nutrición clínica y Dietética Hospitalaria

Artículo Original

Nutr Clín Diet Hosp. 2025; 45(4):426-433
DOI: 10.12873/454garcia

Organoleptic effects of using potato peel flour in cookies

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Recibido: 7/octubre/2025. Aceptado: 8/diciembre/2025.

SUMMARY

Introduction: Cereals, especially wheat, are staple foods and are primarily used as flour. Wheat flour is essential in baking for its ability to give structure to baked goods. The industry is seeking more nutritious alternatives that enhance flavor and texture. Legume flours provide fiber, protein, and sensory variety.

Objective: To determine the effect of using potato peel flour on the organoleptic properties of the biscuits.

Materials and Methods: The quantitative study used a pre-experimental design with 40 Culinary Arts students, selected by convenience. Those with altered sensory perception were excluded. Data were collected using a 12-question questionnaire per variable. Responses were measured on a Likert scale from 1 to 5. The objective was to empirically verify hypotheses.

Results: The "Organoleptic Properties" variable showed a statistically significant difference (p = 0,029) when potato peel flour was incorporated, so the null hypothesis was rejected. This result was obtained using the Wilcoxon test, applied to compare sensory perceptions before and after the modification. Its three dimensions were also significant: Sensory Profile (p = 0,042), Product Modification (p = 0,039), and Sensory Comparison (p = 0,022).

Discussion: The analysis confirmed that the addition of potato peel flour to the recipe significantly altered the organoleptic properties of the cookies, significantly altering their sensory profile and supporting the alternative hypothesis.

Conclusion: The use of potato peel flour significantly influences the organoleptic properties of the biscuits, with good consumer acceptance and improvements in flavor and appearance, suggesting potential interest in this enriched product.

KEYWORDS

Sensory acceptance, food, food innovation, functional ingredients, sensory perception.

INTRODUCTION

In the typical diet of both humans and animals, cereal crops play a key nutritional role. These crops are frequently processed into flour to produce food by-products. Wheat products, in particular, have been a fundamental part of the human diet for centuries. In baking, wheat flour is especially important due to its ability to form quality gluten, which improves the structure of baked goods[1].

One of the most essential ingredients in both baking and pastry is wheat flour. However, the culinary industry constantly seeks innovative and nutritious alternatives, not only to enhance nutritional value but also to influence the texture and sensory qualities. For example, legume-based flours provide fiber, protein and a greater variety of flavors and textures.

Wheat flour, derived from the wheat plant (Triticum aestivum L.), has a global annual consumption of approximately 791.2 million tons. This flour is known for its strong gluten forming capacity, which is why it is commonly used in many food products[3]. Starch, proteins and lipids are amongst the main components of wheat flour, and any alteration in these can significantly affect the final product[4].

In the baking and pastry industry, wheat flour is a widely used ingredient; however, its low dietary fiber and micronutrient content, along with the presence of gluten, limits its nutritional value and may cause adverse effects in sensitive populations. This has driven the search for alternative raw materials for the production of gluten-free products[5]. Never-

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theless, various studies indicate that many gluten-free products present nutritional deficiencies, especially in micronutrients, compared to their traditional counterparts[6].

Potato processing industries generate large quantities of peels that are often disposed of in landfills, causing environmental damage[7]. Although biodegradable and rich in fermentable carbohydrates, they are still considered waste despite the global increase in potato production[8]. Approximately 50 kg of potato peels are produced for every ton of potatoes harvested annually[9].

That is why using potato peel as an additive in functional or fortified foods offers nutritional benefits, mainly due to their high content of phenolic compounds, over 50% of which are found in the peel and surroundings layers[10].

Peru produces around 4.7 million tons of potatoes annually and is the leading producer in Latin America, ranking 14th worldwide[11]. Potatoes are a staple in Peruvian's daily diet. Additionally, the country holds the greatest diversity of wild potato species, cultivated at elevations between 2000 and 4000 meters above sea level, in mountainous regions rich in biodiversity[12].

Therefore, the research problem is posed as follows: How does the use of potato peel flour affect the organoleptic effects of cookies? In this sense,this study aims to explore how the sensory profile is affected when incorporating this flour in the production of cookies, how it influences product modification, and what impact it has compared to a conventional cookie.

