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Effect of adding pineapple (*Ananas comosus*) flour on the sensory and textural properties of wheat flour (*Triticum aestivum*) cookies

Efecto de la adición de harina de piña (*Ananas comosus*) sobre las propiedades sensoriales y de textura de galletas de harina de trigo (*Triticum aestivum*)

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Abstract

Cookies from wheat flour are one of the most consumed bakery products. However, as they are deficient in fiber, usually other ingredients are added to improve the organoleptic and nutritional attributes. In this work, three formulations were followed to prepare wheat flour (WF) cookies with pineapple flour (PF) at 5, 10, and 15% of substitution. The acceptance level of the cookies was analyzed by three consumer groups: children, teenagers, and adults. The physicochemical properties and shelf-life were also evaluated. Cookies containing 15 % of PF reached a 16 mg GAE/100 g of total polyphenols. The content of antioxidants remained at acceptable levels after baking. The proximal analysis showed that the ash, fiber, and protein contents in all treatments were significantly higher ($p \leq 0.05$) than that of commercial samples. Cookies with 5% PF had the highest level of acceptance in the three consumer groups evaluated. The cookies maintained the sensory characteristics after four weeks of storage. The organoleptic and nutritional properties of the cookies were improved after adding pineapple flour. Replacing wheat flour by 5-15% pineapple flour allowed obtaining cookies with an adequate content of protein, fiber, and total polyphenols.

Keywords: cookies, total phenols, fiber, texture, acceptability.

Resumen

Las galletas de harina de trigo son uno de los productos de panadería más consumidos. Sin embargo, al ser deficientes en fibra, normalmente se añaden otros ingredientes para mejorar los atributos organolépticos y nutricionales. En este trabajo se siguieron tres formulaciones para preparar galletas de harina de trigo (HT) con harina de piña (HP) al 5, 10 y 15% de sustitución. El nivel de aceptación de las galletas fue analizado por tres grupos de consumidores: niños, adolescentes y adultos. También se evaluaron las propiedades fisicoquímicas y la vida útil. Las galletas con 15% de HP alcanzaron 16 mg GAE/100 g de polifenoles totales. El contenido de antioxidantes se mantuvo en niveles aceptables después del horneado. El análisis proximal mostró que los contenidos de cenizas, fibra y proteínas en todos los tratamientos fueron significativamente mayores ($p \leq 0.05$) que los de las muestras comerciales. Las galletas con un 5% de HP tuvieron el mayor nivel de aceptación en los tres grupos de consumidores evaluados. Las galletas mantuvieron las características sensoriales después de cuatro semanas de almacenamiento. Las propiedades organolépticas y nutricionales de las galletas mejoraron con la adición de harina de piña. La sustitución de la harina de trigo por un 5-15% de harina de piña permitió obtener galletas con un contenido adecuado de proteínas, fibra y polifenoles totales.

Palabras clave: galletas, fenoles totales, fibra, textura, aceptabilidad.

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1 Introduction

The food industry has been highly questioned because of the presumable relationship of several processed products with obesity; that is why a growing interest in developing new products based on novel ingredients has been observed in recent years. The main goal is to offer products that help the population to maintain a good health (Campo Vera *et al*., 2016). The baking industry has developed attractive products, not only because of their eye-catching presentations but also for reaching more consumers and the improvements in nutritional content (Ganorkar and Jain, 2014). Blending flours is a feasible alternative to add nutritional value to a food product (Vásquez *et al*., 2016).

Bread and cookies are the most consumed bakery products. They are based on wheat flour which is considered as an essential component in foods because of its high content of macronutrients with an important role int the diet (Rodríguez-Lora *et al*., 2020). Cookies can be added or fortified with cereals or other functional ingredients (Ganorkar and Jain, 2014; Gutierrez *et al*., 2017), allowing obtaining food with a high nutritional value (Wang *et al*., 2014; Giuberti *et al*., 2015). The intake of fortified or functional foods can help in maintaining a healthy diet.

