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(RESEARCH ARTICLE)

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Sensory evaluation of pumpkin flour-wheat flour composite cookies: Exploring nutritional enrichment and consumer acceptance

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Abstract

The study comprehensively evaluated the consumer acceptability and sensory characteristics of cookies made from varying ratios of pumpkin flour and wheat flour. The researchers incorporated pumpkin flour at four different levels - 0%, 40%, 50%, and 80% - into the cookie formulations. To assess the sensory profile of these cookie samples, the researchers conducted a thorough evaluation using a 7-point hedonic scale. This scale allowed panelists to rate their level of liking or disliking for key sensory attributes, including color, aroma, taste, aftertaste, and texture. The results of this sensory analysis revealed some interesting trends. As the substitution level of pumpkin flour increased, there was a significant decrease in consumer preference for the color, aroma, and taste of the cookies. However, an intriguing finding was that the aftertaste was actually improved with higher pumpkin flour content. Notably, the cookies made with a 50% pumpkin flour to 50% wheat flour ratio were most preferred by panelists in terms of texture. This suggests that a balanced approach to the flour blend, incorporating a considerable amount of pumpkin flour, can produce cookies with an acceptable and even desirable textural profile. The study demonstrates the potential of pumpkin flour as a nutritious ingredient that can be incorporated into cookie production. The nutritional benefits of pumpkin flour, such as its high content of beta-carotene, fiber, and other vitamins and minerals, make it an attractive alternative to traditional wheat flour. However, the researchers caution that higher substitution levels of pumpkin flour, beyond the 50% ratio, may require further optimization to enhance the overall sensory acceptance of the cookies. Finding the right balance between nutritional enhancement and maintaining desirable sensory attributes will be crucial for the successful development of pumpkin flour-based cookies that appeal to health-conscious consumers.

Keywords: Pumpkin flour; Wheat flour; Cookie; Sensory evaluation; Nutritional quality

1. Introduction

Cookies are a widely consumed baked food that are often enjoyed with beverages and used as weaning foods for infants (Ferial & Azza, 2011). While traditional cookies are made primarily with wheat flour, fat, sugar, and other minor components, there is a growing demand for more nutritious and diversified cookie options (Akinwande et al., 2008). In recent years, consumer preferences have shifted significantly, with people seeking foods that not only satisfy hunger and provide nutrients, but also offer health benefits and contribute to disease prevention (Singh et al., 2023; Hwang et al., 2022). Pumpkin, a nutrient-dense non-wheat flour, has the potential to meet these evolving consumer needs.

Pumpkin is a highly productive, nutritious, and readily available vegetable that belongs to the Cucurbitaceae family (Bhat & Bhat, 2022). It is rich in beta-carotene, a precursor to vitamin A, which has been shown to help prevent a variety of health issues, including eye disorders, cancer, and skin problems (Bhat & Bhat, 2022). However, fresh pumpkin is

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highly perishable and susceptible to microbial deterioration, leading to significant post-harvest losses (Sharma et al., 2022).

Incorporating pumpkin flour into cookie production could not only improve the nutritional profile of these baked goods but also provide a viable solution to the problem of post-harvest losses (Iyagba, 2015). Moreover, the increasing cost of wheat flour, a key ingredient in traditional cookies and pastries, has made it necessary to explore alternative flour sources that can be used to supplement or replace wheat (Amal et al., 2023). The findings of this research could have significant implications for the food industry, public health, and food security. The specific objectives of this study were to evaluate the consumer acceptability and sensory characteristics (color, aroma, taste, aftertaste, texture) of cookies made from different ratios of pumpkin flour and wheat flour.

2. Materials and Methods

2.1. Raw Materials

For the study, a 20-kilogram pumpkin was utilized. In addition to the pumpkin, vital ingredients for making cookies such as wheat flour, sugar, salt, baking powder, eggs, and margarine were included. The solar drying of the pumpkins took place within the laboratory of the Food Engineering Department at the University of Ghana, while the experimental tests were conducted at the Food Technology Department laboratory at Kwame Nkrumah University of Science and Technology, Ghana.

2.2. Pumpkin flour preparation

In order to eliminate soil, rot, and insect damage from fresh unripe pumpkins, the pumpkins underwent a process of washing, peeling and cutting. The pumpkin was then sliced into 1.5cm chunks and arranged on trays for sun drying, which lasted for a period of 72 hours using solar panels. Once dried, the samples were ground into flour using a laboratory grinder. The resulting flour was subsequently sealed in a plastic bag and stored at room temperature until it was required for use.