A study conducted in Bangladesh found that dehydration methods (cabinet drying and sun drying) significantly influence the physicochemical, antioxidant and functional properties of flour made from potato peel, affecting its quality in cake production[13]. Likewise, other studies showed that samples with potato peel flour had higher nutritional content (more protein and calories) compared to those made with mango peel, however, they received a lower acceptance from consumers[14]. Additionally, the use of potato was analyzed in the preparation of quinoa flatbreads, showing potential for reducing acrylamide, a potentially harmful compound formed during the cooking of cereals[15]. It was also found that potato peel flour was the most favorable in terms of both sensory and nutritional acceptance. Fiber levels increased, and the lipid absorption was reduced[16,17].

From a theoretical perspective, the organoleptic properties of food are commonly evaluated to assess and improve product quality and consumer acceptance. Because of this, the use of thresholds is effective in modifying food perception and enhancing its overall quality[18,19].

Appearance is the primary factor influencing food choice, so manufacturers strive to make it appealing through eye-catching colors and presentations[20]. Aroma is also key, as volatile compounds interact with olfactory receptors and anticipate characteristics such as flavor and texture. Flavor depends on the interaction between food compounds and taste receptors that detect basic tastes. Finally, texture, perceived by touch, includes properties such as softness or hardness and affects both preference and the amount consumed[21].

In terms of taste, the experience depends on the interaction between the compounds present in the food and the taste receptors, which recognize basic flavors such as sweet, sour, salty, bitter and umami, sending this information to the brain for interpretation. Finally, texture, perceived through touch, includes characteristics such as softness, hardness and thickness, which influence the preference and amount consumed. Research has shown that foods with firmer textures and larger dimensions tend to produce greater satiety, while foods with softer or blander textures tend to have the opposite effect[20].

Likewise, thresholds are units of measurement used to evaluate the sensory magnitude produced by a stimulus. Through these thresholds it is possible to evaluate how people perceive the sensory changes in food, helping to better understand reactions during tasting. The detection threshold represents the minimum point at which a sensory stimulus becomes perceptible to a person. This threshold marks the first conscious perception of food through any of the senses: sight, hearing, smell, taste or touch[21].

On the other hand, the recognition threshold refers to the specific moment at which a stimulus becomes not only detectable, but also identifiable by the individual. Unlike the detection threshold, here the stimulus can already be clearly recognized as a particular taste, smell, color, texture or other sensory attribute of the product. Finally, the differential threshold determines the smallest perceptible difference between two similar stimuli. This concept is key in sensory analysis, as it allows the identification of subtle variations in the properties of a product, such as changes in taste, color intensity or texture[22].

Also, ISO Standard N.° 13299 establishes standardized procedures for identifying and describing the sensory characteristics of a product, that is, its organoleptic properties[23]. This evaluation is based on sensory perception through taste, sight, hearing, touch and smell, allowing for a detailed analysis of how a product is experienced by consumers.

This standard outlines the methodology for conducting sensory analysis aimed at evaluating the organoleptic properties of a product. The sensory profile refers to the set of data obtained during this evaluation, which accurately describes the perceptions reported by evaluators[24].

Potato peel flour improves the nutritional value of baked goods by providing more protein, fiber, minerals, and antioxidants, as well as enhancing water and oil absorption, resulting in fluffier doughs with greater volume[25].

Its production process includes: selection, washing, steam peeling, blanching at 82°C for 2 minutes, drying (peel at 40°C for 24 hours or 60°C for 4–8 hours; pulp at 40°C for 48 hours), milling, and sifting to obtain a fine powder[26,27].

In baking, cookies made with mixtures of wheat flour and potato flour at 10%, 20%, and 30% show significant changes in their nutritional composition. Higher proportions of root or potato flour increase moisture and carbohydrate content, while decreasing protein, fat, gluten, and crude fiber[28].

On the other hand, the use of compound flours has proven to be beneficial, as it allows the development of breads with a higher protein and dietary fiber content, as well as antioxidant properties. These mixtures not only improve the functional and physical properties of doughs (such as water absorption), but also maintain good sensory acceptability, without negatively affecting taste or texture. This makes potato-based flours a viable option for creating more nutritious and sustainable breads, contributing to innovation in the food industry[29].

