content

The total phenol content of the extracts was determined colorimetrically, using the *Folin-Ciocalteu* method, as described by Singleton *et al*. [28] (1999), Ajila & Prasada [17]), Ashoush & *Gadallah* [8], Bandyopadhyay *et al*. Ashoush & Gadallah [8], Bandyopadhyay *et al*. [29], with some modifications and using Sigma-Aldrich ® brand gallic acid, as a standard: 0.5 mL aliquots of the extract were added to 0.5 mL of *Folin-Ciocalteu's* reagent, followed by the addition of 0.5 mL of a 7.5 % (w/v) aqueous sodium carbonate solution. The mixture was stirred and allowed to stand for 30 min. The absorbance at 765 nm was measured using a VELAB model VE-5000V spectrophotometer. A blank sample consisting of water and reagents was used as a reference. Results were expressed as milligrams of gallic acid equivalents per gram of powder (mg GAE/g powder) by reference to the gallic acid calibration curve using the following equation:

$$y = 0.044\,x + 0.1645 \qquad \text{Eq. (1)}$$

$$R^2 = 0.996$$

Antioxidant activity

The antioxidant activity of the ethanolic extracts of the samples was determined by scavenging the free radical activity by the method described by Ashoush & Gadallah.
[8] with some modifications. An aliquot of 1.5 mL of the samples was taken and placed an amber flask and then 1.5 mL of 0.004 % (w/v) DPPH reagent was added, then shaken and allowed to stand at room temperature in the absence of light for 30 min. The decrease in antioxidant activity was measured using 517 nm. The antioxidant activity was expressed as percentage inhibition of the DPPH radical and was determined by the following equation [8]:

$$\%\ deactividadantioxidante = \frac{(Abscontrol - Absmuestra)}{Abscontrol} x\ 100 \qquad \text{Eq. (2)}$$

Where, *Abscontrol*=absorbance of the blank,
Absmuestra= absorbance of the sample.

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The percentage inhibition was plotted against the concentration of the sample extract. The value of half inhibition concentration (IC50), defined as the amount of sample required to achieve 50% of the free radical scavenging activity.

Cookie formulations

From an initial cookie formulation (F0), the percentages of wheat flour substitution with shell and seed powders of Criollo mango were varied until three formulations were obtained that did not affect the viscosity of the dough or its sensory properties required to form the cookie, considering the lamination operations [9, 22]. As a result, three formulations were obtained by mixing husk and seed powders to replace 33, 36 and 40% of wheat (Table 1) in the base formulation, and subsequently mixing with sugar, butter, vegetable shortening, egg, baking powder, salt and vanilla essence. The formulations were named as F0 (control), F1 (substitution 10% husk powder and 23% mango seed powder), F2 (substitution 13% husk powder and 23% mango seed powder) and F3 (substitution 17% husk and 23% mango seed powder).

Table 1. Percentage of each type of flour in the cookie formulations.

Formulation	% Flour of Wheat	% Powder of shell	% Powder of
F0	100	0	0
F1	67	10	23
F2	64	13	23
F3	60	17	23

Source: Own elaboration

The cookie manufacturing process began by weighing the raw materials and inputs according to the established formulations. The raw materials, fats, vanilla essence, sugar, egg, baking powder and salt were mixed for five minutes using an Oster mixer until a smooth and creamy consistency was obtained. Subsequently, this mixture was combined with the wheat flour, peel powder and Creole mango seed, until a smooth and homogeneous dough was obtained, which was left to rest for 20 minutes. The dough obtained was rolled with the help of a rolling pin to obtain a thickness of 0.5 cm. The cookies were molded using a star-shaped cookie cutter. They were then placed on a previously greased tray and baked in the oven at 180°C for 20 minutes. The cookies were cooled to room temperature and packed in hermetically sealed plastic bags for analysis.

Analysis of cookie formulations

a) Physicochemical characteristics

Moisture content, protein, fat, ash and crude fiber were determined by the AOAC method[1]. Carbohydrate content was calculated by the difference method.

b) Biochemical characteristics

The content of total, soluble and insoluble dietary fiber was obtained using the enzymatic-gravimetric method [1].