This concept began with the manufacture of cookies added with cereals such as rice, barley, or oat as well as fruits such as banana, mango, guava, or pineapple (Singh *et al*., 2008). Fruits play an important role in nutrition and human health preventing and/or controlling chronic diseases mainly due to their fiber content and bioactive molecules. Phenols are important antioxidant, anti-inflammatory, and antithrombotic properties (Morais *et al*., 2015, Macías-Cortés *et al*., 2020). Among fruits, pineapple (*Ananas comosus*) is highly appreciated worldwide because of its antioxidant properties (Chakraborti *et al*., 2015), especially polyphenols but it also contains many minerals and vitamins (Brito *et al*., 2020). Several studies confirm that these characteristics provide protection against cardiovascular disease, diabetes, and cancer; therefore, it is recommended to include this fruit in a healthy and balanced diet (Lima *et al*., 2014; Kandasamy and Shanmugapriya, 2015; Lin *et al*., 2016; Ottaviani *et al*., 2016). Cervo *et al*. (2014) mentioned that regular pineapple consumption can increase the intake of antioxidants and micronutrients. The objective of this study was to evaluate the physicochemical characteristics, level of acceptance, and the content of polyphenols in cookies from wheat flour substituted with different percentages of pineapple flour.

Table 1. Formulation of wheat flour cookies added with different percentages of pineapple (*Ananas comosus*) flour.

Ingredient	**Replacing of WF by PF**			
	T0	**T5**	**T10**	**T15**
Wheat flour (g)	100	95	90	85
Pineapple flour (g)	0	5	10	15
Milk powder (g)	5	5	5	5
Baking powder (g)	2.5	2.5	2.5	2.5
Margarine (g)	30	30	30	30
Sugar (g)	24	24	24	24
Salt (g)	0.5	0.5	0.5	0.5
Egg (mL)	30	30	30	30
Essence of vanilla (mL)	2	2	2	2

WF-wheat flour; PF-pineapple flour; T0-control formulated with 100% WF; T5-cookies made from 95:5 WF:PF; T10-cookies made from 90:10 WF:PF; T15-cookies made from 85:15 WF: PF.

2 Materials and methods

2.1 Materials

Pineapple flour was prepared in the Laboratory of Food Science and Technology at Unidad Académica Multidisciplinaria Reynosa Aztlán (Universidad Autónoma de Tamaulipas). The wheat flour, baking powder, egg, milk powder, margarine, sugar, salt, and vanilla essence (food grade) were purchased from a local supermarket.

2.2 Cookie formulation

Four formulations (Table 1) were followed to prepare cookies based on wheat flour and replaced with 0, 5, 10, and 15% of pineapple flour.

2.3 Obtention of pineapple flour

Pineapple flour was obtained from the peeled fruit. The pineapple pieces distributed on plastic mesh trays and placed in an electric dehydrator (Excalibur®) for 120 h at 55 °C. The size reduction of the dry material was carried out using a Nutribullet food processor. The powder obtained was sieved with a conventional

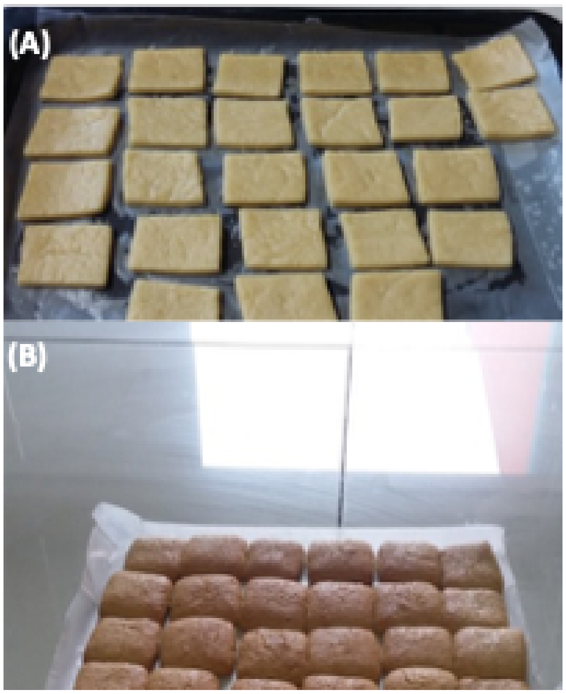

Figure 1. Doug (A) and cookies (B) prepared by substituting wheat flour with 5 % pineapple (*Ananas comosus*) flour.

kitchen sieve (0.7 mm mesh) to standardize the particle size. The pineapple flour was stored in polyethylene bags until used.