The general objective of this research is to idetermine the effect of using potato peel flour on the organoleptic properties of cookies. To achieve this, it is proposed to analyze its influence on the sensory profile of the product, observe changes in its physical characteristics, and compare the cookies made with this flour to a conventional sample in terms of sensory perception.

MATERIALS AND METHODS

The research followed a quantitative approach and was analyzed empirically, allowing conclusions to be drawn. In addition, the studies were oriented towards the verification of hypotheses[30]. An applied-level study with a pre-experimental design was implemented; this type of design was chosen because it involves observing, measuring and experimenting with the reality that the study aimed to understand[31].

The study population consisted of students in the Culinary Arts program. Non-probability convenience sampling was used, selecting available individuals. A total of 40 participants took part in the study. The inclusion criterion was for adults, and the exclusion criterion was for those who had recently consumed foods or beverages with strong flavors (e.g., mint or coffee) or those with temporary health conditions, such as colds or any other illness that affected sensory perception.

The survey technique was used to collect data and obtain evidence on the specific topic. The instrument used was a polytomous questionnaire, which included three or more response options. Each questionnaire consisted of 12 questions per study variable. Respondents were asked to complete the questionnaires using a five point Likert scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree").

The instrument's validity was assessed using a content-based validation approach by a panel of experts and reliability assessment[32]. Once the population was identified according to established criteria, participants were invited to complete the surveys. A descriptive analysis was performed to examine the sample characteristics, and an inferential analysis comparing two related measurements between the variables was applied. The results are presented in tables, highlighting significant correlations and discussing their implications for the use of potato peel flour and its effects on organoleptic properties.

The study did not require formal approval from an institutional ethics committee; however, it adhered to the ethical principles set out in the Declaration of Helsinki. Participants were informed of the research objectives before completing the questionnaire and, through informed consent, agreed to participate voluntarily, without any risk.

RESULTS

Cookies made with potato peel flour were developed to promote the efficient use of potato waste, due to its high nutritional value.

For the production of potato peel flour, the potatoes were first selected, and thoroughly washed to ensure no soil residues remained, as the peels were intended for consumption and had to be safe. Then they were dried to remove moisture and peeled, reserving the peels. A silicone sheet was placed on a tray and a uniform layer of peels was arranged. These were then baked at 80° C for 6 hours, until they were completely dry and brittle. Once dried, they were ground in a food processor until a fine powder was obtained. The flour was then sifted to remove large residues, ensuring a uniform, fine flour.

For the cookies, 40% of the flour used was potato peel flour, and the remaining 60% was wheat flour. This proportion was chosen after preliminary tests determined it to be the most suitable to maintain good texture, color and flavor. The ingredients for this recipe included butter, brown sugar, white sugar, eggs, baking powder, cinnamon, salt, and chocolate chips. All ingredients were mixed and the dough was allowed to rest in the fridge for 30 minutes. After resting, the dough was portioned into 60g balls, then baked at 180°C for 12 minutes. Finally, the cookies were left to cool before evaluation.

In addition to the sensory evaluation, the basic nutritional value of the cookie made with potato peel flour was determined. For a 75 g serving, the product provides 279 kcal, 5.6 g of protein, 11.5 g of total fat, 39.4 of carbohydrates, and 4.2 g of dietary fiber. These values allow for estimating the product's contribution within a regular diet and demonstrate that the incorporation of potato peel flour provides an

important amount of fiber which enhances the functional profile of the cookies.

Table 1 y figure 1, of the total number of respondents, 23 participants selected "I agree" in the pre-test for Variable 1, while another 23 participants selected "Strongly agree" in the post-test, indicating that the organoleptic properties changed according to Variable 1. Likewise, 24 participants selected "Strongly agree" in the pre-test for Variable 2, while 28 participants selected the same option in the post-test, indicating that potato peel flour enhances the cookie's sensory attributes.

Inferential Analysis

In Table 2, since the sample included fewer than 50 respondents, the Shapiro-Wilk normality test was applied. For Variable 1 ("Organoleptic Properties"), the test yielded a Sig.= ,001 and for variable 2 (Potato Peel Flour"), a Sig.= ,131 was obtained. Therefore, the alternative hypothesis (Ha), which states that the data does not have a normal distribution, is accepted. As a result, non-parametric tests, specifically the Wilcoxon test, were used for further analysis.