The total phenol content of the extracts was determined colorimetrically, using the *Folin-Ciocalteu* method, as described by Singleton *et al* [28], Ajila *et al* [17] Ashoush & Gadallah [8], Bandyopadhyay *et al* [29].

The antioxidant activity of the ethanolic extract of the samples was determined by scavenging the free radical activity through the method described by Ashoush & Gadallah [8].

c) Sensory characteristics

The evaluation of the organoleptic characteristics was carried out by a panel of 60 untrained tasters formed by students and teachers, of both sexes between 18 and 50 years of age, from the TecNM Campus Acatlán de Osorio, who evaluated the aroma, texture, flavor, color and general appearance, using a 9-point hedonic scale, in which 1=I dislike it very much, 5=I neither like nor dislike it, 9=I like it very much [8, 30, 29, 26, 22]. For this evaluation, cookies made one day in advance were used, which were stored in polyethylene bags and kept at room temperature to protect the organoleptic characteristics.

Statistical Analysis

The results were expressed as the average value of 3 determinations± the standard deviation. The results of physicochemical, biochemical and sensory characteristics of the cookies were subjected to analysis of variance (ANOVA) for a completely randomized design [22, 21, 31] to determine the existence of significant differences and Tukey's test for comparison between means. All analyses were performed at the statistical package Minitab

(Version 17), considering a value of Alpha0.05 as a significant effect.

DISCUSSION AND ANALYSIS OF RESULTS

Physicochemical characteristics of shell and seed powders

The results of proximate analysis, water absorption capacity (WAC) and oil absorption capacity (WAC), total dietary fiber and total phenols of mango peel and seed powders are presented in Table 2. It can be observed that the highest content of moisture, crude fiber, ash and total dietary fiber was presented by the peel powder while the seed powders were higher in moisture, fat, carbohydrates, AAC and CAL; both powders had similar values in carbohydrate and total phenol content, as well as antioxidant activity (DPPH). These results are in agreement with those reported by Ashoush & Gadalla [8], Chaparro *et al.* [25], Jibaja [32], Serna and Torres [33], Kaur & Brar [18], Bandyopadhyay *et al.* [29], Ajila *et al.* [2], for other varieties.

Table 2. Proximal composition of shell and seed of criollo mango.

Components	Shell	Seed
Humidity (%)	5.43± 0.08	10.90± 0.43
Crude protein (%)	4.43± 0.11	5.68± 0.07
Crude fat %)	2.38± 0.83	10.03± 0.21
Crude fiber (%)	15.76± 0.70	6.49± 0.39
Ash (%)	2.25± 0.56	1.97± 0.35
Total carbohydrates (%)	69.76± 0.42	69.97± 0.7
Total dietary fiber (g/100 g dry basis)	51.89± 0.35	31.92± 0.06
Soluble dietary fiber (g/100 g dry basis)	14.76± 0.08	11.58± 0.70
Insoluble dietary fiber (g/100 g dry basis)	37.12± 0.31	20.34± 0.11
Water absorption capacity (gH2O/g powder)	4.41± 0.05	4.0± 0. 09
Absorption capacity of oil (g oil/g powder)	2.56± 0.11	1.45± 0.21
Total Phenols (mg GAE/g)	31.44± 2.12	31.04± 3.89
Inhibition of DPPH (IC50 in mg)	2.38± 0.048	2.08± 0.019

Source: Own elaboration

Physicochemical characteristics of cookies

Table 3 shows the results obtained for moisture, , protein, crude fiber, fat and ashes present in the cookie formulations with partial substitution of wheat flour by shell powders and Creole mango seed, which are compared with a cookie made with 100% wheat flour, used as a standard. Statistical analysis indicated that in the cookies under study there were significant differences between the contents of protein, fat, crude fiber, ash and carbohydrates ($p= 0.00$) but not in the moisture , as can be seen in the table, the chemical composition varies with respect to the percentage of substitution, this was observed in cookies with banana peel [16], mango seed and peel [8, 20, 29] of other varieties, developed in other investigations.

