UNIVERSIDAD PERUANA UNIÓN

FACULTAD DE INGENIERÍA Y ARQUITECTURA

Escuela Profesional de Ingeniería de Industrias Alimentarias

Elaboración de brownies libres de gluten a partir de harina de arroz (*Oryza sativa*) y maíz morado (*Zea mays L.*)

Tesis para obtener el Título Profesional de Ingeniero de Industrias Alimentarias

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Lima, octubre del 2024

DECLARACIÓN JURADA DE ORIGINALIDAD DE TESIS

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Gluten-free brownies of rice (*Oryza sativa*) and purple corn (*Zea mays L.*)

Brownies libres de gluten de arroz (*Oryza sativa*) y maíz morado (*Zea mays L.)*

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ABSTRACT

Celiac disease is common, affecting 1.4% of the world's population, and requires a gluten-free diet. However, gluten-free products often have nutritional deficiencies and can cause nutritional deficiencies. In addition, additives are used in their production, making them less nutritious. Therefore, the objective of this research was to make gluten-free brownies from rice flour (*Oryza sativa*) and purple corn (*Zea mays L.*) to improve its nutritional properties and content of bioactive compounds, cacao was added to the formulation, with a total substitution of 26%, within which 4 treatments of cacao and purple corn were carried out in the following proportions of 80:20%, 70:30%, 60:40%, and 50:50%. The brownies showed similar proximal parameters to other studies, highlighting the protein content ranging from 7.26 to 7.40 g/100 g. It was observed that the variation in the proportions of cacao and purple corn directly affected the proximal parameters. The physicochemical analyses comply with the Peruvian technical standard, certifying its safety. The antioxidant activity is exceptional, especially in the M133 treatment (80% cacao:20% purple corn) with 248562.05 ± 1627.16 µMol/100g. Sensory analysis shows that the M375 treatment is the most accepted by consumers, although it is recommended to improve the texture. The developed brownies proved to be nutritious due to their high protein content and antioxidants. Because they are gluten-free, they have the potential to be an excellent option for celiacs.

Key words: Anthocyanins, Antioxidants, Bakery products, Cacao, Celiac disease, Celiac food.

RESUMEN

La enfermedad celíaca es común, afectando al 1.4% de la población mundial y requiere una dieta libre de gluten. Sin embargo, los productos libres de gluten suelen tener falencias nutricionales y pueden generar carencias nutricionales. Además, se utilizan aditivos en su

elaboración que los tornan menos nutritivos. Por ello el objetivo de esta investigación fue elaborar brownies libres de gluten a partir de harina de arroz (*Oryza sativa*) y maíz morado (*Zea mays L.*), para mejorar sus propiedades nutricionales y contenido de compuestos bioactivos se adicionó en la formulación cacao, con una sustitución total del 26% dentro del cual se realizaron 4 tratamientos de cacao y maíz morado en las siguientes proporciones de 80:20%, 70:30%, 60:40% y 50:50%. Los brownies mostraron parámetros proximales similares a otros estudios resaltando el contenido de proteína con un rango de 7.26 a 7.40g/100g. Se observó que la variación en las proporciones de cacao y maíz morado afectó directamente los parámetros proximales. Los análisis fisicoquímicos cumplen con la norma técnica peruana, certificando su seguridad. La actividad antioxidante es excepcional, especialmente en el tratamiento M133 (80% cacao:20% maiz morado) con 248562.05 ± 1627.16 µMol/100g. El análisis sensorial muestra que el tratamiento M375 es el más aceptado por los consumidores, aunque se recomienda mejorar la textura. Los brownies desarrollados demostraron ser nutritivos por alto contenido de proteína y además de ser alto en antioxidantes con potencial de ser una excelente opción para celíacos por ser libres de gluten.

Palabras claves: Alimentos para Celiacos, Antioxidantes, Antocianinas, Cacao, Celiaquía, antioxidantes, Productos de Panadería

HIGHLIGHTS

- The variation in the proportions of cocoa and purple corn directly affected the proximal parameters.
- The developed brownies presented a high protein and antioxidant content.
- The brownies proved to be an excellent consumption option for celiacs.

1. Introduction

In 2010, the Food and Drug Administration (FDA, 2010) reported that around 160 foods cause allergic reactions in specific sensitive populations, of which eight foods cause 90% of these food allergies, including wheat and its derivatives (Villanueva, 2017), Celiac disease is a common digestive disorder, its prevalence is 1.4% worldwide and 1.2% nationally, of which the most affected ages are 18 to 29 years (Asociación de Celiacos del Perú, 2019). Consequently, a gluten-free diet is required for its treatment. One disadvantage is that

gluten-free products tend to have nutritional deficiencies, low in fiber, minerals, and vitamins, and high in lipids, sugars, and salt; due to these deficiencies, their intake could cause nutritional deficiencies, which would lead to a caloric-nutritional imbalance (Saturn *et al*., 2010). Additionally, modified starches are used in the production of gluten-free products, which, over time, could influence overweight and obesity in the celiac population. On the other hand, Miranda *et al*. (2018) indicate that in the production of gluten-free foods, additives such as hydrocolloids, proteins, emulsifiers, and others are used to obtain better nutritional and sensory characteristics such as texture and volume among others.

