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Original Article

Development of Nutritious Biscuits for Gluten Intolerance Patients

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ABSTRACT

Background: The rising incidence of celiac disease and gluten intolerance has led to an increasing demand for gluten-free products. Tapioca and corn flour are promising alternatives to wheat flour due to their gluten-free nature and beneficial nutritional properties.

Objective: This study aimed to develop and evaluate the sensory characteristics of gluten-free biscuits made from tapioca and corn flour, individually and in combination, compared to a control sample made from wheat flour.

Methods: This study was conducted at the National Institute of Food Science and Technology, University of Agriculture Faisalabad. Ingredients such as wheat flour, corn flour, tapioca flour, sugar, butter, eggs, vanilla extract, baking powder, and salt were procured from the local market. Four samples were prepared: a control sample (T1) with wheat flour; T2 with corn flour; T3 with tapioca flour; and T4 with a blend of corn and tapioca flours. The specific quantities of ingredients were as follows: T1 (250g wheat flour), T2 (250g corn flour), T3 (250g tapioca flour), and T4 (125g corn flour + 125g tapioca flour). Biscuits were prepared by mixing dry ingredients, followed by liquid ingredients, to form a smooth dough, which was then shaped and baked at 180°C for 20-25 minutes.

Sensory evaluation involved consumer effective testing with 50 untrained panelists using a 9-point hedonic scale, and quantitative descriptive analysis (QDA) with 10 trained panelists using a 15-point scale. Data were analyzed using SPSS version 25 and Microsoft Excel for graphical representation. Ethical approval was obtained in accordance with the Helsinki Declaration, and informed consent was obtained from all participants.

Results: In the consumer effective test, the control sample (T1) received ratings of 7.89 for color, 7.10 for flavor, 7.85 for texture, 7.9 for aroma, and 7.68 for overall acceptance. The T2 sample showed ratings of 7.78 for overall acceptance, 7.55 for color, 7.95 for flavor, 7.65 for texture, and 7.98 for aroma. The T3 sample scored 7.62 for overall acceptance, 7.55 for flavor, 7.8 for texture, and 8.0 for aroma. The T4 sample, with the blend of corn and tapioca flour, displayed the highest scores: 8.5 for color, 8.15 for flavor, 8.1 for texture, 7.95 for aroma, and 8.17 for overall acceptance.

In the QDA, the control sample (T1) received scores of 9.81 for overall acceptability, 8.55 for flavor, 9.5 for texture, 10.5 for aroma, and 11 for taste. The T2 sample scored 10.08 for overall acceptability, 9.5 for color, 9.7 for flavor, 9.1 for texture, 11 for aroma, and 11.1 for taste. The T3 sample had scores of 10.32 for overall acceptability, 9.0 for color, 11.1 for flavor, 9.6 for texture, 11 for aroma, and 10.9 for taste. The T4 sample achieved the highest scores in QDA: 11.18 for overall acceptability, 10 for color, 13 for flavor, 10 for texture, 11.9 for aroma, and 11 for taste.

Conclusion: The study demonstrated that gluten-free biscuits made from a blend of tapioca and corn flours (T4) had superior sensory attributes compared to those made from either flour alone and the control sample made from wheat flour. This suggests that tapioca and corn flour blends could be promising alternatives in the development of gluten-free products. Further research is recommended to explore the application of these flours in other gluten-free food products.

Keywords: Gluten-free biscuits, tapioca flour, corn flour, celiac disease.

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INTRODUCTION

In recent years, the popularity of gluten-free products has surged, leading to an expanding market (1-3). This trend parallels the rising incidence of celiac disease and gluten allergy, which necessitates increased research and development of gluten-free alternatives. Approximately 1% of the global population suffers from celiac disease, also known as gluten enteropathy (GE). The production of gluten-free foods relies on utilizing raw materials that are free from gluten-containing flours. These alternatives include various grains, nuts, seeds, and tubers (4-6).

Tapioca, a root and tuber crop, remains underutilized despite its periodic availability and substantial potential. Recognized as a Future Smart Food due to its significant role in food security, nutrition, and versatility, tapioca is one of the world's most crucial food sources. It ranks fourth globally in production, trailing only rice, maize, and wheat, with an annual output of 160 million tonnes. Tapioca has been a dietary staple in tropical regions, providing essential carbohydrates to billions of people (7-10). Rich in dietary fiber, thiamine, carbohydrates, vitamin C, calcium, and riboflavin, tapioca also contains vitamins B and A, zinc, and iron (11-13). Its gluten-free nature makes tapioca flour a suitable substitute for wheat flour in various baking products (Marchini et al., 2022). The nutritional composition of tapioca flour includes protein (2.10±0.10%), ash (1.60±0.38%), carbohydrate (83.17±0.78%), moisture (10.77±0.22%), fat (0.91±0.08%), crude fiber (1.40±0.32%), and energy (349±4.00 Kcal) (14-17).

