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Original Article

Determination of the Nutritional and Sensory Characteristics of Biscuits Fortified with Cushuro (*Nostoc sphaericum* Vaucher) and Tarwi (*Lupinus mutabilis* Sweet)

Determinación de las características nutricionales y sensoriales de galletas fortificadas con cushuro (Nostoc sphaericum vaucher*) y tarwi (Lupinus mutabilis* sweet*)*

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ABSTRACT

The nutritional and sensory characteristics of food products are essential for consumer acceptance. The objective of this research was to evaluate cookies fortified with cushuro and tarwi, two ingredients recognized for their nutritional properties and potential health benefits. Cushuro, a type of algae found in high-altitude Andean lakes, is an excellent source of protein, vitamins, and minerals such as iron and calcium. Meanwhile, tarwi, an Andean legume, is rich in protein, fiber, and fatty acids, making it a highly nutritious food. The objective of fortifying cookies with cushuro and tarwi stems from the need to enhance the nutritional content of processed foods. Given that cookies are widely consumed, especially by children and adults, incorporating nutrient-rich ingredients like cushuro and tarwi can significantly contribute to a more balanced and healthy diet. The inclusion of these ingredients in cookies could not only improve their nutritional profile but also offer an appealing option for those seeking foods with added value. To assess the impact of these ingredients on cookies, two types were prepared: ones with cushuro and tarwi and ones without. This approach allows us to compare how the addition of cushuro and tarwi affects both the sensory and nutritional characteristics of the cookies, thus providing a comprehensive view of their potential as a food product.

Keywords: Tarwi, cushuro, nutritional analysis, fortified cookies.

RESUMEN

Las características nutricionales y sensoriales en productos alimentarios son de suma importancia para su aceptación por el consumidor. La presente investigación tuvo como objetivo la evaluación de galletas fortificadas con cushuro y tarwi, dos ingredientes que destacan por sus propiedades nutricionales y beneficios potenciales para la salud.

El cushuro, un alga que crece en los lagos de altitud en los Andes, es conocido por ser una excelente fuente de proteínas, vitaminas y minerales, como el hierro y el calcio. Por su parte, el tarwi, una leguminosa andina, es rico en proteínas, fibra y ácidos grasos, convirtiéndolo en un alimento muy nutritivo. El objetivo de fortificar galletas con cushuro y tarwi surge de la búsqueda de alternativas para mejorar el contenido nutricional de los alimentos procesados. Dado que las galletas son un alimento ampliamente consumido, en especial por niños y adultos, incorporar ingredientes ricos en nutrientes como el cushuro y tarwi puede contribuir significativamente a una alimentación más balanceada y saludable. La inclusión de estos ingredientes en las galletas podría no solo mejorar su perfil nutricional, sino también ofrecer una opción atractiva para aquellos que buscan alimentos con un valor agregado. Para evaluar el impacto de estos ingredientes en las galletas, se elaboraron dos tipos: unas con cushuro y tarwi y otras sin ellos. Este enfoque nos permite comparar cómo la adición de cushuro y tarwi afecta tanto las características sensoriales como nutricionales de las galletas, ofreciendo así una visión integral de su potencial como producto alimenticio.

Palabras clave: Tarwi, cushuro, análisis nutricional, galletas fortificadas.

INTRODUCTION

Knowledge about traditional products prevails over the years. With the new generations, there is an attempt to make known these inputs rescued from ancient culinary preparations and brought to modernity with innovative elaborations, in order to take advantage of their benefits or enhance the nutritional properties with certain food combinations without compromising product quality. Among these foods are cushuro and tarwi.

Peru, located in western South America, boasts a wide range of climates due to its geographic condition. According to Britto (2017), there are 13 ecoregions, which generate an environment conducive to a unique biodiversity of vegetation; and more than 12,000 lagoons around its departments, some of which are the habitat of various types of algae. These are photosynthesizing organisms that play an essential role in aquatic ecosystems.