The demand for organic, nutritious, and gluten-free foods has increased significantly in recent years, leading the food industry to seek to improve and enrich products with healthy ingredients (Machuca & Meyhuay, 2017). In this way, this research aimed to make gluten-free brownies to make them nutritious using native Peruvian foods such as purple corn (*Zea mays L.*), which, in addition to not containing gluten, is known for having bioactive compounds that give it antioxidant properties a high content of anthocyanins (*cyanidin-3-glycosidic*) and with anti-cancer properties. Additionally, the use of chuncho variety cacao from Cusco presents a unique advantage because its phenolic compounds do not degrade at high temperatures compared to anthocyanins, which do degrade. Still, taking advantage of the synergistic effect of the phenolic compounds in cacao, a brownie high in antioxidants can be formulated even though it is subjected to high temperatures, as when baking (Vignoli *et al*., 2011) and combining both ingredients with rice flour, a popular food in gluten-free products for its foaming, emulsifying, and absorption capacity that will help in the texture of the final product (Martínez *et al*., 2017).

2. Materials and methods

2.1. Raw material

The rice flour of the Costeño brand and the powdered purple corn were purchased from the Ecoandino brand. Record brand chuncho cacao paste comes from La Convención, Cusco – Peru.

2.2. Experimental methodology

2.2.1. Brownie making process

Figure 1 shows the gluten-free brownie-making processes based on rice flour and powdered purple corn. The methodology was adapted from America's Test Kitchen (2020).

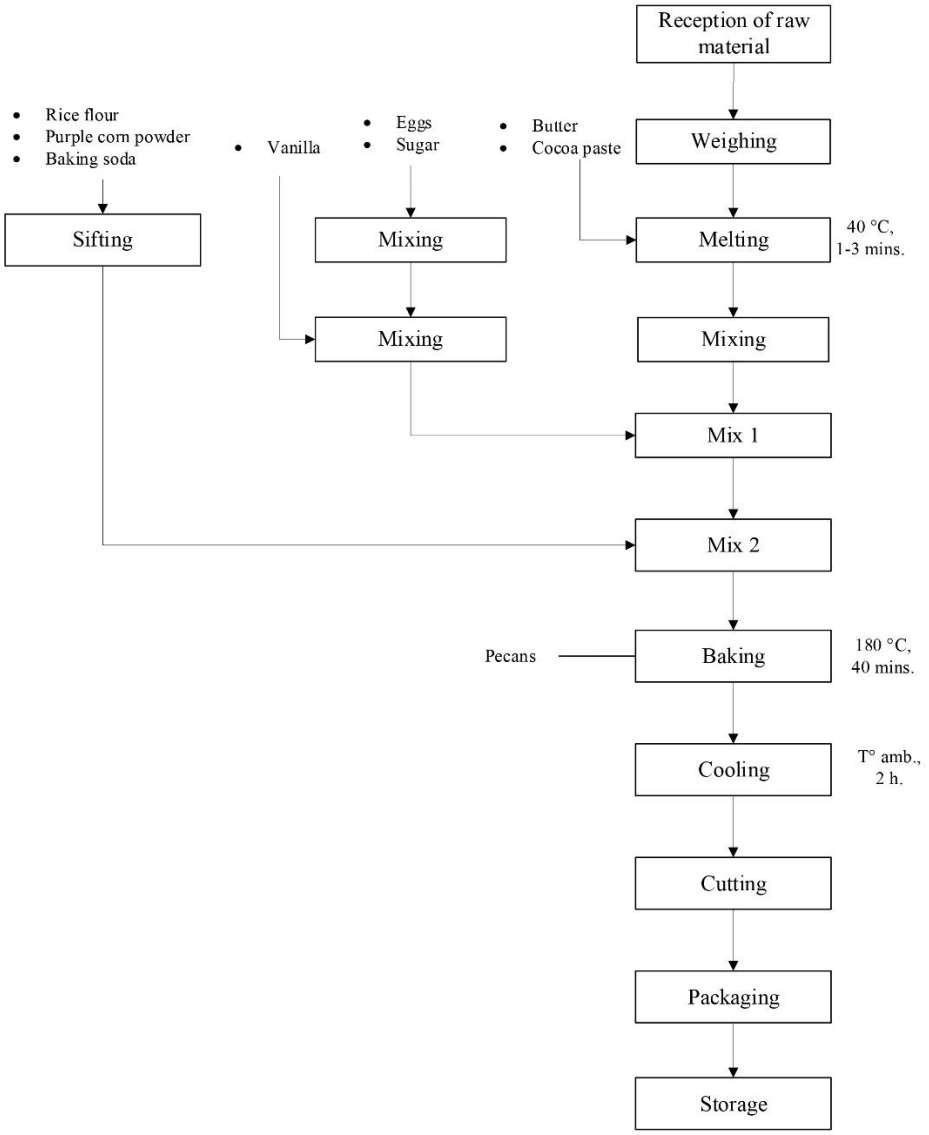


FIGURE 1. Flow chart for making gluten-free brownies

2.2.2. Formulation of Treatments

Table 1 below describes the formulation for making brownies for 1 kg.