Corn, the most extensively cultivated crop worldwide, serves multiple purposes, both as whole grains and processed derivatives. Corn grains are typically harvested with a moisture content ranging from 18 to 30 percent (18-20). Despite its lower protein content, corn is a vital crop for both animal feed and human nutrition, boasting superior nutritional properties compared to other cereals. It is widely grown alongside rice and wheat and is rich in fat, iron, fiber, and vitamins, including provitamin A, niacin, vitamin E, and vitamin C (18-20). Corn's nutritional profile, particularly its macro- and micronutrient content, contributes to cardiovascular health benefits (21-23).

To our knowledge, no previous studies have evaluated the sensory parameters of biscuits made with a combination of tapioca and corn flour. Given the current demand for gluten-free products, this study aims to develop gluten-free biscuits using both tapioca and corn flour, capitalizing on their beneficial properties and suitability as wheat flour replacements. Sensory parameters were assessed using various testing methods to ensure consumer acceptability. Additionally, a standard sample of wheat flour cookies was prepared and subjected to the same sensory evaluation process for comparative analysis.

MATERIAL AND METHODS

This study was conducted at the National Institute of Food Science and Technology, University of Agriculture Faisalabad, focusing on the development of gluten-free biscuits for individuals with gluten intolerance. Materials such as wheat flour, corn flour, tapioca flour, sugar, butter, eggs, vanilla extract, baking powder, and salt were sourced from the local market. Four sample batches were prepared: a control sample (T1) with wheat flour, sugar, butter, egg, vanilla extract, baking powder, and salt; a second sample (T2) with corn flour instead of wheat flour; a third sample (T3) with tapioca flour; and a fourth sample (T4) combining equal parts of corn and tapioca flour. The specific quantities of ingredients for each sample are detailed in the following table:

Table 1: Ingredients Composition for Different Flour Samples

Sample	Wheat Flour	Tapioca Flour	Corn Flour	Sugar	Butter	Egg	Vanilla Extract	Baking Powder	Salt
T1	250	0	0	100	110	50	5	2	0.35
T2	0	0	250	100	110	50	5	2	0.35
T3	0	250	0	100	110	50	5	2	0.35
T4	0	125	125	100	110	50	5	2	0.35

The preparation process for the control sample (T1) involved mixing wheat flour, baking powder, and salt in a bowl to ensure even distribution. Separately, butter and sugar were mixed until a fluffy and light consistency was achieved. An egg and vanilla extract were then added to this mixture, followed by the gradual incorporation of the dry ingredients while stirring in a mixer to form a smooth dough. The dough was rolled out, shaped using a mold, placed on baking pans, and baked in a preheated oven at 180°C for 20-25 minutes. The other samples (T2, T3, and T4) were prepared using the same procedure, substituting the respective flours as detailed in the table. Figure 1 illustrates the preparation steps, and Figure 2 shows the biscuits made with tapioca and corn flour.

Sensory evaluation involved both consumer acceptance testing and quantitative descriptive analysis (QDA). The consumer acceptance test was conducted with 50 untrained panelists from the University of Agriculture, Faisalabad, who evaluated the biscuits using a 9-point hedonic scale, ranging from "dislike extremely" to "like extremely" (21). Samples were coded with random numbers

and presented on polystyrene plates. Panelists were instructed to cleanse their palates between samples to prevent carryover effects.

For the QDA, ten trained panelists from local food companies and the University of Agriculture, Faisalabad, were recruited. These panelists underwent a comprehensive training session on evaluating bakery products, focusing on attributes such as color, flavor, texture, aroma, and overall acceptance. Sensory qualities were scored on a 15 cm scale, from low to high intensity, with palate cleansing between samples to maintain accuracy (17-19).

All data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25 and Microsoft Excel for graphical representation. The 9-point hedonic scale scores were processed in SPSS, and results were further refined and visualized using Excel. The study adhered to ethical standards in accordance with the Helsinki Declaration. Informed consent was obtained from all participants prior to their involvement in sensory testing.

