International Journal of Research and Innovation Management
ISSN 2462-1293
Vol:11 No 1 2025

Nutritional Enhancement of Frozen Cucurbita Puri Bread: A Comparative Analysis of Formulation and Consumer Acceptance

Rusyidah binti Mat Zin Boestami*, Farah Waheeda binti Othman[2]
[1]Department of Mathematics, Science and Computer (JMSK), Politeknik Sultan Idris Shah
[2]Department of Information and Communication Technology (JTMK), Politeknik Sultan Idris Shah
*Corresponding author's email: rusyidahmzboestami@psis.edu.my / rusyidahmatzin@gmail.com

Abstract: Pumpkin (*Cucurbita* spp.) is a nutrient-dense crop rich in antioxidants and fibre, yet its underutilization in processed foods contributes to post-harvest losses in SDG 12: Responsible Consumption and Production. Besides, SDG 3: Good Health and Well-being by promoting nutrient-dense foods and industrial scalability supports SDG 9: Industry, Innovation and Infrastructure. This study aims to (1) develop Frozen Cucurbita Puri Bread with enhanced nutritional value and (2) validate consumer acceptability, targeting health-conscious consumers and food industries. Proximate analyses such as moisture, ash, phenolic and antioxidant content. For sensory evaluation by using 9-point hedonic scale were conducted to compare frozen cucurbita puri bread and plain puri bread. Frozen cucurbita puri bread exhibited superior nutritional properties were 20.19% to 25.23% moisture compared to 24.24% to 30.0% in plain bread. While 54.6 mg/mL phenolic compounds and 15.3 mg/mL antioxidants. For sensory tests confirmed higher acceptability was 5.53 compared to plain puri bread 4.37. The study successfully developed a nutrient-rich and addressing gaps in functional bakery products. Evaluate other nutritional value such as protein or vitamin profiling could further validate health claims and development on biodegradable packaging.

Keywords: *Pumpkin, frozen bread, shelf life, antioxidants, sensory evaluation, microbial stability, puri, Cucurbita spp.*

1.0 INTRODUCTION

Food waste remains a critical global challenge, with over 2.5 billion tons of food lost or wasted annually, representing more than one-third of all food produced worldwide (Global Food Waste in 2024). In the United States alone, nearly 60 million tons almost 40% of the entire food supply are discarded each year, much of it due to confusion over expiration labels and concerns about food safety (RTS - Recycle Track Systems, 2025). Bakery products, including bread, are particularly susceptible to spoilage with microbial contamination and staling significantly limiting their shelf life and contributing to this waste (Taglieri et al., 2020; Hossain et al., 2023). At the same time, consumer demand for nutritious, convenient, and shelf stable food products is driving innovation in the processed pumpkin market, which reached a value of USD 1.59 billion in 2024 and is projected to grow at a CAGR of 10.6% through 2030 (U.S. Processed Pumpkin Market Size, 2025). The scientific name of pumpkin is *Cucurbita spp.*, rich in vitamins, minerals, antioxidants and dietary fiber is increasingly recognized for its potential as a functional ingredient in bakery applications, offering both nutritional benefits and opportunities to extend product shelf life (Różyło et al., 2014).

Despite these promising trends, challenges remain in optimizing the formulation and preservation of pumpkin based bakery products. The shelf life of bread is influenced by a complex interplay of physical staling, microbial spoilage and sensory changes, all of which can be affected by ingredient choice, processing, and storage conditions (Taglieri et al., 2020; Rahman et al., 2022). Recent studies have demonstrated that the inclusion of pumpkin pulp or flour can enhance the nutritional profile and consumer acceptability of bread but may also impact textural properties and susceptibility to spoilage if not properly managed (Różyło et al., 2014). Furthermore, the rapid increase in bacterial colony counts observed in packaged bakery products as they approach expiration underscores the importance of rigorous shelf-life analysis and innovative preservation strategies (Hossain et al., 2023).