Table 1. Formulation for making brownies.

Inputs	True Percentage (%)	Kilograms (kg)
Rice flour	11.18	0.11
Cocoa paste / Purple corn powder	26.32	0.26
Butter	14.47	0.14
Eggs	23.68	0.24
Sugar	15.79	0.16
Vanilla essence	1.32	0.01
Baking soda	0.66	0.01
Pecans	6.58	0.07
Total	**100**	**1**

Table 2 specifies chocolate and powdered purple corn percentages used to make each sample. These data worked based on the "Cacao/Purple Corn" input rate in the general formulation presented in Table 1.

Table 2. Percentage of substitution of cacao by purple corn

Treatment	Cocoa paste (%)	Purple corn powder (%)
M 133	80	20
M 375	70	30
M 418	60	40
M 267	50	50

2.2.3. Proximate Analysis of Gluten-Free Brownies

The proximate characterization of the 4 gluten-free brownie treatments was determined using the methods proposed by the Association of Official Analytical Chemists (AOAC 2019). These were the moisture percentage (AOAC—925.10), ash percentage (AOAC—930.05), fat percentage (AOAC—955.06), crude fiber percentage (NTP—205.003:1980), and protein percentage (AOAC—920.152). Carbohydrates were calculated by difference according to MS-INN Collazos 1993. All analyses were performed in triplicate.

2.2.4. Physicochemical analysis of gluten-free brownies

The pH was determined by the potentiometer method (AOAC—981.12). The titration method (AOAC—942.15) determined the acidity, which was expressed as a percentage of lactic acid. The AOAC method 932.14 (2019) was used to determine soluble solids, and the result was expressed in Brix degrees.

2.2.5. Determination of total anthocyanins

The methodology used was that of Rangana (1977) with modifications. It began with an extraction using 1 g of dry and ground sample (500 µm) with 50 ml of ethanol solvent acidified with 0.1% hydrochloric acid. The sample was then filtered with a Büchner funnel with No. 1 filter paper. The filtrates were diluted with 50 ml of the same acidified ethanolic solution and measured at a wavelength of 535 nm. The anthocyanin content was expressed in mg/100 g of sample.

2.2.6. Determination of antioxidant activity by ABTS

The method of Arnao *et al*. (2001) and Cano *et al*. (1998) was used for the brownie samples. They were analyzed in triplicate using a volume of 10 µL. The antioxidant capacity was

measured in a reaction medium of 2 mM ABTS, 35 µM hydrogen peroxide, and 0.25 µM HRP in a final volume of 1 ml of 50 mM phosphate buffer (pH 7.5). The reaction was measured at a wavelength of 730 nm. Subsequently, 10 µL of the sample was added to the reaction medium, and 5 minutes later, the absorbance was measured again at the same wavelength. The absorbance differences were calculated. Different concentrations of Trolox were used for the calibration curve.

2.2.7. Sensory Analysis by the Just-About-Right (JAR) Method

The JAR (Just-About-Right) evaluation sheet consisted of the attributes: Flavor, Color, Texture, and Aroma. To do this, they were presented with 10g of each treatment, coded with 3 random digits, with the card considering a five-point scale, and they were also provided with a glass of water to rinse between samples. It was carried out in Ñaña, and its surroundings comprised 30 consumers between 18 and 47 years of age, 24% of whom were women and 76% men.

2.2.8. Experimental design

A Completely Randomized Design (CRD) was applied to determine gluten-free brownies' proximal, physicochemical, and sensory analyses. From the data obtained, the mean, standard deviation, coefficient of variation, and analysis of variance (ANOVA) were determined with a p-value of 0.05 (95%). Likewise, the Tukey test and the Normality test were applied. The Minitab 17 program was used for data processing.

3. Results and discussion

3.1. Proximate Analysis of Gluten-Free Brownies

Table 3 shows significant differences ($p < 0.05$) between the treatments evaluated in each proximal parameter. The humidity presents values that vary by 2.28 g/100 g between treatments; the treatment with the highest humidity is M267, which contains 50% cacao and 50% purple corn. A variable decrease in humidity is observed as the proportion of cacao increases and the percentage of purple corn decreases. Therefore, the M133 treatment (80% cacao: 20% purple corn) is the one with the lowest humidity compared to the rest of the treatments, being totally different ($p < 0.05$). Silva (2019) developed research on a muffin based on sweet potato, achira, mashua, and sucralose, determining a greater range of humidity from 35.6 to 39.5 g/100g. His research indicates that the presence of oca increases the humidity of the final product. On the other hand, Alvarado (2024) indicates closer values with 29 g/100g for a wheat flour muffin and 22 g/100g for a sweet potato flour. Compared to

the present research, the difference is due to the difference in its ingredients and proportions.