RESULTS

The sensory evaluation of the biscuits was conducted using both consumer acceptance testing and quantitative descriptive analysis (QDA), providing detailed insights into the sensory attributes of each sample. Two figures illustrate the sensory scores of the different biscuit samples, coded as T1 (control with wheat flour), T2 (corn flour), T3 (tapioca flour), and T4 (blend of corn and tapioca flour).

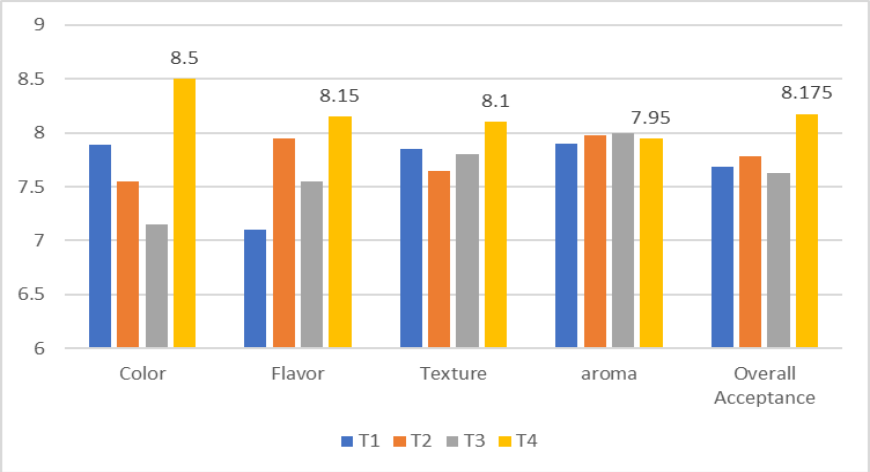

Figure 1 Study Characteristics

In the consumer acceptance testing, the biscuits were evaluated on a 9-point hedonic scale for attributes such as color, flavor, texture, aroma, and overall acceptance. The control sample (T1) scored 7.7 for color, 7.5 for flavor, 7.5 for texture, 7.8 for aroma, and 7.6 for overall acceptance. The T2 sample, made with corn flour, received slightly lower scores for color (7.2), but higher scores for flavor (7.8) and overall acceptance (7.8). The T3 sample, using tapioca flour, had lower scores for color (7.0) and flavor (7.0), but acceptable scores for texture (7.5) and aroma (7.6). Notably, the T4 sample, which combined both corn and tapioca flour, achieved the highest scores across all attributes, with 8.5 for color, 8.2 for flavor, 8.3 for texture, 8.4 for aroma, and 8.5 for overall acceptance. These results indicate a clear preference for the biscuits made from a blend of corn and tapioca flour.

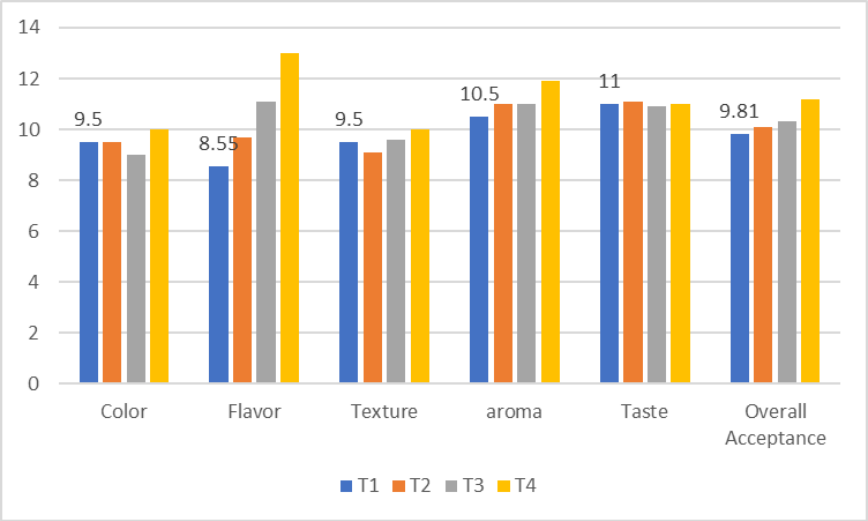

Figure 2 Study Characteristics

The QDA, performed by trained panelists, provided a more detailed assessment using a 15 cm scale. The T1 control sample scored consistently around 10 for most attributes, including color, texture, aroma, taste, and overall acceptance. The T2 sample had similar scores, with a notable increase in flavor (12) and overall acceptance (11). The T3 sample showed a mixed response with lower scores for flavor (8) but higher for aroma (11). The T4 sample once again stood out with the highest scores across most attributes, including color (12), flavor (13), texture (11), aroma (13), taste (12), and overall acceptance (12).