In addition, the nutritional and market advantages of incorporating pumpkin into bakery products, maintaining the quality and safety of frozen pumpkin-based bread throughout its shelf life poses significant challenges. There is a pressing need for systematic research to analyze the nutritional content and consumer acceptance of frozen Cucurbita puri bread (Taglieri et al., 2020; Hossain et al., 2023). This article will contribute:

- Nutritional Analysis: Quantifies moisture, ash and antioxidant content in Frozen Cucurbita Puri Bread, demonstrating its superiority over conventional plain puri bread.
- Consumer Acceptance: Evaluates sensory preferences using a 9-point hedonic scale, bridging the gap between innovation and marketability.

2.0 LITERATURE REVIEW

Recent research on shelf life and quality enhancement of bakery products has increasingly focused on the use of freezing and ingredient fortification to meet consumer demand for healthier and more sustainable foods. Studies by Van Bockstaele et al. (2021) demonstrated that temporary frozen storage can effectively maintain the safety and quality of bakery products, but did not explore the impact of functional ingredients such as pumpkin on nutritional or sensory properties. Buculei et al. (2024) further advanced this field by optimizing freezing techniques for cakes, confirming that rapid freezing can preserve texture and sensory quality for up to 12 months; however, their work was limited to cakes and did not investigate the effects of vegetable-based fortification or antioxidant activity.

Table 1: Comparative Table from Previous Studies

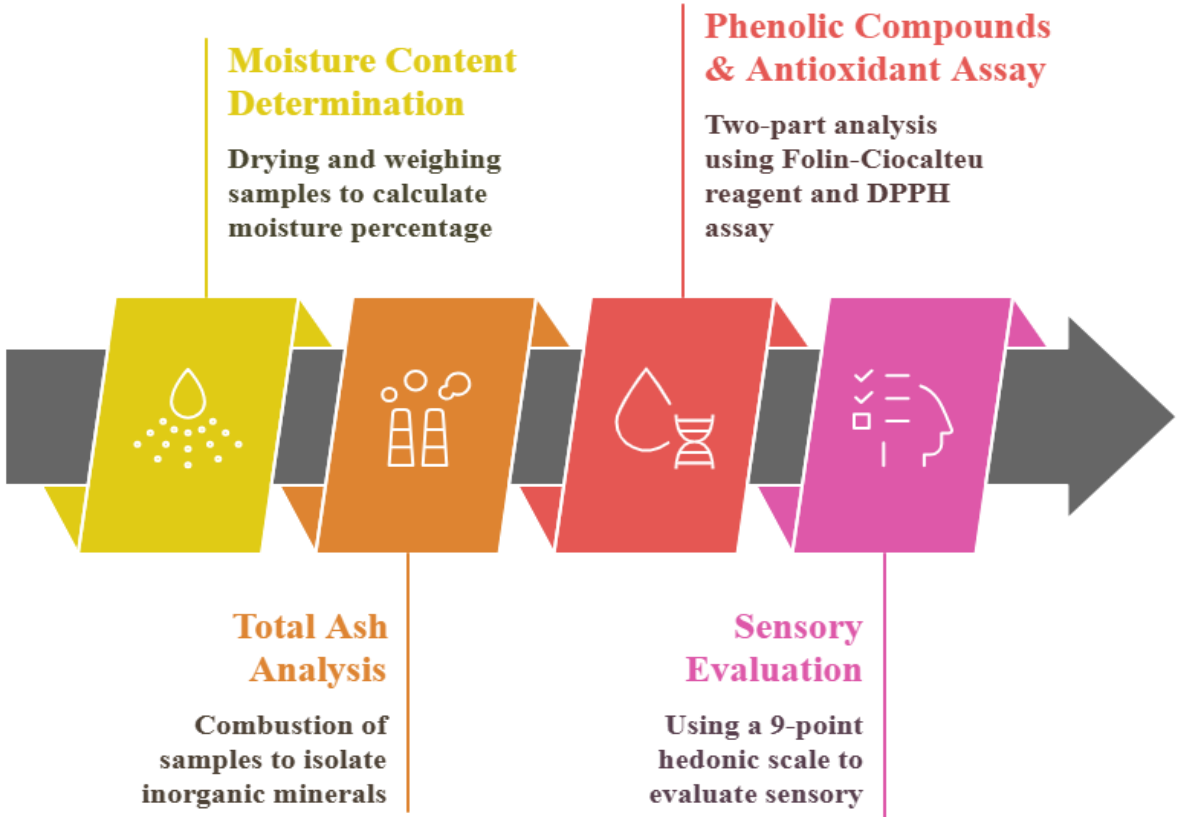
Authors	Method Used	Key Features	Limitations
Bockstaele et al. 2021	Temporary frozen storage, quality or safety tests	Assessed impact of freezing on safety and quality of bakery products, focus on shelf-life and defrosting impact	Did not address functional or nutritional fortification or pumpkin-based formulations
Buculei et al. 2024	Freezing techniques, sensory analysis	Compared rapid freezing protocols for cakes, evaluated shelf life, texture, sensory and environmental benefits	Focused on cakes did not study pumpkin or antioxidant activity
Alija et al. 2025	Pumpkin peel powder in bread, DPPH or ABTS tests	Investigated antioxidant enhancement in bread via pumpkin peel addition, analyzed crust or crumb differences	Did not assess microbial shelf life or consumer sensory acceptance in frozen storage context
Kiharason, 2019	Flour blending, microbial counts	Evaluated shelf life of pumpkin flour-blended bakery products, microbial counts and storage conditions	Limited to up to 20% pumpkin flour did not analyze antioxidants or detailed consumer feedback