Table 1. Frequency of study variables

	Organoleptic properties		Potato peel flour	
	pre test	post test	pre test	post test
	f	*f*	*f*	*f*
Neither agree nor disagree	1	1	0	0
I agree	23	16	16	12
Strongly agree	16	23	24	28
Total	40	40	40	40

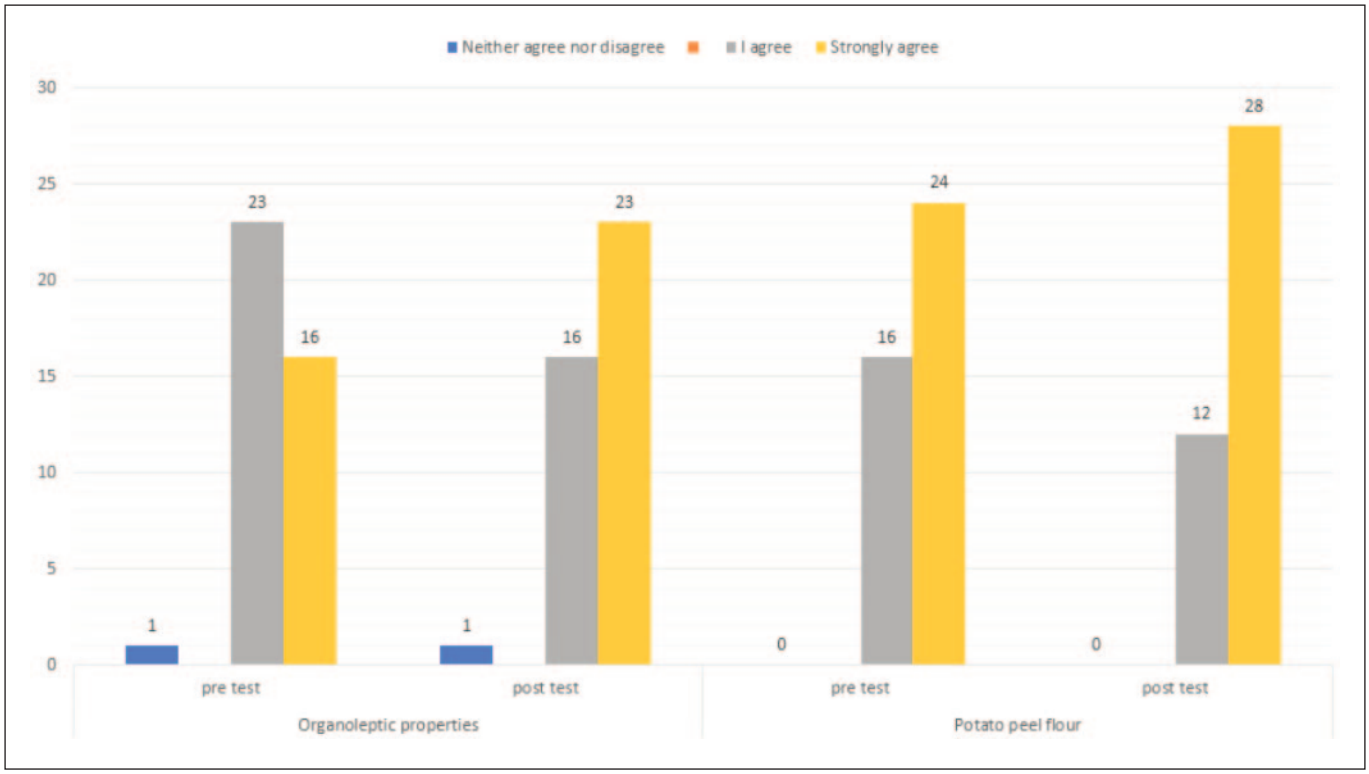

Figure 1. Comparison of pre-test and post-test organoleptic properties of potato peel flour

Table 2. Normality test for a sample

Normality Tests			
	Statistical	**gl.**	**Sig.**
Organoleptic properties	0,893	40	0,001
Potato peel flour	0,957	40	0,131
Sensory profile	0,889	40	0,001
Product Modification	0,884	40	0,001
Sensory Comparison	0,9	40	0,002

SPSS Database.

Hypothesis testing

General hypothesis

-Ho (null hypothesis): There is no difference in organoleptic properties when using potato peel flour in cookies.