2.4 *Preparation of cookies*

Margarine was mixed with sugar using a domestic blender operating at an average speed for two minutes and the egg and vanilla essence were added while still beating. Sifted flour, baking powder, milk powder, and salt were added. The mixture was kneaded for ten minutes to obtain a compact dough. The dough was placed in a plastic bag and kept for twelve hours in the refrigerator at 8 °C. After that, the dough was kneaded for two minutes and rolled out to a uniform thickness of approximately 4 mm. The dough was cut into square shapes and the cookies were baked at 200 °C for 15 minutes, cooled down at room temperature (28 °C) for 15 minutes, and packed in polypropylene bags until analyzed (Figure 1).

2.5 *Chemical composition*

Chemical composition analysis was carried out according to AACC methods (1995). Moisture, ashes, fat, and crude fiber contents were determined based on the official method 935.36, 930.22, 935.38, and 950.37, respectively. Crude protein was determined using the Kjeldhal method (official method 950.36).

2.6 *Quantitative analysis of total phenols*

The quantification of total phenols content (TPC) was performed in the flours and cookies following the Folin-Ciocalteau colorimetric method. Two calibration curves were used: 10 to 100 μg/mL (low concentrations) and 100 to 1000 μg/ mL (high concentrations). Readings were taken at a wavelength of 760 nm using a UV-1800 SHIMADZU spectrophotometer (Corrales-Bernal *et al*., 2014; Singh *et al*., 2016).

2.7 *Texture evaluation*

The puncture compression method was followed to evaluate texture using a Brookfield texture analyzer (model CT3045000). The hardness and fracturability were determined (Hernández-Monzón *et al*., 2014). The cookie, approximately 15 mm thick and measuring 4 x 4 cm, was supported on an aluminum base for hardness testing using a spherical probe. For fracturability, the sample was placed on two parallel supports with a 40-mm separation and broken using an edgeless blade. A crosshead speed of 2 mm/s, 2 mm deformation, and a contact force of 5 g were used for both tests. The measurements were carried out within 24 h after the preparation of cookies.

2.8 *Sensory evaluation*

For sensory evaluation of cookies, an acceptance level test was carried out by untrained panelists (regular consumers). A hedonic scale (Auquiñivin Silva and Castro Alayo, 2015; Gutierrez *et al*., 2017) of 5 points (1= strongly dislike, 2= dislike, 3= neither like nor dislike, 4= like, 5= strongly like) was used for each one of the treatments and the commercial cookie (Velasquez *et al*., 2014). The attributes of color, odor, taste, appearance, and texture were evaluated. Three groups of panelists were used: 30 school children (10 and 11 years old), 30 teenagers (14 and 15 years old), and 30 young adults (18 - 21 years old). For the test, panelists evaluated samples coded with random numbers (4 g) corresponding to a piece of cookie from each treatment and the commercial cookie. A glass of purified water was also provided for mouth washing between samples.

2.9 Shelf-life assessment

The shelf life was determined by stability assessment through texture and moisture gain analysis. Four-week storage at room temperature was chosen to evaluate the stability of the packaged cookies. This time frame was chosen taking into account the shelf-life of similar commercial products and following the methodology recommended by Flores-Morales *et al*. (2016). For texture evaluation, the breaking strength (hardness) and the maximum deformation (fracturability) were measured using a texturometer (Brookfield Model CT3045000) (Barbosa-Martín *et al*., 2018). Moisture quantification was performed based on the AACC official method 935.36 (1995). For storage, the cookies were packed in polypropylene bags, sealed, and labeled as appropriate.