2.3. Wheat-Pumpkin Cookie Preparation

Table 1 Ingredient Formulations for Pumpkin-Wheat Composite Cookie Preparations

Ingredients		**Amount added per(g)**		
	PWC10	**PWC11**	**PWC12**	**PWC13**
Wheat flour	100	60	50	20
Pumpkin flour	0	40	50	80
Powdered sugar	15	15	15	15
Margarine	50	50	50	50
Baking powder	1 tsp	1 tsp	1 tsp	1 tsp
Salt	0.5	0.5	0.5	0.5
Egg	40 ml	40 ml	40 ml	40 ml
Milk	30 ml	30 ml	30 ml	30 ml

Legend: *PWC10=Control(100%WF) *PWC11=(40%PF: 60% WF) * PWC12= (50% PF : 50% WF) *PWC13= (80% PF : 20% WF); Fieldwork, 2023

The researchers prepared the wheat-pumpkin flour composites in various ratios, including 100:0, 60:40, 50:50, and 20:80. The other ingredients were weighed precisely according to the formulations, as shown in Table 1. To make the cookie dough, the researchers first sifted the flour, salt, and sugar together. They then rubbed in the margarine using their fingertips until the mixture resembled breadcrumbs. This step ensured the fat was well incorporated, preventing any lumps of margarine in the dough. By coating the flour with fat before adding the liquid ingredients, the researchers were able to limit gluten development. Next, they mix in the baking powder.

The researchers then whipped the eggs and added the milk to the flour mixture. The dough was carefully kneaded until it became smooth. Using a rolling pin, the dough was removed from the bowl and flattened. Circular cookie shapes were

cut out of the dough using a round cutter. The cookies were baked for 20 minutes at 160°C in an oven. After baking, the cookies were allowed to cool completely for 10 minutes before being wrapped for further analysis. The samples were labeled according to their flour composition. PWC 10 represents the cookies made entirely from wheat flour, PWC 11 represents the cookies made with 60% wheat and 40% pumpkin flour, PWC 12 represents the cookies made with 50% wheat and 50% pumpkin flour, and PWC 13 represents the cookies made with 20% wheat and 80% pumpkin flour.

2.4. Sensory Evaluation

After the completion of cookie preparation, a sensory evaluation was conducted by a panel of sensory experts. The evaluation utilized a 7-point hedonic scale, which consisted of the following parameters: 7 = strongly liked, 6 = moderately liked, 5 = slightly liked, 4 = indifferent, 3 = slightly disliked, 2 = moderately disliked, and 1 = strongly disliked. The purpose of employing the hedonic scale was to identify the most favorable sample for the study. To ensure objectivity, the panelists were provided with water to act as a palate cleanser between sample tastings. The cookies were presented on disposable plates and tissues that were devoid of any odors that could potentially influence the results.

2.5. Data Analysis

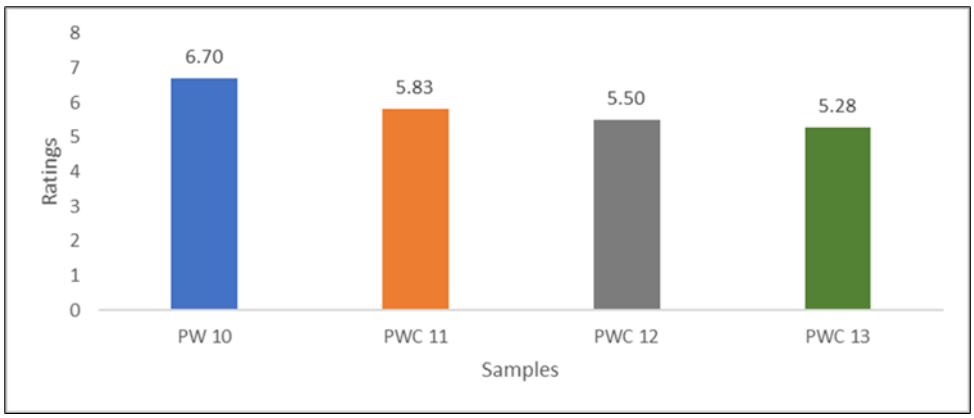
The data collected by the panelists underwent thorough analysis and processing to extract meaningful conclusions from the raw data. Both descriptive and inferential statistics were employed to analyze the results, utilizing SPSS version 26 software. The analysis was carefully conducted with the aim of addressing the research questions and facilitating the identification of potential solutions.