Research by Alija et al. (2025) and related studies have shown that the incorporation of pumpkin peel or flour into bread formulations can significantly increase antioxidant activity, particularly in the crust due to both the bioactive compounds present in pumpkin and the formation of Maillard reaction products during baking. Nonetheless, these studies often did not address microbial shelf life or consumer sensory acceptance in the context of frozen storage. Meanwhile, Kiharason, (2019), evaluated the shelf life and microbial stability of pumpkin flour-blended bakery products, finding that blends up to 20% pumpkin flour could extend storage periods and maintain microbial

International Journal of Research and Innovation Management
ISSN 2462-1293
Vol:11 No 1 2025
safety. However, their analyses were limited in scope, lacking detailed assessment of antioxidant activity, comprehensive nutritional profiling, or structured consumer feedback.

Despite notable progress, several gaps remain in the literature. Most previous works have either focused on the technological aspects of freezing or on the nutritional and antioxidant benefits of pumpkin puri bread but rarely have these been integrated in a single study. There is limited research that systematically analyzes the combined effects of pumpkin enrichment on the nutritional and sensory properties of frozen bakery products. Additionally, few studies have adopted a comprehensive approach that includes both laboratory-based analysis were moisture, ash, phenolic content, antioxidant activity and structured consumer acceptance testing under frozen storage conditions.

3.0 METHODOLOGY



***Flow Chart 1**: Methodology Step analysis of Frozen Cucurbita Puri Bread*

International Journal of Research and Innovation Management
ISSN 2462-1293
Vol:11 No 1 2025

4.0 DATA ANALYSIS

Table 2: Analysis of the sample for Plain Puri Bread and Frozen Cucurbita Puri Bread

Type of sample	Moisture (%)	Total Ash (%)	Concentration antioxidant (mg/mL)	Phenolic compound (mg/mL)
Plain Puri Bread	24.24 – 30.00	-	-	-
Frozen Cucurbita Puri Bread	20.19 - 25.23	0.69 - 0.77	15.30	54.63

Table 3: Sensory evaluation of the sample for Plain Puri Bread and Frozen Cucurbita Puri Bread

