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Original Article

Partial substitution of wheat flour (*Triticum durum*) by sweet potato flour (*Ipomoea batata*) and maca (*Lepidium meyenii*) in a pastry product: alfajores

Sustitución parcial de harina de trigo (Triticum durum) por harina de camote (Ipomoea batata) y maca (Lepidium meyenii) en producto de pastelería: alfajores

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ABSTRACT

With the aim of improving the quality and nutritional value of baking products, the idea of designing alfajores was proposed by partially replacing wheat flour with sweet potato and maca flour. This approach aims to offer products with high levels of nutrients present in sweet potato and maca flours. The main objective of this study was to evaluate the acceptance of alfajores made with these flours, using raw materials grown and produced in Peru. The research was carried out in the Ancash region, specifically at the facilities of the Universidad Nacional de Santa. To obtain sweet potato and maca flours, the same procedure was applied: 15 kg of raw material were used, which was subjected to a disinfection process and then dried at 55 °C for 48 hours. As a result, 2.7 kg of sweet potato flour and 3.5 kg of maca flour were obtained. The formulations used in the preparation of the alfajores consisted of 75 % wheat flour, 22.5 % sweet potato flour and 2.5 % maca flour. The estimated yield was 240 units of alfajores, based on 6 kg of total flour. The sensory analysis was evaluated regarding color, flavor, texture and purchase intensity, and it was observed that in all evaluations a high acceptability of the developed alfajores.

Keywords: Sweet potato, maca, flour substitution, formulation, alfajores.

RESUMEN

Con el propósito de mejorar la calidad y el valor nutricional de los productos de panificación, se plantea la idea de diseñar alfajores sustituyendo parcialmente la harina de trigo por harina de camote y maca. Este enfoque está dirigido a ofrecer productos con altos índices de nutrientes presentes en el camote y la maca. El objetivo principal de este estudio consistió en evaluar la

aceptación de los alfajores elaborados con estas harinas, utilizando materias primas cultivadas y producidas en Perú. La investigación se desarrolló en la región Ancash, en las instalaciones de la Universidad Nacional del Santa. Para obtener la harina de camote y maca, se siguió un mismo procedimiento: se utilizó 15 kg de materia prima, la cual fue sometida a un proceso de desinfección y luego se secó durante 48 horas a 55 °C. Como resultado, se obtuvieron 2,7 kg de harina de camote y 3,5 kg de harina de maca. Las formulaciones empleadas en la elaboración de los alfajores fueron de 75 % de harina de trigo, un 22,5 % harina de camote y 2,5 % de harina de maca. El rendimiento estimado fue de 240 unidades de alfajores en base a 6 kg de harina total. Se evaluó el análisis sensorial respecto al color, sabor, textura e intensidad de compra, donde se obtuvo una alta aceptabilidad de los alfajores.

Palabras clave: Camote, maca, sustitución de harina, formulación, alfajores.

INTRODUCTION

Poor nutrition has become a major public health problem, affecting communities globally, including Peru. Over the years, there has been a significant increase in the preference for consuming foods that prioritize taste pleasure over nutritional value, as is the case for fast foods, which contain many additives and harmful components such as saturated fats, refined flours, and harmful preservatives (Gamarra, 2021). Current food trend pose a significant challenge in promoting healthy eating habits, which has long-term repercussions on consumers' health. According to data from the World Health Organization (WHO, 2020), an alarming 32% of deaths in Peru are caused by non-communicable chronic diseases, such as obesity, diabetes, and cardiovascular disorders, conditions that can be directly caused by or strongly influenced by an inadequate diet.