3. Results and Discussion

3.1. Sensory Characteristics of Pumpkin Flour Cookies

3.1.1. Color

Figure 1 illustrates the results of the panelists' affective color test. The samples were evaluated using a seven-point hedonic scale. The survey indicated that a significant number of panelists expressed a strong preference for sample PWC10. Following that, samples PWC11, PWC12, and PWC13 were ranked in descending order of preference. Notably, as the amount of pumpkin flour was reduced, there was a significant improvement in the color of the products. The analysis also revealed a strong negative correlation between higher levels of pumpkin replacement and decreased preference ($p < 0.05$).



(Legend: *PWC10=Control(100%WF) *PWC11=(40%PF: 60% WF) * PWC12= (50% PF : 50% WF) *PWC13= (80% PF : 20% WF)

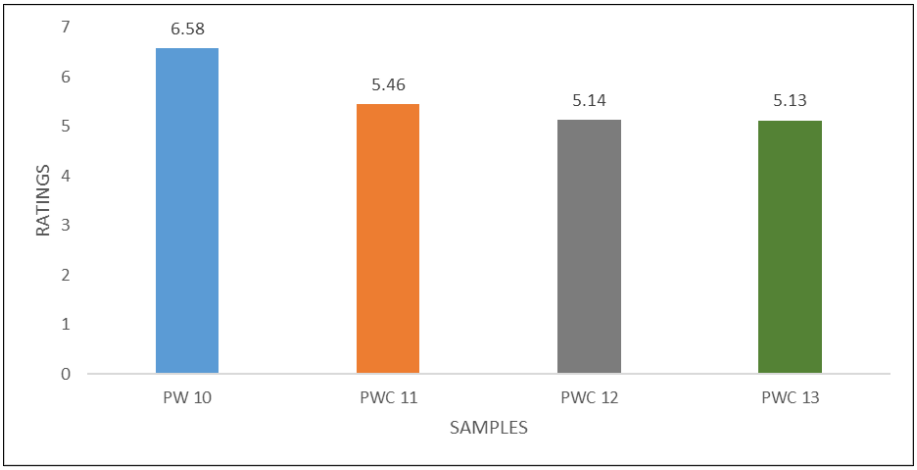
Figure 1 Affective test score for colour. Fieldwork, 2023

The findings of this study align with previous research that emphasizes the importance of color as a key quality attribute in baked goods like cookies. For instance, Chakraborty et al. (2021) highlighted color as a crucial factor influencing consumer acceptance of cookies incorporated with underutilized flours. Similarly, Gulria et al. (2022) observed that incorporating chickpea flour in biscuits led to increased acceptance of their color by a sensory panel. Akhtar et al. (2023) also reported that breads fortified with 10% chickpea flour scored higher in terms of color compared to control breads. Raghavendra et al. (2022) found that wheat bread supplemented with varying ratios of chickpea flour exhibited increased color scores up to 15% substitution level, but a 20% replacement ratio led to a decline in color acceptance.

The color of cookies plays a significant role in their overall appeal. During baking, the Maillard reaction occurs, contributing to the development of color in cookies. Muttamilselvi et al. (2023) observed that an increase in the concentration of composite flours resulted in a more desirable appearance of cookies in terms of color and texture. In this study, the product with the highest level of wheat flour replacement scored the lowest for color, which can be attributed to the lower proportion of wheat flour in the composite. Additionally, the heating process during baking alters the color of the cookie's surface through browning reactions. It is worth noting that wheat flour aids in achieving an appealing color in baked goods due to its unique chemical composition (Sharma & Singh, 2022)

3.1.2. Aroma

The aroma ratings for the samples are depicted in Figure 2. The study findings indicate a general decrease in preference for scent as the proportion of pumpkin flour increased. Among the samples, PWC 11 received the highest aroma rating, followed by PWC 12, and PWC 13 was rated the lowest in terms of aroma preference. Aroma perception is a chemical sensation that occurs when the taste receptors on the tongue interact with taste stimuli. Each taste can be discerned at different intensity levels, ranging from 20 to 30 levels. Various factors such as age, smoking, product viscosity, taste disorders (hypogeusia, ageusia, dysgeusia), and temperature can influence taste sensitivity (Lima et al., 2015).