The ash values are statistically similar ($p > 0.05$) in all treatments with a fluctuation of 0.08 g/100g; compared to Silva (2019), the values are close to the control of a wheat flour muffin with values of 1.1 g/100g. Moreover, Alvarado (2024) reported the ash content of the control of 1.45 g/100g; when other ingredients, such as sweet potato and achira, are incorporated, the ash increases with values of 2.36 and 2.31 g/100g, respectively. Setyani *et al*. (2017) reported values closer to this study in corn brownies with wheat, from 1.96 to 2.04%.

The fat content is different ($\underline{p} < 0.05$) in all treatments, where it is observed that M133 (80% cacao: 20% purple corn) has the highest amount of fat, with 32.34 g/100 g, for the same high proportion of cacao. Thus, M267 (50% cacao: 50% purple corn) presents 25.90 g/100g. The variety of cacao used is chuncho from Cusco (Convention Valley), characterized by a high-fat content of 48 to 52% in roasted beans (Keen *et al*., 2005; Pareja, 2018), thus explaining the result. Other studies on muffins by Alvarado (2024) and Silva (2019) report smaller amounts of 9.17 to 9.96 g/100g and 2.15 to 4.4 g/100g, respectively. This is explained by the different raw materials used, and it is highlighted that they did not use cacao in their formulation. However, Setyani *et al*. (2017) reported more similar values in corn and wheat brownies, with 13.6 to 19.26% (in 100% corn flour substitutions).

Regarding the protein content, two well-marked groups are observed with a similarity ($p > 0.05$) between the treatments of the first group of M267 (50% cacao: 50% purple corn), M418 (60% cacao: 40% purple corn), M375 (70% cacao: 30% purple corn) and the other group of M133 (80% cacao: 20% purple corn), M375 (70% cacao: 30% purple corn), M418 (60% cacao: 40% purple corn), the range of variability of the content goes from 7.26 to 7.40 g / 100g, being high compared to the study by Silva (2019) which determined values of 1.17 to 3.99%, while Alvarado (2024) reported values of 7.40% in sweet potato muffin and a higher value of 13% for achira muffin. Setyani's study *et al*. (2017) reported similar data where they determined values between 8.54 and 10.13% in brownies made from corn and wheat with substitutions between 100% and 50%. The type of proteins present in the evaluated brownies may be mainly from cacao, with the most significant proportion being glutenins, albumins, prolamines, and globulins (Voigt & Biehl, 1993; Niepage, 1961; Zack & Keeney, 1976).

Crude fiber varies in a range of 0.44 to 0.50 g/100g and shows a significant difference ($p < 0.05$) between treatment M133 and M267, while in turn, treatments M375, M418, and M267

are similar ($p > 0.05$), and M133, M375, and M418 are also identical. While carbohydrates range from 46.91 to 51 g/100g, there are significant differences ($p < 0.05$) between treatments. Nutritionally and compositionally, purple corn is similar to the more commonly consumed yellow corn in that it is rich in starch (61% to 78%) and non-starch polysaccharides (approximately 10%) (Sinha *et al*., 2011).

Table 3. Proximate Analysis of Gluten-Free Brownies

Treatment	Moisture	Ash	Fat	Protein	Crude Fiber	Carbohydrates
M133	11.82 ± 0.05^{d}	1.68 ± 0.03^{a}	32.34 ± 0.05^{a}	7.26 ± 0.04^{b}	0.44 ± 0.01^{b}	46.91 ± 0.12^{d}
M375	12.58 ± 0.02^{c}	1.65 ± 0.04^{a}	30.19 ± 0.02^{b}	$7.30 \pm 0.07^{a,b}$	$0.46 \pm 0.02^{a,b}$	48.27 ± 0.03^{c}
M418	13.34 ± 0.06^{b}	1.63 ± 0.05^{a}	28.05 ± 0.03^{c}	$7.35 \pm 0.02^{a,b}$	$0.48 \pm 0.03^{a,b}$	49.64 ± 0.06^{b}
M267	14.10 ± 0.10^{a}	1.60 ± 0.01^{a}	25.90 ± 0.02^{d}	7.40 ± 0.05^{a}	0.50 ± 0.01^{a}	51.00 ± 0.52^{a}

Values are expressed as mean ± SD (n=3). Different letters in the same column represent a significant difference ($p < 0.05$) between samples.

3.2. Physicochemical analysis of gluten-free brownies

Table 4 shows the results of pH, titratable acidity (% lactic acid), and soluble solids (° Brix), where significant differences are evident ($p < 0.05$) between treatments.

The pH range varies by 0.8 between treatments, with M133 containing the lowest value and M267 the highest. In turn, the results obtained are similar to other research on brownies based on white quinoa, as specified by Gómez. *et al*. (2022), with a pH of around 6.12, while Arzapalo *et al*. (2015) reported values of 6.7 for white quinoa and 6.45 for black quinoa, slightly more acidic. Zambrano (2023) reported lower values in brownies with partial substitution of quinoa flour from 5.4 to 5.9. Likewise, Silva (2019) reported closer values of 7.3 to 7.9 pH in muffins with sweet potato, achira, and mashua (Machado *et al*., 2020) in chocolate brownies, a range of 5.8 to 6.48.