In particular, cushuro (*Nostoc sphaericum*) is an edible algae that has not yet been industrialized (Corpus *et al.*, 2021). According to Aguilera *et al.* (2020), this is one of the foods that grows in the depths of lakes, springs and streams located in Ancash, Cajamarca, Puno, Cerro de Pasco, Junín, Huancayo, Cuzco, La Libertad and Amazonas. Known by various names such as murmumta, llullucha, crespito, and llayta, cushuro is classified as a cyanobacteria and belongs to the kingdom Eubacteria. It can have spherical, cylindrical, lobular, laminar, or irregular shapes, often covered in a gelatinous substance (Ponce, 2014; Echevarría *et al.*, 2017).

Nutritionally, cushuro is notable for its high levels of iron, protein, and calcium, as demonstrated in several studies (Inocente *et al.*, 2019). According to Peru's Food Composition Tables (Ministry of Health, 2017), 100g of dried cushuro contains approximately 83% water, 29 g of protein, and 86g of iron (Asalde and Iparraguirre, 2023). However, cushuro flour production is limited, and its market availability is

scarce, leading to higher costs compared to more accessible and affordable tarwi flour.

Tarwi (*Lupinus mutabilis*), as described by Díaz and Flores (2017), is a herbaceous legume with pronounced thick stems cultivated in temperate and cold regions, including Peruvian areas like Cajamarca, Ancash, Cusco, and Puno, among others. Tarwi is rich in alkaloids ranging from 0.02% to 4.45%, which is why it has a bitter taste and cannot be consumed directly; however, there are sweet varieties. Also known as chocho, tarhui, tarwi, or lupino, this legume is rich in vitamins, minerals, iron, and unsaturated fats, with a protein content of 40-50% of plant origin (Asalde and Iparraguirre, 2023).

Currently, Peruvians consume a wide variety of processed foods—cookies, desserts, cakes, etc.—which are often high in sugars, trans fats, saturated fats, and sodium (Díaz, 2020). However, learning about tarwi and cushuro and incorporating them into these products could improve nutritional value and promote healthier eating habits, particularly due to their high protein and iron content (*Sermini et al.*, 2017 and Zavaleta, 2018).

MATERIALS AND METHODS

Experimental tests were conducted in the Physicochemistry Laboratory of Le Cordon Bleu University, using inputs such as cushuro, tarwi and wheat flour, among others. In addition, the equipment listed in Table 1 was used for both the preparation of the cookies and the moisture analysis.

The preparation process began with receiving and weighing of inputs (ingredients) as seen in Table 2. The formulation was based on the one previously used for the preparation of cookies with pituca and cushuro flour (Meza, 2022).

The recipe incorporated 60g of tarwi flour and 20g of cushuro flour, as tarwi flour, rich in protein, contributes a crunchy texture and firm structure due to its ability to retain air and form a stable protein network during baking. However, excessive amounts of tarwi flour could result in overly dense or dry textures. On the other hand, cushuro flour, high in soluble fiber and protein, provides a softer, fluffier texture and enhances moisture retention. This proportion of cushuro complements tarwi properties, maintaining a balance between crispness and softness.

Table 1.

Equipment used in the research

Equipment
Electric oven (Thomas)
Hand mixer (Electrolux)
Moisture analyzer balance (A&D MX-50)
Analytical balance (Henkel)
Heating plate

Table 2.

Formula for cookies fortified with cushuro and tarwi and non-fortified cookies

Inputs (ingredients)	Quantity	
	Non-Fortified cookies	Fortified cookies
Tarwi flour	0 g	60 g
Cushuro flour	0 g	20 g
Wheat flour	400 g	320 g
Salted butter	120 g	120 g
Egg	120 g	120 g
Brown sugar	150 g	120 g
Vanilla extract	15 mL	15 mL
Baking powder	5 g	5 g

To begin the preparation, the butter and sugar were beaten until a light and fluffy mixture was obtained (creamed). Next, the eggs, vanilla, cushuro and tarwi flour, and then the wheat flour and baking powder were added, sifted through a sieve with a 1 mm mesh size; everything was mixed until a non-sticky dough was obtained.