The moisture contents of the treatments were higher than the control formulation and ranged between 4.89% and 5.12%, these values are below the maximum limit (15%) established for bakery products considered in NOM-247-SSA1-2008[35]. Formulation F3 presented a higher percentage moisture content (5.12%).12%), this may be due to the fact that the higher the percentage of substitution of by-product powders, the greater the interaction between water and hydroxyl groups present in the carbohydrates of the dietary fiber, through hydrogen bonds [7, 22], this behavior coincides with that reported in cookies with a partial substitution of wheat flour from 5 to 50% [8, 29] with mango peel and seed powders, 25% of banana peel powder [16], 12% of mango peel powder combined with 12% of pineapple peel powder [15]; the moisture values reported in this investigation were lower than those reported in these investigations but higher than those published by Aslam *et al*. [29] and Kaur & Brar [18] in cookies with 15 to 30% substitution of mango peel and seed flour.

The ash content for three formulations was higher with respect to the control formulation, the higher the substitution of wheat flour by mango by-product powders, the higher the ash content in the cookies Table 3). The values reported in this study are higher than those found in cookie formulations with 5 to 10% substitution [20] with mango seed and peel flour and 30 % of mango seed flour [18]; are similar to that reported by Bandyopadhyay *et al.* [29] for cookies 20-50% mango peel and seed powders; and lower than that reported by Falla and Ramon [16] for a cookie with 25% substitution of wheat flour for banana peel powder.

Formulation F0 was superior in protein content compared to formulations F1 and F2. Formulation F3 presented a higher protein content (6.14%), because the shell content in the mixture was increased; this slight increase coincides with what was found by Aslam *et al.* [20] in two cookies with 15% substitution of wheat flour by mango shell and seed powders, for each formulation respectively; the values of protein percentage of the formulations of this study are as follows
lower than the 12.2% protein found in cookies with 25% banana flour [16] and
cookies with 25% of banana flour [16] and
higher than 4.35% of a formulation 30% mango seed powder developed by Kaur & Brar [18].

With respect to fat content, the three formulations were slightly higher than the 19.47% found in the control cookie (F0), with the F1 formulation having the highest fat content.
fat (19.38 %) while the F3 was lower (19.38 %) while the F3 was lower (19.38 %) while the F3 was
(19.35%). The results obtained are lower than those reported by Aslam *et al.* [20] in cookies with 15% mango peel and seed powder, as well as those published by Kaur & Brar [18] in a cookie formulation with 30% mango seed powder and slightly lower than those reported by Falla and Ramón [16] in cookies with 25% banana peel powder (19.7%) and those published by Cedeño and Zambrano [15] in cookies with pineapple peel powder.

The formulations in this study presented a higher crude fiber content than the control formulation, with the highest percentage found in treatment F3 (12.04%). The crude fiber content of the cookie formulations in this study was lower than that found in cookies with 5-15% mango peel and seed powders developed by Aslam *et al*. [20] and higher than the fiber content found in cookies with 25% banana peel [16] and 30% mango seed [18].

The carbohydrate content in all formulations was lower compared to the control formulation (1.20%), being the cookie of formulation F1 the one with the highest carbohydrate content, 59.61%, compared to the other formulations. Aslam *et al.* [20] found that the greater the substitution of peel and mango seed powder in their formulations, the carbohydrate content of the cookies decreased, the same can be observed in the values reported in this research for this chemical characteristic (Table 3); the values reported are higher than those published by Falla and Ramón [16] in cookies with 25% banana flour and lower than those reported in a formulation that substitutes 30% of wheat flour with mango powder flour, developed by Kaur & Brar [18].

Table 3. Proximal composition of cookies with different levels of flour substitution by by-product powders of Criollo mango (Mangifera indica L.)*.