Poor nutrition is a persistent problem in our society and often finds its root in the excessive consumption of processed and ultra-processed foods; products that usually contain added or refined sugars, providing low-nutrition "empty" calories, as well as salt and saturated fats (Flores, 2020). These foods not only contribute to weight gain and obesity but are also associated with the development of chronic pathologies (Maldonado, 2020). This category also includes sweets, whose consumption has shown a considerable increase in recent decades. An example is the alfajor, whose consumption has grown significantly, driven both by its appealing taste and by its increasing presence on digital media and social networks (Trivi, 2020). It is crucial to reflect on our food choices and consider how these products impact our long-term health.

Healthy foods are fundamental for human well-being, as they represent an invaluable source of essential nutrients that strengthen and nourish the body (WHO, 2018). Adequate consumption not only provides the energy necessary for daily activities but also supplies the indispensable components for the proper functioning of organs and systems. In this regard, a balanced diet, rich in proteins, carbohydrates, healthy fats, vitamins, minerals, and fiber, plays a key role in disease prevention and in the promotion of overall health.

Within this group of foods, maca stands out as an Andean superfood with high nutritional and functional value. It contains proteins, fiber, minerals, unsaturated fatty acids, glucosinolates, phenolic

compounds, phytosterols, alkaloids, and macamides, among other bioactive compounds (Yábar & Reyes, 2019; Bahukhandi *et al*., 2021; Biasi *et al*., 2023). These components provide not only high nutritional value but also multiple benefits, such as improved reproductive health, antioxidant, anticancer, hepatoprotective, and immunomodulatory effects (Bahukhandi *et al*., 2021; Leitao *et al*., 2020; Baquerizo *et al*., 2021). Another example of a healthy food is sweet potato (*Ipomoea batatas* L.), a tuber with an outstanding nutritional profile, characterized by its high carbohydrate content that provides energy, as well as its richness in carotenoids, provitamin A, and vitamins C and B complex (Instituto Nacional de Investigación Agropecuaria, 2020). In addition, it provides dietary fiber, niacin, and proteins that promote proper digestion and strengthen the body, also being a source of minerals such as zinc, iron, phosphorus, potassium, and calcium, which are essential for bone, muscle, and immune system health (Vidal *et al*., 2018). Due to this combination of vitamins, minerals, and bioactive compounds, sweet potato is considered a complete food that contributes to vitality and overall well-being (Vidal *et al*., 2018; Bai *et al*., 2021; Silva *et al*., 2022; Cartabiano-Leite *et al*., 2020). Among its varieties, purple sweet potato stands out for its anthocyanin content, compounds with potent antioxidant activity that help eliminate free radicals and, in synergy with hydroxycinnamic acids, provide protection against processes related to degenerative diseases (Bai *et al*., 2021; Philpott *et al*., 2004).

There is a growing interest in discovering healthier and more nutritious food alternatives. An innovative trend that not only promotes health but also highlights cultural and nutritional richness is the use of native Peruvian foods for the replacement in certain conventional flours or commercial foods (Pascual & Zapata, 2010; Sandoval, 2022), opening a promising outlook for conscious and sustainable eating.

The raw materials selected for the flours are sweet potato and maca, traditional Peruvian crops with high nutritional value in vitamins, minerals, and fiber; additionally, they have the capacity to regulate blood sugar and lipid levels (Rosell *et al*., 2024; Ludvik *et al*., 2004). In contrast, maca is chosen as a valuable source of proteins and essential nutrients, having been shown to increase endurance and vitality (Ulloa *et al*., 2024).

The incorporation of sweet potato and maca flour in bakery products and pastry emerges as an essential pillar to increase the nutritional value of these products, offering a variety of health benefits. Sweet potato, rich in starch, becomes an ally in providing a spongy and delicate texture in both bread and cakes (Vázquez-Chavéz & Hernández-López, 2023). This combination, in addition to giving a pleasant flavor and a pinkish hue to the dough, not only captivates the children but also opens the door to healthier and more balanced pastry options, contributing to the overall well-being of children and the general public.

In this line of research, the focus on the partial substitution of wheat flour with sweet potato and maca flour in alfajores becomes highly relevant. These Peruvian foods could play a fundamental role in reformulating eating habits and promoting healthier alternatives in pastry (Mendoza & Navarrete, 2022).