According to the Peruvian Technical Standard (NTP) 206.013, biscuits' maximum allowed titratable acidity is 0.7% expressed in lactic acid. In this research, titratable acidity varied from 0.08 to 0.41%, within the limits permitted by the standard. In addition, other research reported similar values, such as 0.05 to 0.08% (Silva, 2019), 0.03 to 0.06% (Alvarado, 2024), and 0.25 to 0.38% (Machado *et al*., 2020) in chocolate plum brownies.

Finally, the soluble solids values are in a variation range of 9.08 ° Brix, being the highest with 30.30 ° Brix in the M267 treatment (50% cacao: 50% purple corn), as the formulation increased the cacao content without increasing the sugar percentage, the soluble solids decreased, being the lowest at 21.22 ° Brix of the M133 treatment that contains 80% cacao,

due to the presence of polyphenols, theobromine, caffeine, pyrazines, aldehydes, and esters, among others, responsible for the astringent and bitter taste characteristic of cacao (De Araujo *et al*., 2016; Pareja, 2018). Research reported similar data such as Zambrano (2023) in an approximate range of 37 to 65° Brix, Gómez *et al*. (2022) values from 65.34 to 45.54° Brix, Machado *et al*. (2020) values from 45.4 to 51.20° Brix.

The variability of the results can be explained by the different raw materials used in these investigations, as research with a similar composition has yet to be published.

Table 4. Physicochemical analysis of Gluten-Free Brownies

Treatment	pH	Titrable Acidity (% Lactic acid)	Soluble solids (°Brix)
M133	6.50 ± 0.01^{d}	0.41 ± 0.02^{a}	21.22 ± 0.03^{d}
M375	6.79 ± 0.02^{c}	0.31 ± 0.01^{b}	24.27 ± 0.12^{c}
M418	7.00 ± 0.02^{b}	0.25 ± 0.03^{c}	27.00 ± 0.20^{b}
M267	7.30 ± 0.02^{a}	0.08 ± 0.00^{d}	30.30 ± 0.10^{a}

Values are expressed as mean ± SD (n=3). Different letters in the same column represent a significant difference ($p < 0.05$) between samples.

3.3. Antioxidant Activity by ABTS and Anthocyanins

Table 5 shows the results of the antioxidant activity (AA) expressed in µMol/100g and the anthocyanin content (mg/100g), where significant differences are observed ($p < 0.05$) between treatments for both parameters. Regarding the antioxidant capacity, it is observed that the M133 treatment (80% cacao: 20% purple corn) has the highest activity, which is closely linked to its majority composition of bioactive compounds present in cacao, proportionally when its presence in the formulation decreases, the antioxidant activity also decreases by about 57408.4 (µMol/100g).

According to Borja *et al*. (2022), polyphenols are the most abundant bioactive compounds in cacao, with around 35 types detected, which would be responsible for their high antioxidant activity. Among its main groups of polyphenols are phenolic acids, benzoic acids, and flavonoids (flavones, flavanols, flavanones, flavanol glycosides, procyanidins) (Bordiga *et al*., 2015; Rodriguez-Carrasco *et al*., 2018). It should be noted that the polyphenol content varies between varieties, as supported by other studies with the Criolla, Trinitario, and Forastero varieties (Martini *et al*., 2008; Borja *et al*., 2022).

A particularity of the polyphenols present in cacao is that their AA does not decrease at high temperatures due to the effectiveness of flavonoids in eliminating free radicals, which is

influenced by the spatial arrangement and the total number of hydroxyl groups in their molecules. Furthermore, specific structural patterns, such as a catechol group in the B ring, a double bond in the C ring, and hydroxyl groups in certain positions, enhance flavonoids' ability to eliminate free radicals (Vignoli *et al*., 2011).

There is a complication in comparing AA values with other research, mainly due to differences in extraction methods, solvents, and proportions used (Jonfia-Essien *et al*., 2008), in addition to the fact that the composition of the product to be compared is different, however, to have some idea of the impact of the Peñalver research *et al*. (2023) determined the AA in a brownie based on moringa and spirulina, obtaining 299.25 µMol/100g, a different value from that reported in the present investigation.

The other bioactive compounds in this product are anthocyanins, phenolic compounds widely present in the plant kingdom, characterized by their deep purple, blue-reddish color (Pergola *et al*., 2006). They have a significant antioxidant potential because they protect against various diseases caused by oxidative stress (30); however, these substances, depending on the type of food in which they are present, have a synergistic or antagonistic behavior that can help increase or decrease the total antioxidant activity of the food (Gulcin, 2020; Smeriglio *et al*., 2016).

The specific compounds belonging to this group present in purple corn from Peru are cyanidin-3-dimalonylglucoside, cyanidin-3-glucoside, pelargonidin-3-glucoside, peonidin-3-glucoside and their respective malonate homologs (Aoki *et al*., 2002; Pascual-Teresa *et al*., 2002; Pedreschi & Cisneros-Zevallos, 2007; Yang & Zhai, 2010). Other studies also mention that cacao has anthocyanins. Still, they indicate that during the fermentation process, they are degraded. Their content decreased significantly (Chóez-Guaranda *et al*., 2024), as indicated by the fact that they recorded the degradation of cyanidin 3-galactoside after 5 days of fermentation in Trinitario cacao varieties from Cuba and Cameroon (De Taeye *et al*., 2016). Another study reported degradation of the same compounds at the end of 5 days of fermentation from initial values of 13.26 to 1.78 mg (Peláez *et al*., 2016). The same is evident with the compound *cyanidin 3-O-galactoside* 0.26mg reported by (Oracz *et al*., 2015).