The dough was left to rest at room temperature for 30 minutes. After resting, it was rolled out and cut. Using a rolling pin, the dough was flattened to a thickness of 0.4 cm and then cut into circles with a 3.8 cm diameter cookie cutter (Figure 1).

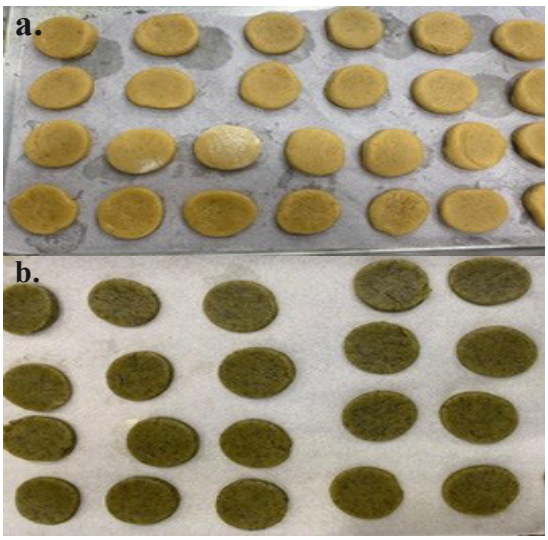

Figure 1. Comparison between unbaked cookies: non-fortified cookies with cushuro and tarwi (a) versus fortified cookies (b)

The dough circles were placed on a metal tray lined with parchment paper, and the oven was preheated for 15 minutes at 180°C. Afterward, the cookies were baked for 11 minutes at the same temperature. Following their preparation, two evaluations were conducted: nutritional value and acceptability. Detailed chemical and physicochemical analyses were carried out following the procedures described in Table 3 (Meza, 2022; Quelal, 2023).

Table 3.

Tests conducted on cookie samples

Parameter	Method
Protein	AOAC 950.36
Iron	AOAC 975.03
Crude fiber	NTP 205.003:1980
Fat	NTP 206.017:1981
Humidity	Thermogravimetric principle

Source: Meza, 2022 and Quelal, 2023

Proximate analyses were conducted because they are a requirement for foods of this type (INACAL, 2016), and chemical analyses were necessary to determine changes in the nutritional properties of the cookies. Proximate analyses included fiber determination, based on measuring insoluble residue after acidic and alkaline digestion; fat quantification using organic solvent extraction with a Soxhlet apparatus; and moisture evaluation by measuring weight loss after drying the sample at 105 °C until constant weight.

Additionally, specific chemical analyses were carried out, such as protein determination using the Kjeldahl method, which measures total nitrogen in the sample, and iron quantification using atomic absorption spectrometry after digesting the sample with a mixture of concentrated acids. These procedures provided a precise characterization of the nutritional and mineral components of the samples, allowing for an integral assessment of their quality and nutritional value. Protein, iron, crude fiber, and fat analyses were performed at "La Molina Calidad Total Laboratories – National Agrarian University La Molina," accredited by the National Institute of Quality (INACAL). Moisture analysis was

conducted in the laboratories of Le Cordon Bleu University.

A survey was employed for the sensory evaluation (Severiano, 2019). A five-point hedonic scale was used to evaluate texture, flavor and appearance, where 1 represented "dislike it very much", 2 "dislike it", 3 " neither like nor dislike it", 4 "like it" and 5 " like it very much".

The acceptability test was conducted with adult participants (students and teachers) aged 20–50 years. Participants were informed about the survey's purpose and provided consent to participate. Each received a glass of water and both cookie samples, with instructions to observe, taste, and answer the questions. Subsequently, the information collected was analyzed.

RESULTS AND DISCUSSION

Chemical and Physicochemical Analysis

The results of the cookie analyses are shown in Table 4. According to the Peruvian Food Composition Tables (2017), 100 g of dehydrated cushuro contains 29 g of protein. In contrast, Leiva and Sulluchuco (2018) reported 0.4 g of protein in fresh cushuro. This difference is explained by the effects of high temperatures and sugars, which trigger the Maillard reaction and affect protein quality in foods. Conversely, lower temperatures and lower sugar concentrations induce structural changes in proteins, enhancing their digestibility. As a result, cookies with added cushuro showed a higher protein content.