Characteristic (%)	**Formulations** F0	F1	F2	F3
Humidity	0.89± 0.01	4.89± 0.03A	4.99± 0.21A	5.12± 0.18 a
Ashes	0.66± 0.08	1.32± 0.05b	2.02± 0.08TH	2.16± 0.14A
Proteins	6.01± 0.19	5.26± 0.61a	5.81± 0.24b	6.14± 1.8 b
Grease	19.31± 0.81	19.47± 0.55a	19.38± 0.48TH	19.35± 0.26 a
Crude Fiber	1.20± 0.03	9.44± 0.25A	10.85± 0.29b	12.04± 0.8c
Carbohydrates	71.93± 1.02	59.61± 0.82A	56.95± 0.68b	55.17± 0.6c

* Non-common letters indicate significant difference, according to Tukey's Test at 95%.
Source: Own elaboration

Dietary fiber content, total phenolics and antioxidant activity

There were significant differences in the content of dietary fiber, total phenols and antioxidant activity with respect to the level of substitution of wheat flour by mango peel and seed powders (p=0.00), as shown in Table 4.

The total dietary fiber (TDF) content in the three formulations was higher than that obtained in formulation F0 (6.08g/100 g cookie) and that reported in cookies added with 12% *Arracacia xanthorrhiza* flour prepared by García & Pacheco [9] and lower than that reported by Benítez *et al.* [22] in cookies containing 12.5% flaxseed flour and in a cookie made with 70:30 of plantain of the pepita and sweet potato variety, made by León-Mendez *et al* [34]. Ajija *et al.* [7], indicate that, during baking, some components present in both peel and seed could contribute to the formation of additional dietary fiber.

As shown in Table 4, the higher the substitution of wheat flour by by-product powders of creole mango, the higher the phenol content in the cookie formulations, this behavior coincides with that reported by Bandyopadhyay *et al.* [29], Ajija *et al.* [7], Ajija *et al.*, [2], Ashoush & Gadallah [8] in cookies with mango peel and seed. There are publications indicating that conventional cooking treatments significantly reduce the total phenol content in various vegetables [2, 29], this may explain the total phenol content of the treatments in this study.

DPPH is a free radical stable to characteristic absorbance at 517 nm, it reacts with antioxidants converting it to 2,2-diphenyl-1- picrylhydrazine. The degree of decrease in absorbance at 517 nm is an indication of the scavenging potential of the oxidative extract, caused by the hydrogen donating capacity [7]. Cookies with shell and seed extract showed a DPPH radical scavenging dependent on the concentration of total phenols, that is, the antioxidant activity showed a significant increase ($p<0.01$) with the level of substitution of by-product powders, this behavior coincides with that reported in cookies incorporating seed and shell powders separately [7, 8]. With the increase in the incorporation of native mango peel, the DPPH radical scavenging activity increased. In the case of cookies with 13% and 23% of husk and seed powder (T2), respectively, the ethanolic extracts of the samples corresponding to 5.5, 6.5, 7.5, 9.5 10.5 mg of cookie powder showed 43.22, 47.16, 51.91, 58.97 and 62.92 % scavenging activity, respectively. This increase in free radical could be attributed to the increase in polyphenol content by incorporating Creole mango by-product powders.

In Table 4, it is observed that to obtain 50% of the DPPH radical scavenging activity for the cookies with 33, 36 and 40% substitution of wheat flour by mixtures of mango by-product powders, 4.31, 2.71 1.95 mg were required, respectively, while in the case of the control cookie it was 210 mg. From the results obtained, the incorporation of mango peel and seed powders in cookie formulations increases health benefits by increasing antioxidant properties and dietary fiber content.

Table 4. Proximal composition of cookies with various levels of flour substitution by Creole mango by-product powders* (IC50 in mg)*.

	Formulations			
Featur	F0	F1	F2	F3
Total dietary fiber (g/100 g b.s)	6.08± 0.40	22.92± 0.^{81c}	25.26± 3.^{2b}	27.61± 0.38TH
Insoluble dietary fiber g/100 g b.s)	4.25± 0.02	16.54± 0.^{84c}	18.18± 0.^{28b}	19.81± 0.25a
Soluble dietary fiber (g/100 g dry basis)	2.13± 0.19	6.38± 0.25c	7.09± 0.^{56b}	7.8± 0.^{42a}
Total phenols (mg GAE/g)	1.68± 0.05	29.24± 0.^{06c}	31.71± 0.^{09b}	34.92± 0.^{03a}
Inhibition of DPPH (IC50 at mg)	210± 36	4.31+0.^{5a}	2.71± 0.^{7b}	1.95 ±0.^{6c}