(Legend: *PWC10=Control(100%WF) *PWC11=(40%PF: 60% WF) * PWC12= (50% PF : 50% WF) *PWC13= (80% PF : 20% WF)

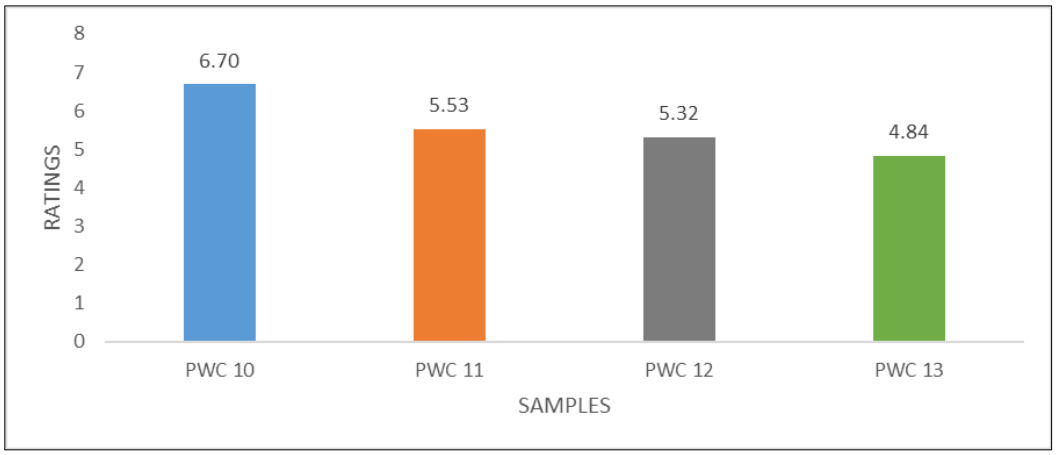
Figure 2 Affective test score for aroma. Fieldwork, 2023

3.1.3. Taste

Figure 3 illustrates the results of the affective test ratings for the investigated samples. The taste of pumpkin flour was strongly disliked by the panelists in the study. As the levels of pumpkin flour substitution increased, the taste ratings decreased. Among the samples, PWC 10 received the highest taste score, followed by PWC 11, PWC 12, and PWC 13. There was a significant difference between the products at a 95% confidence level. Taste perception is influenced by the interaction between taste stimuli and taste receptors on the tongue, enabling humans to differentiate between basic tastes like sweet, sour, bitter, umami, and salty (Kawai et al., 2022).

Incorporating alternative flours can impact taste acceptability of baked products. For instance, Nair et al. (2023) found that incorporating coconut flour up to 20% in cakes enhanced sensory attributes like taste and texture, while higher levels (30%) adversely affected taste scores. Similarly, Rajan et al. (2022) reported that replacing wheat flour with more than 30% coconut flour in biscuits led to decreased taste acceptability due to the strong coconut flavor.

The bitter, beany flavor imparted by chickpea flour has been reported to negatively influence taste ratings in baked goods. Gupta et al. (2022) observed that pita breads with chickpea flour scored lower on taste compared to control breads. Rani et al. (2021) also noted that fortifying bread with over 10% chickpea flour resulted in decreased taste scores versus control bread. Singh et al. (2020) enriched bread rolls with 10-20% chickpea flour and found the taste to be poorer than control samples, suggesting the use of flavor masking agents. Chandra et al. (2023) investigated wheat-chickpea flour blends and reported declining taste scores with increasing chickpea flour ratio due to the distinct beany flavor. These studies align with the current findings on lower taste acceptability with higher pumpkin flour incorporation levels.