This innovation is not only aimed at providing healthier alternatives but also seeks to promote the use of local resources,

thus boosting the agricultural economy and safeguarding Peru's rich biodiversity in the process.

MATERIALS AND METHODS

Sweet Potato Flour

The sweet potato flour (*Ipomoea batatas*) was obtained from the purple variety, which was purchased at a local market in the city of Chimbote. The flour production process was adapted from that described by Sing & Villalobos (2015) and Cruz (2019). The raw material was subjected to an initial washing, removing dust, soil, or impurities, followed by disinfection with chlorine at a concentration of 60 ppm. Subsequently, a second washing was performed to remove chlorine residues. Then, the sweet potatoes were cut into pieces or slices small enough to optimize the drying process. They were later placed in a tray dryer, model SBT-10x10, for 24 hours at 55 ºC. After the drying period, the dehydrated sweet potato was ground and sieved using a grain mill and a vibratory sieve, model MDMT-60XL, obtaining 2.7 kg of sweet potato flour. The approximate yield was 25%.

Maca Flour

Fresh yellow maca roots were purchased from a local market in Chimbote. They underwent an initial washing to remove dust, soil, or impurities, followed by disinfection with chlorine at a concentration of 60 ppm. Afterward, a second washing was carried out to remove chlorine residues. The roots were then cut into pieces or slices small enough to optimize the drying process and subsequently placed in a tray dryer, model SBT-10x10, for 24 hours at 55 ºC.

The dried maca roots were ground and sieved using a grain mill and a vibratory sieve, MDMT-60XL, through a 0.2 mm mesh to obtain fine maca flour. The yield obtained was approximately 30%; this value serves as a reference to determine the amount of raw material needed according to the desired amount of flour.

Formulations

The proposed formulation for the preparation of alfajores involves a partial substitution of wheat flour with sweet potato flour (22.5%) and maca flour (2.5%), to improve the nutritional profile of the product without compromising its characteristic texture and flavor. This choice is based on a review of the functional and sensory properties of both ingredients, as well as preliminary tests aimed at maintaining the acceptability of the alfajor.

Sweet potato flour (*Ipomoea batatas*) stands out for its high starch content, which provides superior water absorption capacity. This starch acts as a binding agent, allowing for softer, more cohesive, and spongy doughs, ideal for bakery products. According to Ayol (2022), these characteristics make it suitable as a partial substitute for wheat flour in cookie formulations.

Maca flour (*Lepidium meyenii*) contributes valuable nutritional compounds, although its strong flavor can become bitter if used in large proportions. For this reason, it was used at only 2.5%, allowing its properties to be leveraged without negatively affecting the sensory profile of the product.

The final proportion, composed of 75% wheat flour, maintains the traditional structure of alfajores, while the inclusion of alternative flours adds functional and nutritional value without drastically altering consumer acceptance. Table 1 presents the corresponding substitution percentages

for the flours, considering a total value of 100% for the flours.

Table 1 shows the contrasting proportions between sweet potato flour and maca flour. This analysis is not only based on differences in flavor but also on the binding property of the starch present in sweet potato, which allows its use in higher quantities when combined with wheat flour in the preparation of bakery products. The influence of color is also considered, resulting from the pigments present in purple sweet potato. These pigments provide a distinctive pinkish hue to the dough and the final product.

Table 1.
Formulation of the substitution of sweet potato and maca flours in alfajores

FLOURS	PERCENTAGE
Wheat flour	75%
Sweet potato flour	22.5 %
Maca flour	2.5 %

Bakery products

For the development of this research, a formulation adapted from the original alfajores recipe was used, in which wheat flour was partially substituted with sweet potato and maca flours. The composition of the ingredients used is presented in Table 2.