2.10 Statistical analysis

All experiments were carried out in triplicate (n=3). All data are the mean ± standard deviation (SD). An analysis of variance (ANOVA) with a level of significance of 5% was carried out to analyze data. The differences between means were determined by the Tukey test using the Statistica v 7.0 software.

3 Results

3.1 Chemical composition

Prepared cookies following the different formulations (Table 1) are shown in Figure 1. The dough was easy to handle, mix and cut. Figure 1A shows the uniformity of the dough and the smooth appearance of the obtained cookies (Figure 1B). Some cracks were visible; however, the surface was smooth. The average size of the cookies was 4 x 4 cm with a thickness of about 1.5 cm.

The results obtained from the chemical composition of the cookies are shown in Table 2. Each test was performed in triplicate and the average and standard deviation were reported.

The percentage of moisture in cookies increased as the percentage of pineapple flour substitution increased (5.65, 7.24, 10.09% for T5, T10, and T15, respectively), although the highest moisture content is still in the low range for foods. The low moisture content in the cookies prevents changes in the properties or deterioration by microbial growth. Also, low moisture values result in increased shelf life and facilitate their transportation and storage. Arun *et al*. (2015) indicated that the moisture content increased when the fiber content increased in a wheat cookie added with banana peel flour at 5, 10, and 15%, reporting moisture contents of 6.25, 6.37, and 6.55%, respectively. Those authors also observed that the protein content decreased, and the fiber content increased. Similar behavior was found in this paper as the percentage of protein in prepared cookies decreased and the fiber content increased as the pineapple flour content increased. Cerón *et al*. (2014) produced a wheat flour cookie added with potato flour and they mentioned that, as the percentage of substitution increased, the percentage of protein decreased, and the dry matter and ash increased. Logroño *et al*. (2015) also reported a similar effect on the fiber and protein content in wheat cookies added with quinoa, pea, carrot, and tocte.

Table 2. Chemical composition (g/100 g dry basis), of wheat flour cookies, added with different percentages of pineapple (*Ananas comosus*) flour.

Treatment	Moisture (%)	Ash (%)	Fat (%)	Fiber (%)	Protein (%)	Carbohydrates (%)
T0 (Control)	5.58 ± 0.76^{a}	1.44 ± 0.02^{a}	0.512 ± 0.06^{a}	1.01 ± 0.57^{c}	7.05 ± 0.00^{c}	84.41 ± 1.29^{d}
T5	5.65 ± 0.84^{a}	1.48 ± 0.04^{ab}	0.512 ± 0.01^{a}	1.69 ± 0.05^{a}	9.10 ± 0.17^{e}	81.57 ± 0.63^{b}
T10	7.24 ± 0.77^{b}	1.51 ± 0.22^{ab}	0.507 ± 0.12^{a}	1.69 ± 0.22^{a}	8.05 ± 0.09^{d}	81.00 ± 0.80^{ab}
T15	10.09 ± 0.57^{c}	1.60 ± 0.02^{b}	0.493 ± 0.11^{a}	1.74 ± 0.07^{a}	5.95 ± 0.13^{b}	80.13 ± 0.62^{a}
Commercial	13.19 ± 0.40^{d}	0.67 ± 0.03^{c}	12.14 ± 0.24^{b}	ND	3.46 ± 0.37^{a}	70.54 ± 0.43^{c}

ND: Non-detected. Different letters in the same column indicate significant differences (p<0.05). T0: 0% PF; T5: 5% PF; T10: 10% PF; T15: 15% PF; Commercial: commercial cookie.

The ash content of the cookies increased slightly as the flour substitution increased, as reported also by Cerón *et al*. (2014). The proximal analysis of the cookies made with pineapple flour, showed higher values of ash (> 85%), fiber (> 170%) and protein (> 122%), fat content was lower (~ 95%) than the commercial cookies that contain pineapple in their formulation (See Table 2).