Formulation	Texture	Colour	Sweetness	Aroma	Overall Acceptance
Plain Puri Bread	4.40 ± 1.40	3.97 ± 1.83	3.73 ± 1.70	3.97 ± 1.43	4.37 ± 1.38
Frozen Cucurbita Puri Bread	5.50 ± 1.33	5.33 ± 1.29	5.33 ± 1.32	4.87 ± 1.42	5.53 ± 0.819

Table 4: The data of significant differences for Sensory evaluation

Attribute	Significant
Texture	0.533
Color	0.048
Sweetness	0.080
Aroma	0.900
Overall Acceptance	0.005

5.0 FINDINGS AND DISCUSSION

The incorporation of pumpkin purée into frozen bread formulations significantly influenced the physicochemical, microbiological, and sensory properties of the final product, aligning with the project's objectives to enhance nutritional value and shelf life while maintaining consumer acceptability.

The moisture content analysis revealed a clear reduction in water content for pumpkin puri bread compared to plain puri bread. The average moisture content for plain puri bread ranged from 24.24% to 30.0%, whereas frozen cucurbita puri bread samples exhibited lower values between 20.19% to 25.23% as shown in Table 2 Analysis of sample for Plain Puri Bread and Frozen Cucurbita Puri Bread. This reduction is notable as lower moisture in bakery products is closely linked to extended shelf life and reduced susceptibility to microbial spoilage. A finding consistent with recent studies on pumpkin-enriched bread products (Kiharason, 2019; Alija et al. 2025). The decrease in moisture content can be

attributed to both the functional properties of pumpkin and the modified baking process supporting that pumpkin addition can enhance product stability during frozen storage.

Total ash content, representing the mineral composition, was measured between 0.69% and 0.77% for pumpkin puri bread samples as shown in Table 2 Analysis of sample for Plain Puri Bread and Frozen Cucurbita Puri Bread. These values indicate that the inclusion of pumpkin contributes positively to the mineral profile of the bread as pumpkin is known for its richness in essential elements such as potassium, magnesium, and iron. The results align with the broader literature, which highlights the nutritional enhancement achieved through the fortification of bakery products with pumpkin or its derivatives (Jasper et al. 2020).

The quantification of total phenolic compounds and antioxidant activity further underscores the functional advantages of pumpkin puri bread. The phenolic content was determined to be 54.63 mg/ml, while antioxidant activity reached 15.30 mg/ml as shown in Table 2 Analysis of sample for Plain Puri Bread and Frozen Cucurbita Puri Bread. These findings are significant, as phenolic compounds and antioxidants play critical roles in human health by mitigating oxidative stress and supporting immune function. Moreover, their presence contributes to the product's potential as a functional food, meeting consumer demand for healthier bakery options (Li et al., 2024). The observed levels are comparable to those reported in recent research on pumpkin-fortified breads, confirming the efficacy of the formulation in delivering bioactive compounds (Alija et al. 2025).

Sensory evaluation using a 9-point hedonic scale revealed that pumpkin puri bread was consistently rated higher than plain puri bread across all attributes, including texture, color, sweetness, aroma, and overall acceptance as shown in Table 3 Sensory evaluation of sample for Plain Puri Bread and Frozen Cucurbita Puri Bread. Notably, the overall acceptance score for pumpkin puri bread was 5.53 compared to 4.37 for the plain variant, with statistical analysis indicating a significant difference, $p = 0.005$ in Table 4 The data of significant different for Sensory evaluation. These results demonstrate strong consumer preference for the pumpkin-based formulation, echoing findings from recent literature where pumpkin puri improved both sensory and nutritional qualities of bread products (Kiharason, 2019; Li et al., 2024). The enhanced sensory evaluation can be attributed to the natural color, flavor and texture modifying properties of pumpkin which align with evolving consumer expectations for innovative and health promoting foods.