* Non-common letters indicate significant difference, according to Tukey's test at 95%.
Source: Own elaboration

Sensory evaluation

Statistical analysis indicated that there were significant differences among the formulations ($p = 0.000$), with respect to aroma, texture, flavor, general appearance and color. As can be seen in Table 5, the greater the substitution of wheat flour for by-product powders of Criollo mango, the lower the perception of the attributes evaluated in the three formulations compared to the base formulation. In the formulation with the highest percentage of substitution, lower scores were obtained in color and aroma, but not in texture, flavor and general appearance, while the F2 formulation presented better ratings in aroma, flavor, color and general appearance. This difference in the evaluation of flavor can be related to the perceived sensation of astringency, which is given by the content of tannins present in the mango peel and seed, which interact with proteins of the saliva in the mouth, causing dryness, roughness and roughness in the tissues of the mouth; This coincides with that published by Falla and Ramón [16] for green banana cookies and in cookies with pineapple peel and mango peel, both separately, carried out by Cedeño and Zambrano [15]. The content of polyphenols present in mango peel provided a darker coloration to the cookies of this research, as the percentage of substitution of wheat flour for peel powder increased; these polyphenols also present in the cookies of this research, as the percentage of substitution of wheat flour for peel powder increased.

compounds provide intense colors, especially red, yellow and orange, shades that when incorporated into a formulation and then subjected to a baking process where the product is exposed to high temperatures (180°C) completely change the appearance of the final product, This coincides with that reported by Falla and Ramón [16] in cookies made with green banana peel powder (10%) and in cookies with mango peel powder (12%) and pineapple peel (8%) made by Cedeño and Zambrano [15]. It has been reported that substitutions greater than 10-15% of wheat flour by mango peel flour in cookies present values below an optimum level (7) on the 9-point scale [7, 8, 20, 29]; for substitutions with mango seed, Ashoush & Gadallah [8], Kaur & Brar [18] and Bandyopadhyay *et al*. [29], have reported that with up to 40% incorporation of seed flour, the overall appearance, color, texture, flavor and general texture scores are above the minimum acceptable level; these data coincide with those reported in this research.

Table 5. Sensory evaluation of cookies with various levels of flour substitution by Creole mango by-product powders*.

Characteristics	Formulations			
	F0	F1	F2	F3
Aroma	8.± 0.25	7.± 0.26[b]	7.± 0.20[a]	6.± 0.23[c]
Texture	8.± 0.24	7.± 0.25[c]	6.± 0.22[b]	7.± 0.21[a]
Taste	8.± 0.31	7.± 0.29[a]	8.± 0.28[b]	7.± 0.22[b]
Color	8.± 0.20	7.± 0.21[a]	7.± 0.26[b]	6.± 0.28[b]
Apariencia general	8.± 0.27	7.± 0.28[a]	7.± 0.25[b]	7.± 0.23[b]

* Non-common letters indicate significant difference, according to Tukey's test at 95%.
Source: Own elaboration

CONCLUSIONS

The chemical compositions of Creole mango peel and seed powders showed that they are a good source of bioactive compounds such as dietary fiber and total phenols. The total dietary fiber content in Creole mango by-product powders showed a balanced ratio of FDI/FDS, which is important for establishing the nutritional effects of the fiber in the powders.

Cookies with a substitution ratio of 40% (17% shell and 23% seed) were shown to be higher in dietary fiber content, as well as in total phenol content than the control cookie, and therefore had higher antioxidant activity. As a result of the increase in the content of bioactive compounds, the IC50 value increased compared to the control cookie.

From the present study, it can be concluded that incorporating up to 13% peel powder with 23% seed powder in a cookie without affecting its quality or organoleptic acceptability, will have a higher dietary fiber content, higher total phenol content than those found in the control cookie. Based on the above results, it is thus possible to incorporate mango seed and peel powders as a potential source of functional compounds in bakery products.

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