Regarding moisture content, the cookie with added cushuro had 2.7%, compared to 1.8% in the cookie without cushuro. These results are within the limits established by NTP (2016), which sets a maximum moisture content of 12% for cookies. This indicates that both the cookies with and without added cushion are within the permitted range, which is beneficial since it prevents the formation of fungi and yeasts. Similarly, the iron content in the cookie with cushuro was 6.34 mg, while the cookie without cushuro had 3.78 mg. All other parameters were also within the limits established by the standard.

Table 4.
Results of tests conducted on cookie samples

Tests (per 100g of sample)	Results	
	Fortified cookies	Non-fortified cookies
Protein (g)	11.8	8.7
Iron (mg)	6.34	3.78
Fat (g)	15.8	15
Crude fiber (g)	0.7	0
Humidity (%)	2.7	1.8

Sensory Analysis

The samples were coded as follows: sample (a) for the cookie without cushuro and tarwi, and sample (b) for the cookie with cushuro and tarwi. For texture (Figure 2), sample (a) received higher scores, with an acceptance range between 4 and 4.5, while sample (b) scored between 3 and 4. This indicates lower acceptance of the cookie with cushuro and tarwi. No scores of 1 or 2 were recorded. This is explained by the lower amount of gluten in sample (b), with 320 g of wheat flour compared to 400 g in sample (a). According to Diaz and Flores (2017), gluten and water play an important role in the properties of the ingredients, as gluten is a protein present in wheat, barley and rye. This protein helps to increase the volume of the dough and gives it a viscoelastic texture that traps air, resulting

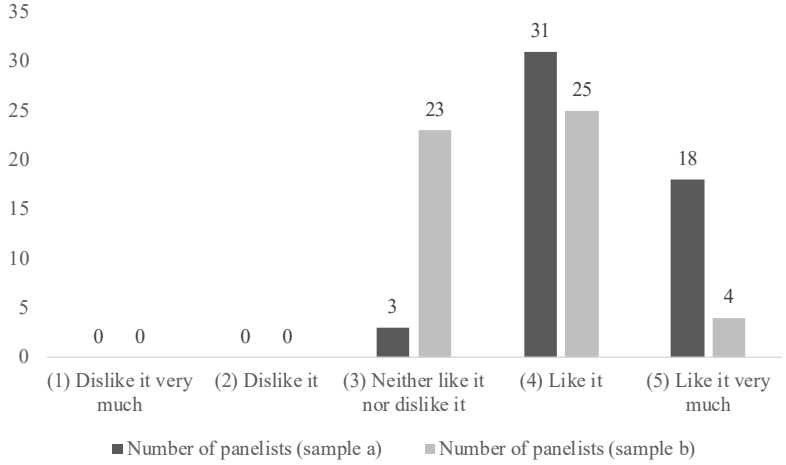

Figure 2. Texture attribute scores for samples (a) and (b): 1 "dislike it very much", 2 "dislike it", 3 "neither like nor dislike it", 4 "like it", 5 "like it very much"

in greater consistency. Therefore, the lower approval of the sample with cushuro and tarwi, which contains less gluten, in terms of texture, can be explained by this factor.

Flavor results (Figure 3) show that sample (a) had higher acceptance compared to sample (b), with a score of 4, classified as "like it." This surpassed the scores for sample (b). Similarly, no scores of 1 or 2 were recorded.

Concerning this, Cajavilca (2022) developed three different formulations of cookies using Andean grains, including kiwicha, cañihua, quinoa, and tarwi. The study evaluated sensory attributes such as flavor, texture, color, and appearance through three-point hedonic testing with 30 panelists aged 8 to 35 years. The formulations were as follows:

(a) 33% tarwi, 29% cañihua, 33% kiwicha, and 4% quinoa

(b) 50% tarwi, 13% cañihua, 29% kiwicha, and 8% quinoa

(c) 25% tarwi, 25% cañihua, 25% kiwicha, and 20% quinoa

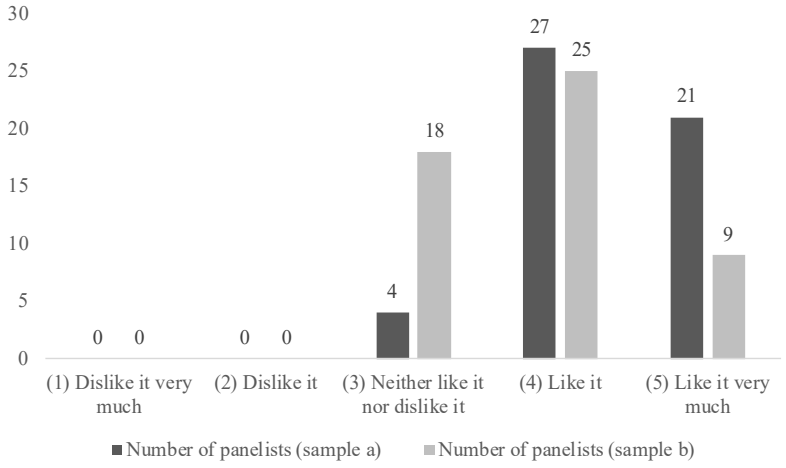

Figure 3. Flavor attribute scores for samples (a) and (b)

The second formulation, with 50% tarwi (240 g), showed the highest acceptability, with the addition of panela, cane honey, cloves, and other ingredients improving flavor and acceptance.

Figure 4 shows the results of the sensory test concerning appearance. It can be seen that cookie (a) received a score of 4 in appearance, thus outperforming sample (b). No scores of 1 or 2 were recorded.

The greenish color of cushuro, a characteristic of the algae, contributed to a similar shade in the cookies. However, this pigment was not appealing to the panelists, which may explain the lower score for sample (b) compared to sample (a). Cutipa (2022) studied French bread by substituting wheat flour with cushuro flour at different percentages (5%, 10%, 15%, and 20%). Sensory characteristics such as aroma, flavor, texture, and appearance were evaluated using a hedonic scale, with the 5% substitution showing the highest acceptability. The author noted that browning, or the Maillard reaction during baking, can cause color changes in cookies, impacting their acceptance. Similarity in color significantly influences consumer acceptability, and the greenish hue in sample (b) likely contributed to its lower score compared to the cookies without added cushuro and tarwi.

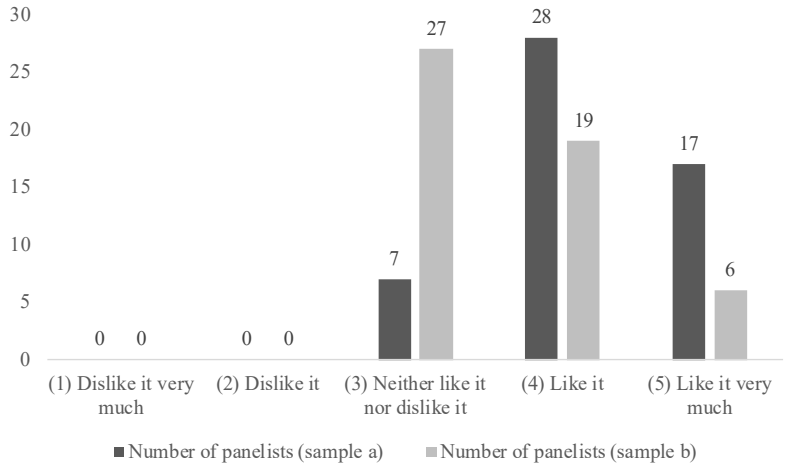

Figure 4. Appearance attribute scores for samples (a) and (b)

CONCLUSIONS

The fortified cookie exhibited higher levels of iron and protein compared to the non-fortified cookie. These results were determined from the nutritional characteristics obtained through chemical and physicochemical analyses, revealing higher protein and iron content in the cookies with added cushuro and tarwi. Sensory characteristics were evaluated using a 5-point hedonic scale, and the non-fortified cookie was the most accepted by panelists, despite having lower nutritional value compared to the fortified cookie.

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