-Ha (alternative hypothesis): There is a difference in organoleptic properties when using potato peel flour in cookies.

In Table 3, since the significance value of the variable "Organoleptic Properties" was 0,029, which is less than 0,05, the null hypothesis is rejected and the alternative hypothesis is accepted. This indicates that there is a statistically significant difference in the organoleptic properties of cookies when using potato peel flour.

Table 3. Level of significance of the variable "organoleptic properties"

Test Statisticians	
Organoleptic properties	
Z	-2,179b
Asymp. Sig. (bilateral)	0,029

SPSS Database.

In Table 4, for the Sensory Profile dimension, the significance level was 0,042, which is less than 0,05. This indicates a significant difference in the sensory profile of the product after the addition of potato peel flour. Considering that the organoleptic properties of the product changed, the overall sensory profile was also affected, as participant's perception differed compared to the conventional cookies.

On the other hand, regarding the second dimension "Product modification", the significance value was 0.039,

Table 4. Level of significance of the three dimensions

Test Statisticians			
	Sensory profile	**Product Modification**	**Sensory Comparison**
Z	-.497b	-2,059c	-2,292c
Asymp. Sig. (bilateral)	0,042	0,039	0,022

SPSS Database.

which is lower than 0.05. Therefore, there is a significant difference in this dimension, suggesting that the addition of potato peel flour produces noticeable modifications in the product's characteristics, related to the first dimension of the sensory profile.

Finally, regarding the "Sensory Comparison dimension, the significance value was also less than 0,05, at 0,022. The addition of potato peel flour affected how it was perceived sensorily before and after modification, indicating that respondents perceived a noticeable difference between the two cookies.

DISCUSSION

According to the general hypothesis, the results obtained from the statistical analysis indicated that the incorporation of potato peel flour had a significant effect on the organoleptic properties of the cookies, with a significance level of less than 0,05 (sig=0,029). These findings led to the rejection of the null hypothesis and the acceptance of the previously stated alternative hypothesis. It can be concluded that the modification of the recipe through the use of potato peel flour caused perceptible changes in the product, significantly altering its sensory profile.

Previous studies reported positive effects from the use of potato peel flour in flatbreads, as it reduced acrylamide levels (potentially harmful compounds in high-carbohydrate foods) without changing the sensory acceptability of the bread. However, in a study carried out in the United States, although acrylamide levels were not evaluated, it was suggested that the use of potato peel flour instead of wheat flour could increase the acrylamide formation in products, given its high carbohydrate content. Nevertheless, it is considered a viable ingredient to enhance the nutritional value of some products such as cookies[15].

ISO Standard N° 13299 establishes guidelines for compliance with sensory evaluation methods in products and evaluates the organoleptic characteristics of food products[23]. The use of this standard helps to analyze more deeply and in detail the sensory perception of food, which was necessary for evaluating the respondent's perceptions of cookies made with

potato peel flour. Analyzing the dimensions of the sensory profile, product modification and sensory comparison under this concept, shows that the use of this flour aligned with the sensory standards perceived by the respondents.

According to the first specific hypothesis, the results showed a significant difference, with a significance level of 0,042, less than 0,05. This indicates that the sensory profile was affected when making the change from wheat flour to potato peel flour. The sensory evaluation of the respondents was positively affected, the cookies exhibited a more golden color, a more pleasant aroma, a more intense flavor and a more attractive texture compared to cookies made with only wheat flour.

In research related to the use of Chinese potato peel flour and soy flour in cookies to reduce gluten, the authors reported that the sensory profile of these cookies was positively affected, highlighting their color, flavor and crunchiness. This background is consistent with the results of the study, as color and were also aspects highly valued by the evaluators. These changes in the sensory profile of the cookies highlight their potential to improve presentation, which is a very important factor in the perception of product quality[18].

On the other hand, the use of different vegetable by-products in breads has been studied to achieve gluten-free bread formulations. Among these, potato peel flour stood out; when using 5% of this flour into the bread, it showed a positive sensory acceptance as well as a good nutritional balance[33]. These findings are consistent with our study, since it was found that the profile of our cookies was also enriched with the addition of this flour, making it a product with potential for commercialization as a healthier alternative to conventional options.