In the formulation presented, the value of 100% corresponds exclusively to the sum of the flours considered (wheat flour, maca flour, and sweet potato flour). The other ingredients used in the preparation (such as cornstarch, powdered sugar, margarine, manjar blanco, and chia) were calculated proportionally based on the total amount of flours used. In this way, the percentages assigned to these ingredients are not part of the sum equivalent to 100%, but rather represent specific ratios with respect to the flour base established for the preparation of the alfajores.

For the alfajores production process, the procedure described by Sing and Villalobos (2015) was adapted, together with prior knowledge in the preparation of bakery products with partial flour substitution.

Table 2.
Formulation for the Preparation of Alfajores

	INGREDIENTS	PERCENTAGE	FOR 1 Kg OF FLOUR
Sum of flours equivalent to 100%	Wheat flour	75%	0.75
	Maca flour	2.5 %	0.025
	Sweet potato flour	22.5 %	0.225
Percentage considered based on the total amount of flour	Cornstarch	25%	0.25
	Powdered sugar	30%	0.3
	Margarine	65%	0.65
	Manjar Blanco	75%	0.75
	Chía	10%	0.1

The alfajores preparation process, as indicated in Figure 1, begins with weighing the dry ingredients: wheat flour (75%), sweet potato flour (22.5%), and maca flour (2.5%) on an analytical balance. Subsequently, the flour mixture was sifted through a 0.5 mm mesh to remove lumps and impurities, obtaining a homogeneous mixture. Next, a three-stage kneading process was carried out. The first kneading incorporated margarine (65%) and powdered sugar (30%) in a mixer, performed at medium speed for 5 minutes. In the second kneading, sifted cornstarch (0.5 mm mesh) was added, kneading at medium speed for an additional 3 minutes. Finally, in the third kneading, the flour mixture was added and kneading continued for 4 minutes at medium speed, ensuring the complete integration of all components. Once the dough was obtained, molding and baking were carried out. The dough was rolled out with a rolling pin until reaching a thickness of 8–10 mm and shaped using a round cutter with a diameter of 5 cm. The dough discs obtained were placed on a baking tray.

The oven was preheated to 150 °C for approximately 10 minutes, and once the temperature was reached, the trays with the dough were placed in the oven. Baking was carried out at the same temperature for 25 minutes. During baking, a tray with chia seeds was also placed in the oven, in order to toast them and use them as a coating for the alfajores. The baked dough pieces were allowed to cool at room temperature (23–25 °C) for approximately 20 minutes, as were the chia seeds.

For the final process, the filling was applied using manjar blanco with a No. 10 round piping tip, ensuring uniform distribution. The coating of the alfajores was carried out manually by immersing the edges in toasted chia seeds. Finally, the alfajores were individually packaged and sealed in high-density polypropylene (HDPE) bags by thermal sealing. The product was stored at a temperature of 20 °C to 25 °C and at a relative humidity of 40–60%, protected from direct light.