The amount of anthocyanins present in the treatments have significant differences ($p < 0.05$) due to the variation in the purple corn content in the brownie formulation, with M133 (80% cacao: 20% purple corn) containing the lowest amount of anthocyanins with 16.32 mg/100g

and the M267 treatment (50% cacao: 50% purple corn) containing more than double the anthocyanins (40.97 mg/100g).

For the preparation of the brownies, they were subjected to 180°C for 15 minutes; this is a factor that clearly affects the final anthocyanin content because they degrade with high temperatures, as they can change their color and also their antioxidant capacity (Aprodu *et al*., 2020; Enaru *et al*., 2021). These compounds may present changes in their mechanisms, such as glycosylation, cleavage, and polymerization, that will cause the loss of this pigment and, therefore, its degradation, producing a darkening (Rodriguez-Amaya, 2019; Laleh *et al*., 2005; Riaz *et al*., 2016).

Table 5. Analysis of antioxidant activity and anthocyanins

Treatment	Antioxidant activity (µMol/100g)	Anthocyanins (mg/100g)
M133	248562.05 ± 1627.16^{a}	16.32 ± 0.11^{d}
M375	229343.38 ± 1514.93^{b}	24.62 ± 0.03^{c}
M418	210435.39 ± 1341.21^{c}	32.81 ± 0.10^{b}
M267	191153.60 ± 1254.20^{d}	40.97 ± 0.06^{a}

Values are expressed as mean ± SD (n=3). Different letters in the same column represent a significant difference ($p < 0.05$) between samples.

3.4. Sensory Analysis by the Just-About-Right (JAR) Method

Figure 2 shows the percentages of reduced JAR levels on three scales for each treatment. Treatment M133 was evaluated as "JAR" at 41% for aroma, as "Too Much" at 41 and 48% for texture and color items, respectively, and 45% as "Too Little" for the flavor attribute. At the same time, the best "JAR" score was the M375 treatment (with 70% cacao and 30% purple corn), with "JAR" scores of 69, 48, and 66% for the attributes of flavor, color, and aroma, respectively. Sample M418 was rated as "Too little" by 55% for the flavor attribute, "Too much" for the texture attribute by 52%, and "JAR" for the color and aroma attributes by 45 and 52%. Finally, M267 was rated as "JAR" for the color and aroma attributes at 48% each, as "Too little" for the flavor at 48%, and as "Too much" for the texture attribute at 66%.

A lower rating is observed in the texture because it is a gluten-free brownie; that is, it tends to crumble a little faster than any other brownie that contains gluten, improving the product's texture.