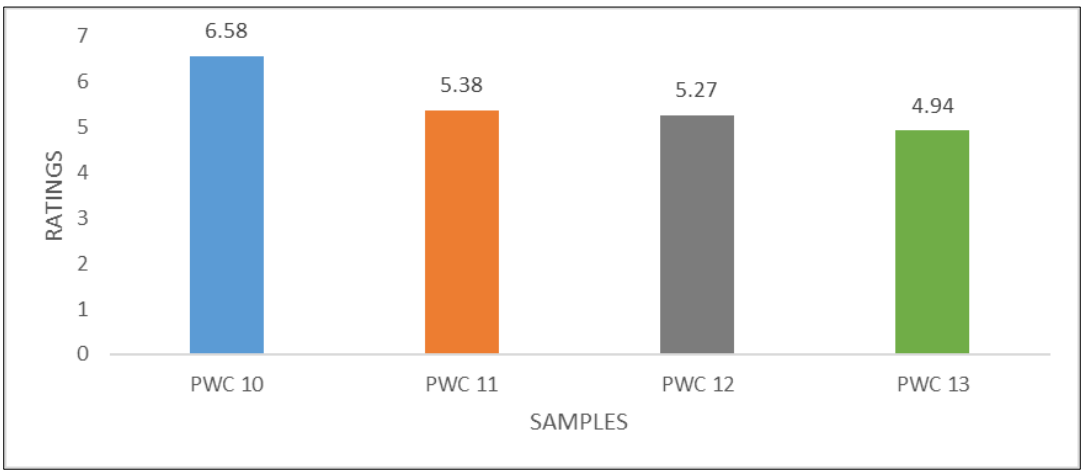
Legend: *PWC10=Control(100%WF) *PWC11= (40%PF: 60% WF) * PWC12= (50% PF: 50% WF) *PWC13= (80% PF: 20% WF)

Figure 3 Affective score for Taste. Fieldwork, 2023

3.1.4. Aftertaste

Figure 4 presents the results of the affective test ratings for aftertaste of the studied samples. Interestingly, the substitution of pumpkin flour led to a significant improvement in aftertaste scores. PWC 10 exhibited the least pronounced aftertaste, followed by PWC 11, PWC 12, and PWC 13 in ascending order. These findings contradict some previous studies which reported that lower levels of non-wheat flour substitution were preferred by consumers due to the more familiar wheat-based flavor profile (Sanz-Penella et al., 2013). Aftertaste refers to the lingering taste sensation experienced after consuming a product. The panelists' comments and perceptions of aftertaste were assessed and recorded in this study, as depicted in Figure 4.

Incorporating nutrient-dense ingredients like pumpkin flour can help improve the nutritional value of baked snacks like cookies, which are often criticized for their high content of refined carbohydrates, fats, and lack of fiber and protein (Kaur et al., 2023). Pumpkin is a good source of carotenoids, vitamins, and minerals (Sharma et al., 2021), which could contribute to a more appealing lingering flavor when used in baked goods. However, aftertaste perception can be influenced by various factors like individual taste preferences, product formulation, and baking conditions (Pathare et al., 2023).



Legend: *PWC10=Control(100%WF) *PWC11=(40%PF: 60% WF) * PWC12= (50% PF : 50% WF) *PWC13= (80% PF : 20% WF)

Figure 4 Affective Test Score for Aftertaste. Fieldwork, 2023

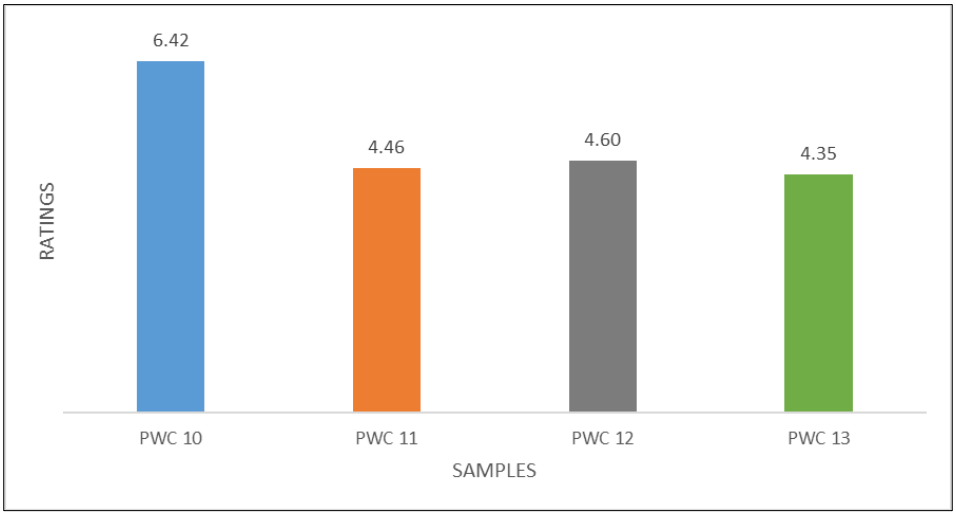
These recent findings highlight the potential of using pumpkin flour as a value-added ingredient to enhance the aftertaste profile of cookies and other baked snacks, contrary to the assumption that higher levels of wheat flour are always preferred for a familiar taste. Further research is needed to optimize formulations and processing conditions to develop nutritionally-enriched baked products with desirable sensory attributes like aftertaste.