The content of total phenols in cookies prepared with different percentages of pineapple flour were 0.1 ± 0.01, 3.53 ± 0.10, 5.64 ± 0.05, and 16.35 ± 0.10 mg equivalent of gallic acid (mgEAG) per 100 grams of sample for control, T5, T10, and T15, respectively. The commercial sample had 1.75 ± 2.08 mgEAG per 100 g. The total polyphenols content in T5, T10, and T15 increased proportionally to the percentage of replacement of wheat flour with pineapple flour. The total phenols contents for the mixtures with 5, 10 and 15 % pineapple flour were 3.53 ± 0.01, 5.64 ± 0.05 and 16.35 ± 0.10 mgEAG per 100 g. These results indicate that the total phenols remained after baking the cookies. Also, it suggests that the drying process allowed maintaining a good proportion of active polyphenolic compounds. The values reported in this study were higher than those reported by Ramírez and Pacheco de Delahaye (2011) who found 8.91 mg GAE/100 g in fresh pineapple but lower than 197.87 mg GAE/100 g reported by Morais *et al*. (2015) in pineapple pulp.

The differences in the values could be explained according to the results reported by Da Silva *et al*. (2013), who quantified the total phenols content in pineapple pulp and pineapple peel before and after the drying process at 60 °C. The authors explained that the increase in the total phenols content after the drying process could be due to the release of phenolic contents caused by the alteration of the cell walls, exposing the vacuoles where these compounds accumulate in fruits and vegetables. Chang *et al*. (2006) mentioned that heat-processed tomato juice had a much higher antioxidant content than the fresh ones and, in their study, the authors reported values ranging from 30 to 50 mg GAE/100 g in processed tomato from several varieties. The highest value reported in this study was for cookies with 15% of pineapple flour reaching a 16 mg GAE/100 g. This value could be considered as a significant amount of antioxidants which can be beneficial for health. A functional food provides nutriments and secondary metabolites with the potential to promote physiological benefits or reduce the risks of disease (Ashwell, 2002). The formulation developed in this study provides cookies with a high amount of protein, fiber, and polyphenols as well as a low amount of fat; that is why these cookies could be considered as a functional food.

3.2 Texture evaluation

The texture, flavor, and appearance are the main quality attributes assessed by consumers to buy a product. Among them, the texture is the most important attribute since it is usually affected when using alternative raw materials (González-Álvarez and Valencia-García, 2013). Hardness and fracturability are frequently used to evaluate texture in cookies. Hardness is related to the force required to compress a piece of food between the molars; it is expressed in units of force. Fracturability is the initial peak of force during the deformation of the sample, and it is related to the force required to break a piece of food (González *et al*., 2015). The results obtained from the instrumental evaluation of the texture are shown in Table 3. The cookies with flour substitution levels of 5 and 10% had similar hardness values (2.35 and 2.34 kg, respectively) meanwhile the cookies with flour substitution of 15% required more strength to be compressed (2.75 kg). All treatments showed a significant difference ($p<0.05$) when compared to the commercial cookie.

Similar values of hardness (2.649 kg) were reported by Shing *et al*. (2013) in cookies prepared from a partial substitution of wheat flour by sweet potato flour in a 60:40 ratio. In other study, Wang *et al*. (2015) also mentioned that hardness increased in cookies added with quinoa flour.

Table 3. Results from the mechanical test of wheat flour cookies added with different percentages of pineapple (*Ananas comosus*) flour.

Treatment	Hardness (kg)	Fracturability (kg)
T0 (Control)	2.4 ± 0.23^a	2.27 ± 0.33^a
T5	2.35 ± 0.17^a	2.32 ± 0.38^a
T10	2.34 ± 0.15^a	2.57 ± 0.42^a
T15	2.75 ± 0.12^c	2.59 ± 0.51^a
Commercial	0.63 ± 0.05^b	1.03 ± 0.17^b

Average values of six repetitions and standard deviation. Different letters in the same column indicate significant differences ($p<0.05$). T0: 0% PF; T5: 5% PF; T10: 10% PF; T15: 15% PF; Commercial: commercial cookie.