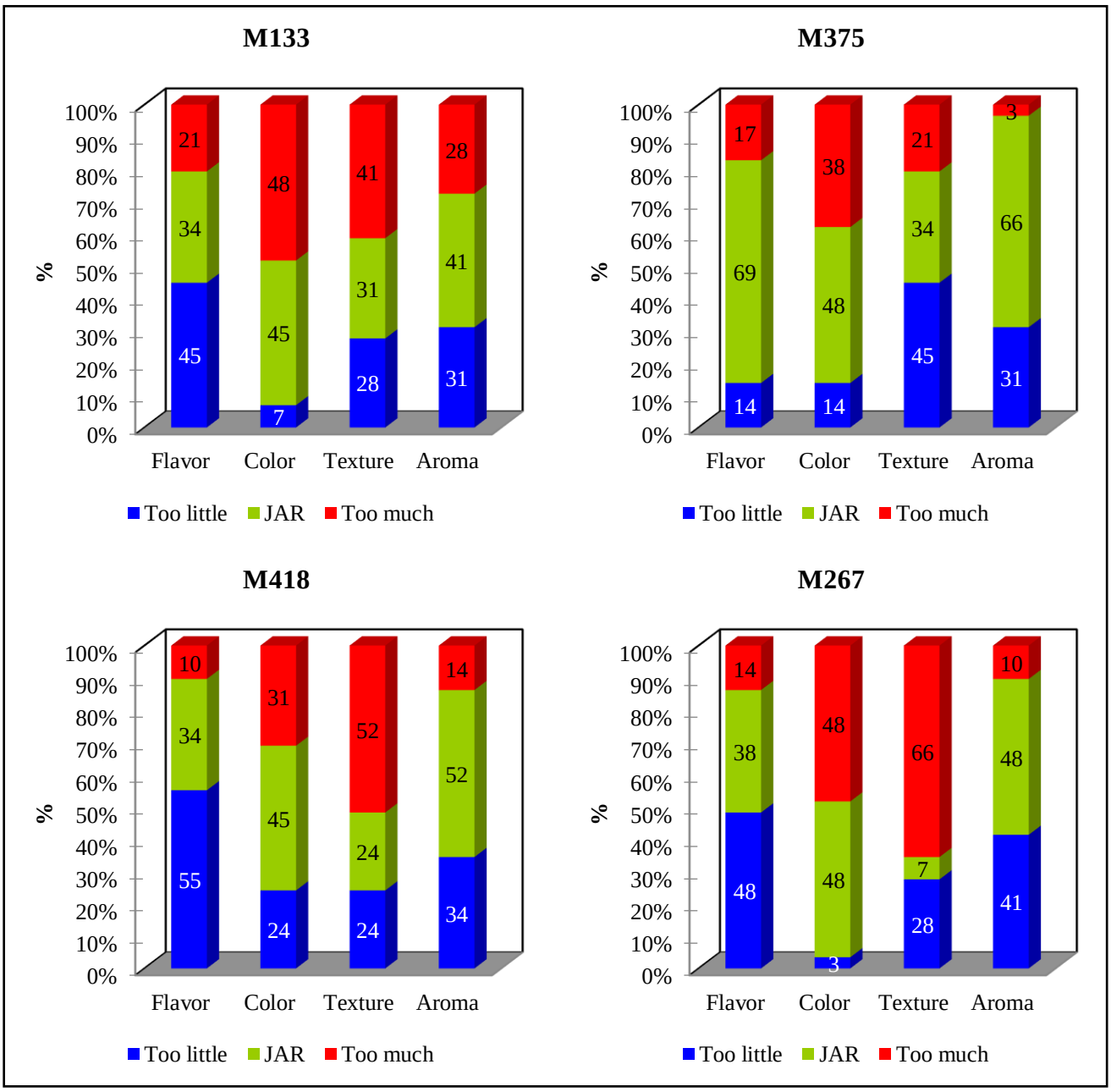


Figure 2. Percentages for JAR levels by treatments

Figure 3 shows the "Mean Drops vs treatment," M375 is the best evaluated as "JAR." This indicates that 3 of the 4 parameters are optimally accepted by consumers who evaluated the product; the observation is based on improving the texture.

Regarding the other treatments, more than 20% of consumers penalized the texture attribute with a mean drop value > 1, rating the texture as “Too much and Too little,” a sensory attribute that would undoubtedly be better recommended for a gluten-free product.