3.1.5. Texture

Figure 5 displays the affective test ratings for texture of the studied samples. The ratings ranged from dislike to like. Among the pumpkin samples, PWC 12 was found to have the most preferred texture, followed by PWC 11 and PWC 13, though there was no significant difference between the latter two ($p < 0.05$). These findings align with recent studies reporting that increasing levels of non-wheat flours can impact the texture and physical characteristics of baked products (Garg et al., 2023; Kaur et al., 2022). The type of flour used influences not just the nutritional composition but also attributes like texture, spread ratio and color of the final product.

Incorporating vegetable-based ingredients like pumpkin can improve the texture acceptability of baked goods. Balaswamy et al. (2022) found that breads with 10-25% pumpkin additives were preferred over wheat-only breads in terms of texture and overall acceptability. However, exceeding 15% pumpkin negatively impacted acceptance, likely due to factors like appearance and flavor changes. Similarly, Kumar et al. (2021) reported that bread with 5-10% pumpkin flour exhibited improved texture and sensory scores compared to control.

These findings align with Chawla and Bhandari (2020), who observed that while pumpkin flour up to 10% enhanced bread quality attributes like texture and acceptability over wheat bread, higher levels led to decreased consumer acceptance. Introducing novel ingredients to staple foods requires adaptation from consumers, even if they offer nutritional benefits (Singh et al., 2019). The panelists in the current study moderately to strongly appreciated the products, preferring the bread with 10% pumpkin over others, similar to See et al. (2018) who found wheat-pumpkin flour breads had good sensory characteristics.



Legend: *PWC10=Control(100%WF) *PWC11=(40%PF: 60% WF) * PWC12= (50% PF : 50% WF) *PWC13= (80% PF : 20% WF)

Figure 5 Affective test for texture. Fieldwork, 2023

4. Conclusion

This study investigated the consumer acceptability and sensory characteristics of cookies formulated with different ratios of pumpkin flour and wheat flour. The findings revealed that as the substitution level of pumpkin flour increased, there was a significant decrease in consumer preference for color, aroma, and taste attributes of the cookies. However, the aftertaste scores improved with higher pumpkin flour incorporation. In terms of texture, the cookies with 50% pumpkin flour substitution (PWC12) were most preferred by the sensory panelists, suggesting an optimal ratio for achieving desirable textural qualities. The control sample made from 100% wheat flour (PWC10) scored highest for color, aroma, and taste, aligning with consumer familiarity and expectations for traditional wheat-based products.

The study highlights the feasibility of incorporating nutrient-rich pumpkin flour into cookie formulations to enhance their nutritional profile. However, higher substitution levels beyond 50% may require further optimization to improve sensory acceptance, particularly for attributes like color, aroma, and taste. Strategies such as flavor masking, incorporation of natural colorants, or combining pumpkin flour with other flour sources could be explored to develop more appealing pumpkin-enriched cookie products.

Overall, the findings demonstrate the potential of pumpkin flour as a value-added ingredient in baked goods like cookies, contributing to sustainable food production and addressing consumer demands for nutritious snacking options. Future research should focus on optimizing formulations, processing conditions, and sensory characteristics to develop highly acceptable pumpkin flour-based products suitable for commercialization.

Compliance with ethical standards

Disclosure of conflict of interest

The authors wish to confirm that there are no known conflicts of interest associated with this publication, and there has been no financial support for this work that could have influenced its outcome.

The study was conducted independently by the authors without any undue influence or competing interests from funders, institutions, companies, or other entities.

The authors have no financial or personal relationships with organizations or individuals that could potentially introduce bias or a conflict of interest regarding the results and findings presented in this manuscript. Furthermore, the authors confirm that the research was carried out objectively and ethically, adhering to the principles of scientific integrity and transparent reporting.

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