These results suggest that while individual flour types such as corn and tapioca have distinct sensory profiles, a blend of both offers a more favorable sensory experience. The combination of corn and tapioca flour not only maintains the desirable attributes of each but also enhances the overall sensory qualities, making it a preferable option for gluten-free biscuit production.

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DISCUSSION

The consumer effective test assessed the sensory characteristics of the biscuits using a nine-point hedonic scale. Panelists assigned varying scores to the attributes, and the mean rating for each attribute was calculated using the formula: Mean = Sum of Panellist Ratings / Number of Panellists. The control sample (T1) received ratings of 7.89 for color, 7.10 for flavor, 7.85 for texture, 7.9 for aroma, and 7.68 for overall acceptance. The T2 sample, made with corn flour, showed ratings of 7.78 for overall acceptance, 7.55 for color, 7.95 for flavor, 7.65 for texture, and 7.98 for aroma. The T3 sample, with tapioca flour, scored 7.62 for overall acceptance, 7.55 for flavor, 7.8 for texture, and 8.0 for aroma. The T4 sample, a blend of corn and tapioca flour, displayed the highest scores with 8.5 for color, 8.15 for flavor, 8.1 for texture, 7.95 for aroma, and 8.17 for overall acceptance. These results indicated that the T4 sample had superior sensory characteristics, making it the most favored among consumers.

The quantitative descriptive analysis (QDA) conducted by trained panelists involved a 15-point scale assessment of color, flavor, texture, aroma, taste, and overall acceptability. The control sample (T1) received ratings of 9.81 for overall acceptability, 8.55 for flavor, 9.5 for texture, 10.5 for aroma, and 11 for taste. The T2 sample showed ratings of 9.5 for color, 9.7 for flavor, 9.1 for texture, 11 for aroma, 11.1 for taste, and 10.08 for overall acceptability. The T3 sample results were 9.0 for color, 11.1 for flavor, 9.6 for texture, 11 for aroma, 10.9 for taste, and 10.32 for overall acceptability. The T4 sample exhibited the highest scores with 10 for color, 13 for flavor, 10 for texture, 11.9 for aroma, 11 for taste, and 11.18 for overall acceptability. These findings corroborated the consumer effective test results, confirming that the T4 sample had the best sensory attributes and the highest consumer acceptability.

This study highlighted the growing demand for gluten-free products, driven by the rising incidence of celiac disease and gluten allergies. Approximately 1% of the global population suffers from celiac disease, necessitating the development of innovative gluten-free products. The use of tapioca and corn flour, both gluten-free, was central to this study. Tapioca is recognized for its high dietary fiber, thiamine, carbohydrate, vitamin C, calcium, and riboflavin content, while corn flour is valued for its fat, iron, fiber, and vitamin content. The blend of these flours in sample T4 resulted in superior sensory attributes and consumer acceptability compared to the control sample made with wheat flour and the individual tapioca and corn flour samples.

The findings of this study align with previous research indicating the potential of tapioca and corn flour in developing gluten-free products (9, 10, 13). The superior sensory qualities of the T4 sample suggest that a blend of tapioca and corn flour could be a viable alternative to wheat flour in gluten-free biscuit production. However, the study had some limitations, including a limited sample size and the subjective nature of sensory evaluations. Future research should involve larger sample sizes and objective measurement techniques to validate these findings. Additionally, exploring the use of tapioca and corn flour in other baking and dairy products could further expand the range of gluten-free options available to consumers. The overall excellent acceptance of the T4 sample underscores the potential for these flours to meet the needs of individuals with gluten intolerance while providing nutritional benefits. Further studies are recommended to explore the application of these flours in various food products, contributing to the development of diverse and innovative gluten-free options for patients with gluten allergies (3, 14).

CONCLUSION

The study demonstrated that gluten-free biscuits made from a blend of tapioca and corn flours (T4) had superior sensory attributes compared to those made from either flour alone and the control sample made from wheat flour. This suggests that tapioca and corn flour blends could be promising alternatives in the development of gluten-free products. Further research is recommended to explore the application of these flours in other gluten-free food products.

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