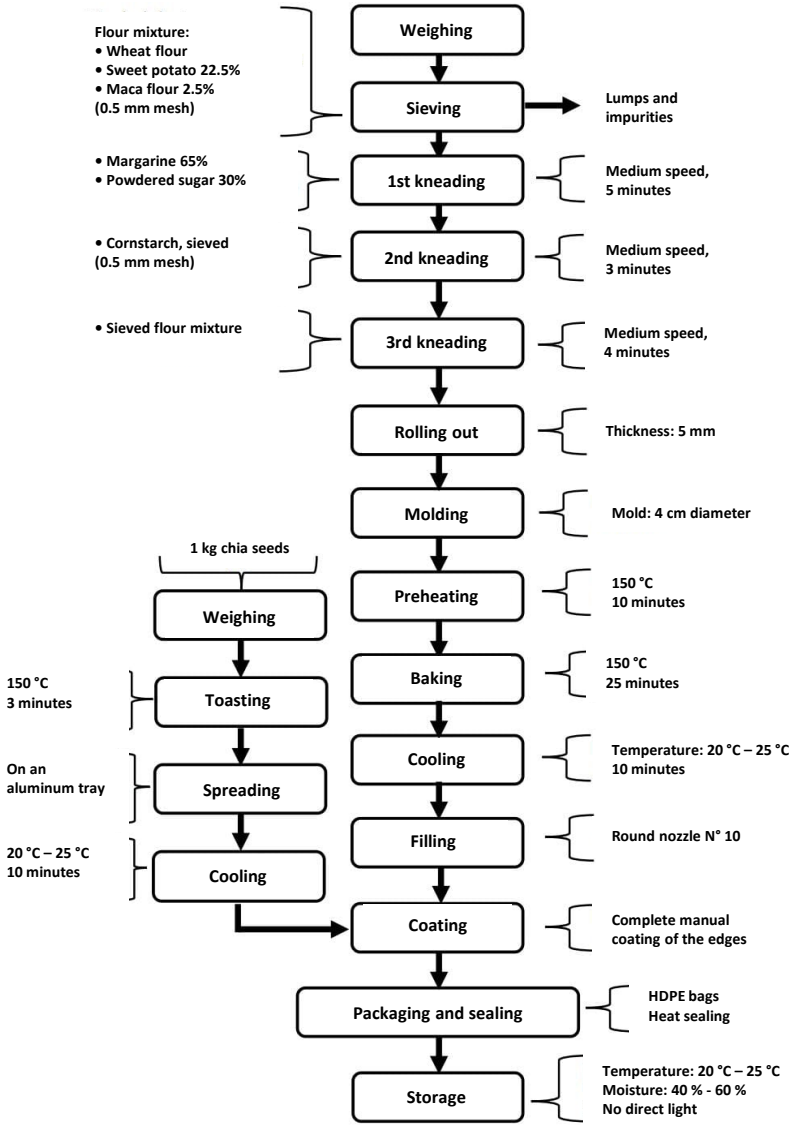

Figure 1. Block diagram of the alfajores preparation process

Number of alfajores per amount of flour

To determine the yield, that is, how many alfajores will be obtained, the following formula was applied, as shown below:

$$\frac{\textit{Total weight of the dough ingredients(g)}}{\textit{[Weight for each maca dough disc (g) . 2]}}$$

Sensory analysis of the bakery product: Alfajores

Following the evaluation approach suggested by Agudelo *et al*. (2019), an intriguing sensory analysis was carried out in the city of Chimbote. This study was conducted during an entrepreneurship fair, attracting the active participation of 50 individuals. The elements subjected to evaluation included color, aroma, flavor, texture, and even the predisposition to purchase the product. For this purpose, a hedonic scale (Table 3) was defined with meticulously established criteria.

Meanwhile, to perform the purchase intensity test, Agudelo *et al*. (2019) used a different hedonic scale (Table 4).

Table 3.
Hedonic scale for sensory evaluation

HEDONIC SCALE	
Very pleasant	1
Pleasant	2
Good	3
Unpleasant	4
Very unpleasant	5

Table 4.
Hedonic scale for purchase intention

HEDONIC SCALE	
Yes, I would buy it	1
In doubt	2
I would not buy it	3

RESULTS AND DISCUSSION

Yield obtained in the preparation of alfajores

For the preparation of the alfajores, weight distribution was carried out for the formulation. Table 5 shows the weights indicated for each ingredient. It should be noted that the sum of the flour mixture amounts to 1 kg, representing 100%. The other ingredients, such as cornstarch, powdered sugar, and margarine, are external additives to the main mixture and are not considered within the 100%. In this way, these additives are properly proportioned according to the total amount of flour.