In the present work, fracturability values ranged from 2.27 to 2.59 kg. Statistical analysis indicated that the partial replacement of wheat flour with pineapple flour did not affect the fracturability of cookies (p<0.05); however, Ahmad *et al*. (2015) found that the force required to fracture a cookie added with green tea powder decreased as the amount of powder increased. The authors explained that the hardness in the cookie was caused by the interaction of the proteins and starch present in the ingredients and stated that increased fiber contents may have an important effect on the textural parameters of cookies.

3.3 *Sensory evaluation*

The sensory test evaluates the distinctive characteristics of a food product (Orrabalis *et al*., 2014) and the hedonic scale is one of the most used methods for this purpose. In this study, the samples were evaluated based on the typical attributes of traditional cookies including color, appearance, odor, taste, and texture. The panelists were grouped by age range (three groups of habitual consumers: school-age children, teenagers, and young adults). The results of the evaluation were presented by attributes and by consumer groups. The numerical values of the evaluated attributes were found mainly between 4 and 5 (like slightly and like very much, respectively). Statistical analysis showed that school-age children did not notice the difference (p>0.05) among treatments (5, 10, and 15%) in the attributes of color, appearance, odor, and texture. In a similar study, López-Villafuerte *et al*. (2013) assessed the acceptability of a cookie added with whey protein using school-age children as panelists. The authors reported similar results where consumers found no differences among treatments; however, in the present study, this group of consumers found a significant difference (p<0.05) in the taste attribute in T5 and T10. T5 was the most accepted treatment in the school-age children and young adult groups (p<0.05) in the color, odor, and taste attributes. In the appearance attribute, T10 was better accepted in the school-age children group (p<0.05). The highest score in the texture of the cookie was observed in T15, with a mean value of 4.3 in the children's group, while in the other groups, the commercial cookie was the most accepted. Figure 2 shows the attributes evaluated by each one of the consumer groups. The T5 treatment (partial substitution with 5% pineapple flour) was the most accepted sample in all groups. This cookie has an important content of polyphenols, protein, and fiber as well as the lowest moisture content.