By utilizing a potato by-product such as the peel, and converting it into flour for the development of new products, both the sensory and nutritional profile of foods can be enhanced. The law N° 30988 becomes highly relevant, as it promotes the reduction and prevention of food losses and waste throughout all stages of the food chain, seeking to maximize the use of residual materials[34]. The modification of products through the incorporation of these by-products not only improves their sensory and nutritional value, as observed in our cookies, but also contributes to a more sustainable and responsible use of food sources.

According to the second specific hypothesis, the results showed a significant difference, with a significance level of 0,039, which is lower than 0,05. This indicates that the modification of the product was significant when incorporating the potato peel flour. The respondents perception of the product was positively impacted, as they reported that the addition of potato peel flour provided a more pleasant and attractive flavor, something they had not experienced before.

Likewise, the concept of the differential threshold, derived from sensory analysis, allows comparisons between products and indicates which are better accepted by consumers. This tool enables the food industry to more accurately evaluate consumer preferences and select the most appropriate formulations. Therefore, when comparing wheat flour cookies with those containing potato peel flour, the results demonstrated greater acceptance of the latter among respondents[35].

According to ISO Standard N° 13299, which establishes guidelines for evaluating the sensory profile of a product based on consumer acceptance, it is essential to carry out comparative studies to determine which product is more attractive to consumers[24]. Once the organoleptic characteristics of a product are approved, they are then applied, as in our case, where we compared two types of cookies: one made with 100% wheat flour and the other with 40% potato peel flour, as they better met the desired sensory profile.

In relation to the third specific hypothesis, the results showed a significant difference, with a significance level of 0,002, which is less than 0,05. This demonstrates that the sensory comparison was affected by the use of potato peel flour. The sensory evaluation by respondents was positively influenced, as they noted that the flavor provided by the potato peel flour was new and more appealing to the palate when compared to conventional wheat flour.

In addition, research on how sensory perception influences food intake has shown that sight, smell, and taste are crucial in the selection of food products[20]. This confirms what was observed in our study: sensory comparison plays a key role in choosing the preferred product, especially in terms of appearance and flavor, where respondents favored the cookies made with potato peel flour[36]. Likewise, other studies evaluated the nutritional and sensory quality of cookies made with wheat flour supplemented with 10%, 20%, and 30% potato peel flour. They found that cookies with added potato peel flour had a better sensory acceptance than conventional ones, as the flavor was more pleasant to the consumer's plate[28]. These results align with our findings, demonstrating that adding potato-based flour enhances the sensory characteristics of baked goods.

By taking advantage of as much food as possible, in this case potato peels, we not only use food in a more responsible way, but we also add greater nutritional value to our meals[37]. Which is why Law N°. 30988 stands out, since its main focus is the responsible use of food products. By using potato peels, which are products that are usually not used, emphasis is placed on maximizing their use in the best way, in this case, by making potato peel flour[38].

The implications of the study show that this research contributes to expanding the existing knowledge on the use of agro-industrial by-products, specifically potato peels, in the production of bakery products. As this is a topic with limited

information, the findings offer an initial basis for future research aimed at the recovery of food waste. Finally, from a practical perspective, the results show the potential of potato peels as a functional input in the food industry, particularly in baked goods.

LIMITATIONS OF THE STUDY

During the development of this study, some limitations were identified, the most relevant being the difficulty in accessing national scientific information specifically related to the use of potato peel flour. The scarcity of previous research in this area limited the depth of the theoretical framework and made it difficult to compare it with similar studies conducted in the Peruvian context. Likewise, the pre-experimental design used did not include a control group with the same external validation conditions, which restricts the generalization of the results obtained.

CONCLUSIONS

The use of potato peel flour significantly influences the organoleptic properties of cookies. The evaluators showed good acceptance, highlighting improvements in taste and appearance, which suggests a potential interest in consuming this enriched product. Regarding the sensory profile, a slight change was observed: the cookies displayed a subtle sweetness, darker color, balanced texture between soft and crunchy, and a more attractive aroma, which resulted in a positive perception by the participants. As for the modification of the product, potato peel flour provided nutritional benefits, increasing fiber and vitamins, in addition to improving the overall flavor of the cookie. Finally, in the sensory comparison, cookies with potato peel flour showed notable differences compared to traditional ones, with a more intense golden color, a grainier texture, slightly spicier and smoked flavor and more striking aroma, characteristics that made them more attractive to consumers.

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