Table 5.
Quantity of ingredients used in the dough for 1 kg of flour

INGREDIENTS	QUANTITY (Kg)
Wheat flour	0.750
Maca flour	0.025
Sweet potato flour	0.225
Cornstarch	0.250
Powdered sugar	0.300
Margarine	0.650
TOTAL	3.05

It was established that each alfajor disc should have an average of 18 grams of dough. To determine the yield of alfajores obtained from the total amount of flours, it will be calculated by substituting the values into Equation 1, as proposed in the methodology.

$$\frac{\textit{Total weight of the dough ingredients(g)}}{\textit{[Weight for each maca dough disc (g) . 2]}}$$

Next, we substitute:

$$Units_{Alfajor} = \frac{3050\ (g)}{20\ (g).2}$$

$$Units_{Alfajor} = 76.25$$

It is reported that per kilogram of flour, a total of 76 alfajores are obtained, that is, 152 dough discs. This value exceeds that obtained by Chávez and Montañez (2021), who reported that, based on 40 kilograms of flour, they achieved a production of 1,466 products including different types of alfajores and King Kong, without accounting for losses; that is, per kilogram of flour, they obtained 36.65 products, which is lower than the yield obtained in this study.

Results of the sensory analysis of the bakery product: Alfajor

COLOR APPEARANCE

Although flavor and texture are the most relevant sensory attributes in the evaluation of a product, color was also considered as an analysis parameter due to the characteristic pinkish tone observed in the alfajor shells. This color is due to the presence of pigments inherent to purple sweet potato, which give the product a distinctive appearance. As it is the first attribute perceived by consumers, it is expected that this chromatic attribute will increase the acceptance and visual appeal of the alfajores in the market.

Figure 2 shows that the color observed in the alfajores was directly influenced by the presence of purple sweet potato flour in the formulation, which generated a characteristic pinkish hue. This visual aspect positively captured the attention of the evaluators, and was perceived as a differentiating attribute compared to conventional alfajores.

The pinkish hue acquired by the alfajor shells not only constitutes a distinctive aesthetic feature but may also influence the purchase decision, especially among consumers who value appearance as an indicator of novelty or quality. Schnaider (2023) highlights the importance of color in pastry products, showing how attractive tones enhance acceptance. In this case, the natural pigments of purple sweet potato proved to be functional at both the visual and nutritional levels, confirming their viability as an ingredient in innovative bakery products.

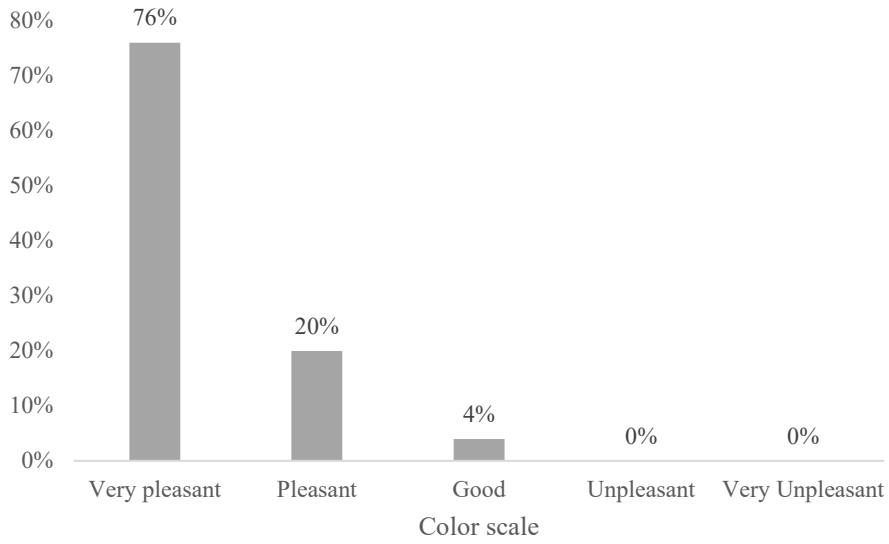

Figure 2. Results regarding color

FLAVOR ASPECT

To ensure that the alfajores would have a pleasant flavor for the taste buds, care was taken to avoid exceeding the percentage of maca flour, which could contribute bitterness to the alfajor. With a higher percentage of sweet potato flour, a noticeably sweet flavor is perceived.