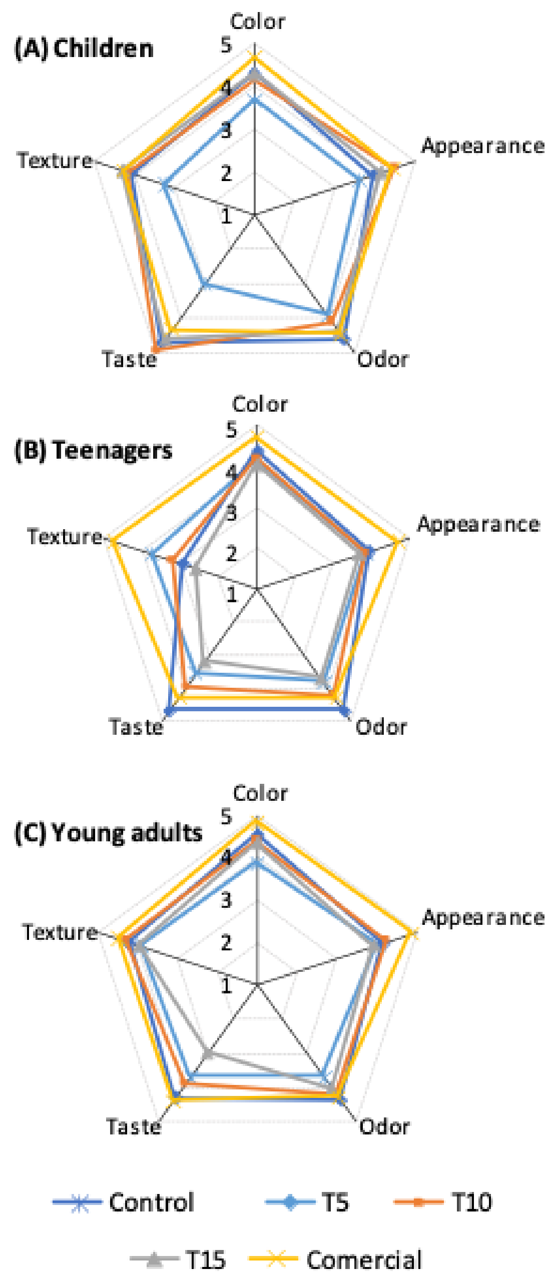

Figure 2. Sensory profile of wheat flour cookies added with different percentages of pineapple (*Ananas comosus*) flour. (A) School-age children, (B) Teenagers, (C) Young adults. Control: 0% PF; T5: 5% PF; T10: 10% PF; T15: 15% PF; Commercial: commercial cookie.

Table 4. Moisture content, hardness, and fracturability of wheat flour cookies added with different percentages of pineapple (*Ananas comosus*) flour stored for 28 days.

Pineapple flour (%)	Storage (Days)	Moisture content (%)	Hardness (kg)	Fracturability (kg)
5	0	4.695±0.426	2.285±0.818	2.207±0.334
	7	6.245±0.642	2.330±0.173	2.268±0.384
	15	6.024±0.703	3.264±0.293	3.079±0.589
	21	5.409±0.305	2.958±0.443	2.910±0.917
	28	4.132±0.125	3.060±0.116	2.765±0.442
10	0	6.451±0.654	2.531±0.373	2.516±0.415
	7	7.306±0.841	2.323±0.147	2.516±0.416
	15	7.991±0.358	3.411±0.765	2.797±0.445
	21	8.731±0.635	3.378±0.572	2.956±0.420
	28	6.633±0.425	3.363±0.297	3.063±0.602
15	0	10.203±1.456	2.526±0.277	2.524±0.427
	7	10.614±1.023	2.740±0.124	2.741±0.648
	15	9.472±0.878	2.384±0.312	2.187±0.244
	21	6.987±0.542	3.204±0.525	2.383±0.378
	28	8.219±0.632	2.798±0.267	1.918±0.487

Table 5. Significance (p value), regression coefficient (R^2), and model coefficients from the multiple regression analysis for moisture content, hardness, and fracturability of wheat flour cookies added with different percentages of pineapple (*Ananas comosus*) flour stored for 28 days.

	Moisture content		Hardness		Fracturability	
Parameter	p-value	Model coefficient	p-value	Model coefficient	p-value	Model coefficient
Constant		1.54524		1.31928		1.08276
Pineapple flour	0.002	0.67285	0.077	0.21815	0.024	0.25674
Storage	0	0.20535	0.829	0.07058	0.084	0.0823
Pineapple flour x storage	0.186	-0.0081	0.008	-0.00184	0.208	-0.00486
Pineapple flour^2	0.232	-0.0089	0.399	-0.00984	0.009	-0.0108
Storage^2	0.691	-0.00575	0.201	-0.00085	0.061	-0.0009
Regression coefficient (R^2)	0.829		0.619		0.716	

3.4 Shelf-life assessment

Many deteriorative issues in foods are related to chemical, biochemical, or physical changes including lipid oxidation, enzymatic browning, and gain or loss of moisture. These processes could change the appearance, taste, and texture of foods, as well as the main cause of nutrient loss. Changes in food quality can be assessed with instrumental assays (Subramaniam and Wareing, 2016). In this work, the results obtained from the moisture gain, hardness, and fracturability assessment are shown in Figure 3. 3D plots were obtained using a second-order polynomial equation fitted to the data by multiple regression analysis. The independent variables were level of substitution with pineapple flour and storage time for each one of the analyzed properties. The regression model included the main effects, the interaction, and the quadratic effects. The data used for multiple regression analysis is shown in Table 4. The statistical significance, regression coefficient and the coefficients for the regression model are shown in Table 5.