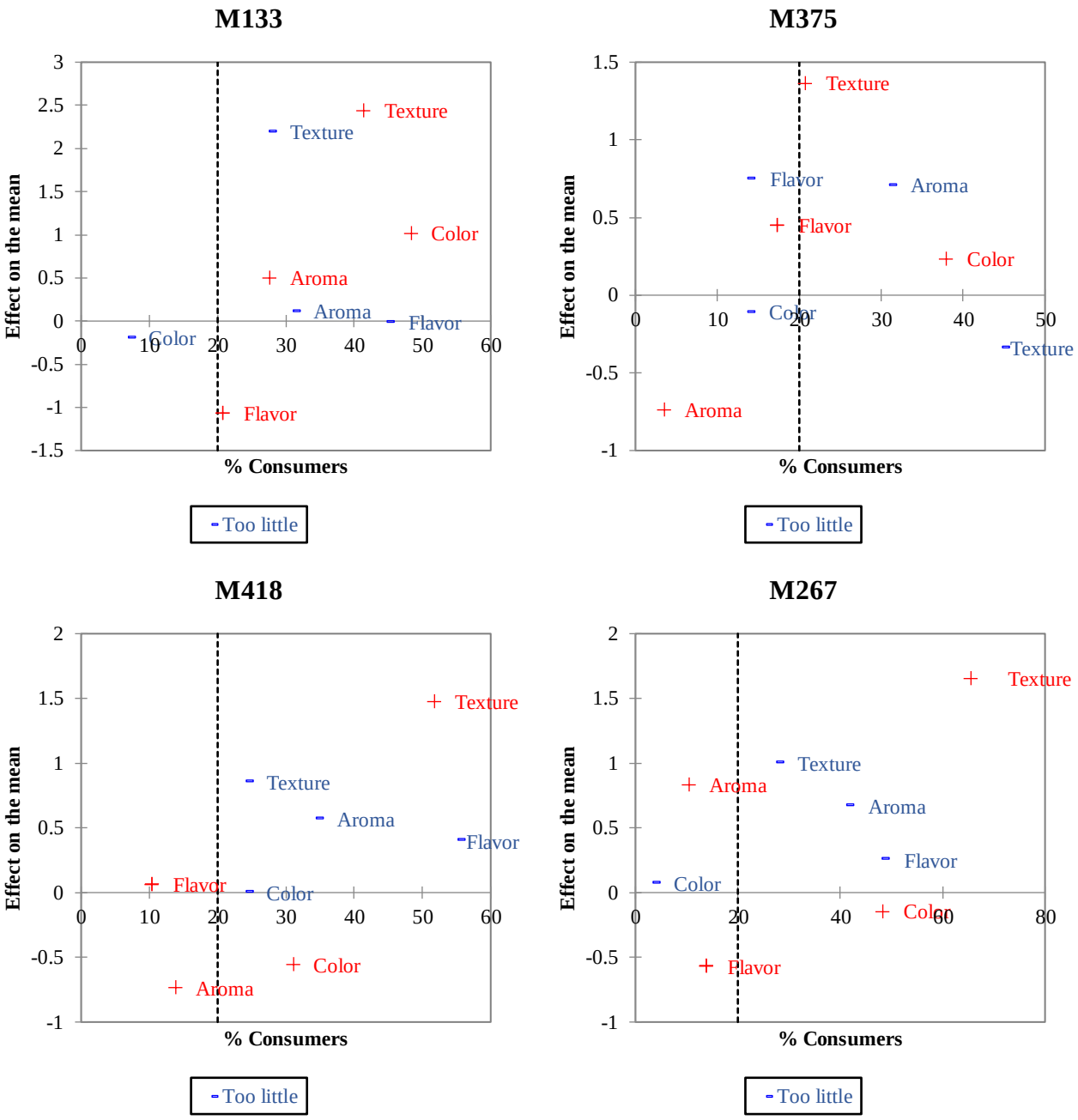


Figure 3. Mean Drops vs. % for each treatment

4. Conclusion

Gluten-free brownies made from purple corn and rice showed proximal parameters similar to those of other studies. The proportion of cacao and purple corn directly affects these parameters, highlighting the protein content, which is high compared to other brownies made from wheat. However, although the fat content was high due to the high proportion of cacao, it can be considered an energetic and nutritious food because around 50% of its calories come from carbohydrates. The physicochemical analyses of pH, acidity, and soluble solids are within the recommendations of the Peruvian technical standard, certifying that the

samples were safe for subsequent sensory analysis. The antioxidant activity of the brownies is exceptional, reaching high concentrations of µMol/100g, with the M133 treatment (80% cacao: 20% purple corn) having the highest quantity, mostly coming from the phenolic compounds in cacao that are more resistant to high temperatures. However, it is the treatment with the lowest anthocyanin content, with 16.32 ± 0.11 mg/100g. The results of the sensory analysis by "JAR" indicate that the M375 treatment is the most accepted by consumers in terms of flavor, color, and smell; however, the texture is an attribute that is recommended to be improved, considering that it is a gluten-free brownie. Finally, the gluten-free brownies developed are nutritious, provide calories, and have a high level of sensory acceptance in a proportion of 70% cacao and 30% purple corn. They can also be suitable for people with celiac disease.

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ANEXOS

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"AÑO DEL FORTALECIMIENTO DE LA SOBERANÍA NACIONAL"

RESOLUCIÓN N° 1324-2022/UPeU-FIA-CF-T

Lima, Ñaña 20 de diciembre de 2022

VISTO:

El expediente de **Lina Sheriff Ricce Maldonado**, identificado(a) con Código Universitario Nº 201710307, de la Escuela Profesional de Ingeniería de Industrias Alimentarias de la Facultad de Ingeniería y Arquitectura de la Universidad Peruana Unión;

CONSIDERANDO:

Que la Universidad Peruana Unión tiene autonomía académica, administrativa y normativa, dentro del ámbito establecido por la Ley Universitaria Nº 30220 y el Estatuto de la Universidad;

Que la Facultad de Ingeniería y Arquitectura de la Universidad Peruana Unión, mediante sus reglamentos académicos y administrativos, ha establecido las formas y procedimientos para la aprobación e inscripción del perfil de proyecto de tesis en formato artículo y la designación o nombramiento del asesor para la obtención del título profesional;

Que **Lina Sheriff Ricce Maldonado**, ha solicitado: la inscripción del perfil de proyecto de tesis titulado "Elaboración de brownies libres de gluten a partir de harina de arroz (Oryza sativa) y pigmento de maíz morado (Zea mays L.)" y la designación del Asesor, encargado de orientar y asesorar la ejecución del perfil de proyecto de tesis en formato artículo;

Estando a lo acordado en la sesión del Consejo de la Facultad de Ingeniería y Arquitectura de la Universidad Peruana Unión, celebrada el 20 de diciembre de 2022, y en aplicación del Estatuto y el Reglamento General de Investigación de la Universidad;

SE RESUELVE:

Aprobar el perfil de proyecto de tesis en formato artículo titulado **"Elaboración de brownies libres de gluten a partir de harina de arroz (Oryza sativa) y pigmento de maíz morado (Zea mays L.)"** y disponer su inscripción en el registro correspondiente, designar como asesor a **Ph.D. Silvia Pilco Quesada** para que oriente y asesore la ejecución del perfil de proyecto de tesis en formato artículo el cual fue dictaminado por: **Mg.Sc. Daniel Sumire Qquenta y Mg. Marita Ada Shirley Diaz de la Vega Huanca**, otorgándoles un plazo máximo de doce (12) meses para la ejecución.

Regístrese, comuníquese y archívese.

UNIVERSIDAD PERUANA UNION - FACULTAD DE INGENIERÍA Y ARQUITECTURA - DECANA

Dra. Erika Inés Acuña Salinas
DECANA

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