Figure 3 shows that flavor was one of the most carefully balanced attributes in the formulation. The higher proportion of sweet potato flour provided a natural and pleasant sweetness, while the controlled incorporation of maca flour avoided bitter notes, thus preserving a positive gustatory experience.

Flavor constitutes one of the most sensitive factors in the evaluation of bakery products. In this research, an adequate balance was achieved between functional ingredients and the organoleptic characteristics of the product. As noted by Schnaider (2023), the incorporation of alternative ingredients can modify the flavor profile; however, appropriate formulation design allows consumer acceptance to be preserved. The combination of sweet potato and maca in specific proportions proved effective in maintaining a pleasant flavor, demonstrating that it is possible to innovate without compromising the sensory quality of the product.

TEXTURE ASPECT

The dough of an alfajor is typically soft, tender, and buttery. It may have a cookie-like consistency or be spongier depending on the recipe. Figure 4 shows that the texture of the alfajores was described as soft and homogeneous, with a consistency similar to that of traditional alfajores. The presence of sweet potato starch contributed to this structure, providing a tender and slightly spongy bite.

Texture is a critical property that directly influences the perception of quality in a pastry product. In this formulation, the inclusion of sweet potato flour contributed to achieving a cohesive, soft, and easy-to-consume dough. Schnaider (2023) also mentions that a balanced texture—neither too dense nor too fragile—is fundamental for sensory acceptability. The

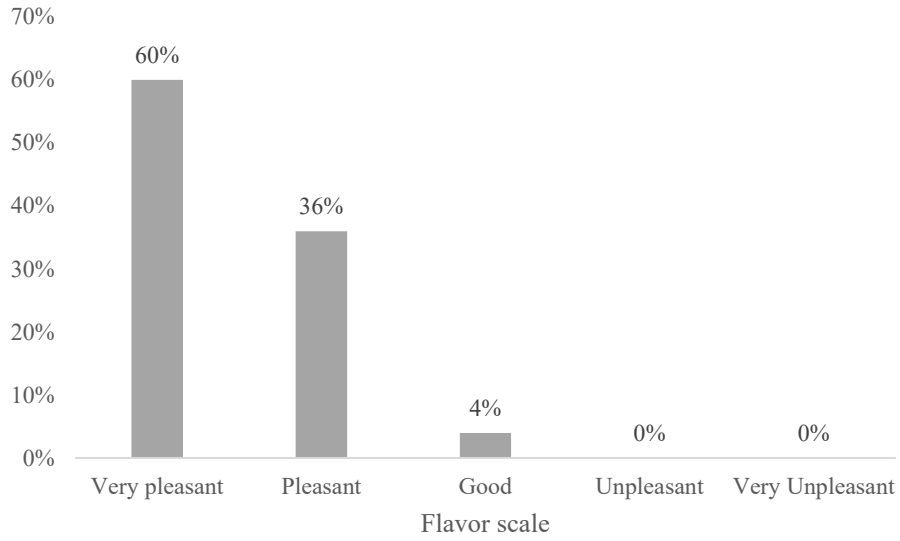

Figure 3. Results regarding flavor

texture achieved in this research allowed for an experience similar to that expected by consumers, validating the use of alternative ingredients in artisanal products.

Purchase intention evaluation

Evaluating purchase intention allows the assessment of how commercially viable the product would be in the market. Therefore, according to the results, the product would be fully accepted in this context.

In Figure 5, it is observed that the evaluation of purchase intention revealed a highly positive response from the evaluators, who expressed a high level of willingness to purchase the product. This result suggests that the sensory attributes as a whole were perceived as satisfactory, generating confidence and satisfaction in the potential consumer.