The addition of pineapple flour increased slightly the moisture content (Figure 3A), probably due to the increase in the content of fiber (Arun *et al*., 2015) or because of the followed methodology where the moisture content was subjected to daily relative humidity variation during in the evaluation period; however, statistical analysis showed no significant change (p>0.05) during the four weeks evaluated. This behavior could be due to the very short evaluation time. Barbosa-Martín *et al*. (2018) conducted a study on cookies added with Stevia rebaudiana Bertoni leaves to analyze its moisture content during six

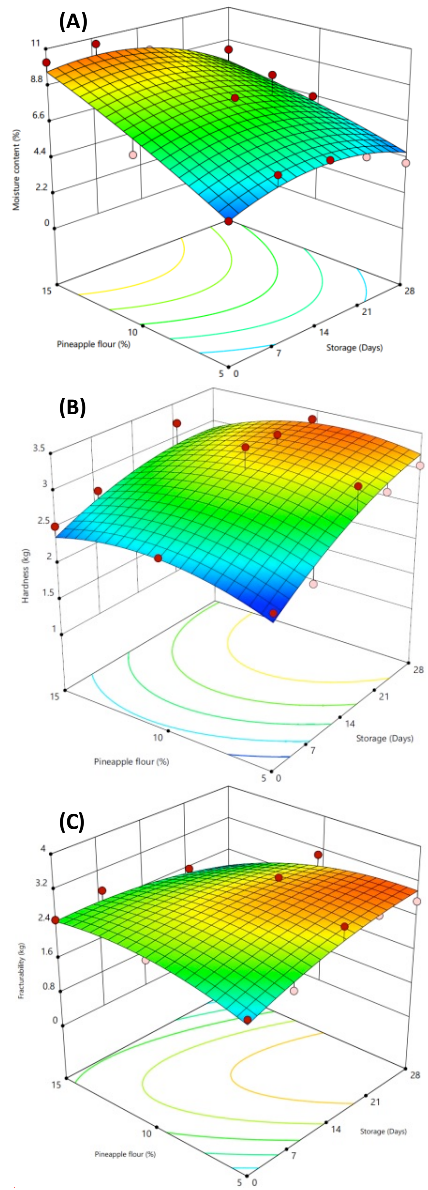

Figure 3. Moisture gain (A), hardness (B), and fracturability (C) during the storage of wheat flour cookies added with different percentages of pineapple (*Ananas comosus*) flour.

months of storage and reported that the moisture increased as storage progressed increasing two-folds the initial value after six months. Rangrej *et al*. (2015) evaluated the storage stability in cookies added with flaxseed oil and the moisture content increased from 3.7 to 7.8% after 14 days of storage. The trend reported by these two studies was not observed in this study, showing higher stability in the cookies added with pineapple (*Ananas comosus*) flour.

The hardness of the cookies (Figure 3B) was expressed as the maximum load for their breakage. Statistical analysis indicated that both the replacement of flour and the storage time had a significant effect ($p<0.05$). The storage time had a more important effect than the addition of pineapple flour. In both cases, the hardness showed a tendency to increase, although, for the treatment with 15% pineapple flour, the values decreased as the storage time increased. Despite the increase in hardness, some studies have shown that hardness values between 1.2 and 11.9 kg are adequate for cookies (Velasco-González *et al*., 2013); therefore, even after 28 days of storage, the texture of cookies can be considered as adequate.

In the fracturability test (Figure 3C), statistical analysis showed no significant effect ($p>0.05$) of flour replacement on all treatments during storage. The fracturability values are related to the hardness of the cookies. The behavior in all the cookies was similar to that observed in sensorial texture evaluation.

Conclusions

The addition of pineapple flour improved the organoleptic and nutritional properties of the cookies, resulting in a pleasant and well-accepted product with an adequate content of protein, fiber, and total polyphenols. The three levels of substitution of wheat flour by pineapple flour were sensory accepted by the consumer groups; however, the 5% pineapple flour substitution was the most accepted. The texture of the cookies was within acceptable and pleasant parameters, according to the evaluation of consumers. In addition, these cookies do not tend to hydrate quickly due to the nature of their ingredients, allowing maintaining the fracturability during storage. Finally, the cookies retained the optimal sensory characteristics for consumption after four-weeks storage.

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