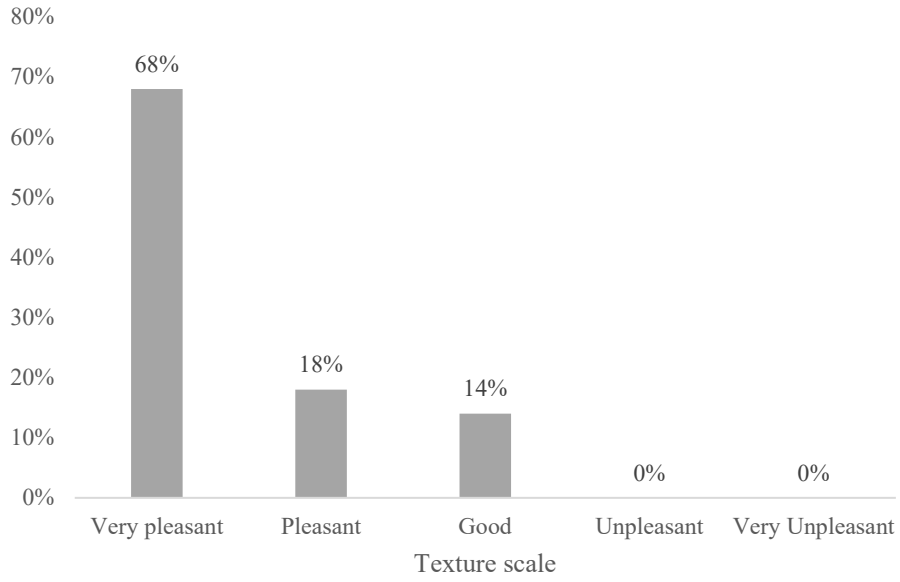

Figure 4. Results regarding texture

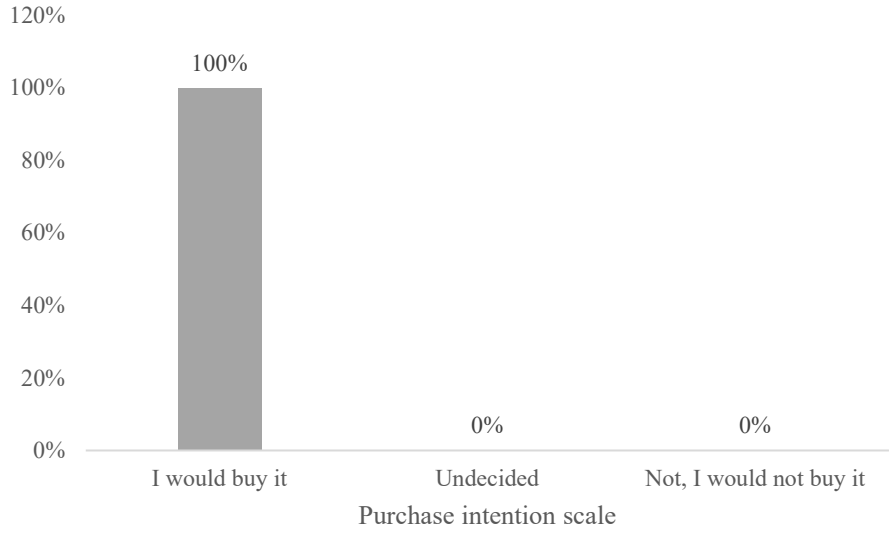

Figure 5. Results regarding purchase intention

CONCLUSIONS

The partial substitution of wheat flour with sweet potato and maca flour in alfajores showed positive sensory acceptance, as reflected in the consumers' evaluation. The theoretical nutritional analysis suggests a higher potential nutrient contribution, which supports the feasibility of using alternative flours in pastry products. This provides a basis for future research in pastry-making, promoting the search for alternative ingredients and benefiting both consumers and the food industry.

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