6.0 Conclusions

This study demonstrated that Frozen Cucurbita Puri Bread achieves its dual objectives of nutritional enhancement and shelf-life optimization. The incorporation of pumpkin significantly improved the bread's antioxidant and phenolics while reducing moisture content. Sensory evaluations further confirmed consumer preference for the pumpkin formulation, underscoring its market potential. The project aligns with SDG 3 (Good Health and Well-being) by promoting nutrient-dense foods and SDG 12 (Responsible Consumption and Production) by valorizing pumpkin, a frequently wasted crop. Its industrial scalability supports SDG 9 (Industry, Innovation and Infrastructure). Future Recommendations: (1) Nutritional Expansion: Analyze protein and vitamin content to strengthen health claims. (2) Packaging Innovation: Explore biodegradable materials to enhance sustainability.

7.0 Acknowledgements

The authors wish to thank the Department of Science and Mathematics (JMSK), Politeknik Sultan Idris Shah for providing facilities and support. Authors also want to thank MYIPO for copyright products in notification number LY2018005823. Furthermore, also wants to thanks in I-COMPEX 2018 award in Gold medal.

Declaration of generative AI and AI-assisted technologies in the writing process
(Authors must disclose any use of generative AI or AI-assisted technologies in the preparation of their manuscript. This includes assistance with language refinement, content generation, or any other part of the writing process)

During the preparation of this manuscript, the author(s) used OpenAI's ChatGPT to assist in improving the readability and language of the text. All content generated by ChatGPT was subject to thorough review, editing, and revision by the author(s) to ensure its accuracy, completeness, and alignment with the research objectives. The author(s) take full responsibility for the integrity and content of the published work. This declaration complies with IARTC 2025 guidelines on the use of generative AI in scientific writing.

REFERENCES

Alija, D., Olędzki, R., Nedelkoska, D. N., Pejcz, E., Wojciechowicz-Budzisz, A., Stamatovska, V., & Harasym, J. (2025). Cucurbita maxima Plomo Peel as a Valuable Ingredient for Bread-Making. *Foods*, *14*(4), 597. https://doi.org/10.3390/foods14040597.

Alija, D., Olędzki, R., Nedelkoska, D. N., Wojciechowicz-Budzisz, A., Pejcz, E., Jankuloska, V., Xhabiri, G., & Harasym, J. (2025). Prolonged Proofing Modulates the Acrylamide Content, Nutritional and Functional Characteristics of Pumpkin (Cucurbita maxima Plomo) and Soft Wheat Composite Bread. *Foods*, *14*(3), 437. https://doi.org/10.3390/foods14030437.

Buculei, A., Gatlan, A. M., Oroian, M., Butnaru, M., & Chetrariu, A. (2024). Evaluating Freezing Techniques And Quality Indicators For Frozen Cakes: Effects On Shelf Life, Texture, And Sensory Properties. *International Multidisciplinary Scientific GeoConference SGEM*, *24*, 69–76. https://doi.org/10.5593/sgem2024v/6.2/s24.09.

Global food waste in 2025. (2024, June 27). Greenly. https://greenly.earth/en-us/blog/industries/global-food-waste-in-2022.

Hossain, M. I., Faruk, M. O., Tuha, M. a. S. M., Mimi, S., Islam, K. R., Ali, M. S., & Sahabuddin, M. (2023). Comparative safety analysis of newly prepackaged backed food products and those approaching the expiry date in Bangladesh. *Heliyon*, *9*(7), e17513. https://doi.org/10.1016/j.heliyon.2023.e17513.

Jasper, E., Cornelius, A., & Buhari Salam, S. (2020, February). *Quality Evaluation of Bread Fortified with Pumpkin (Cucurbitapepo) Seed Milk*. Global Scientific Journal. https://www.globalscientificjournal.com/researchpaper/Quality_Evaluation_of_Bread_Fortified_with_Pumpkin_Cucurbita_pepo_Seed_Milk_.pdf.

Kiharason, J. W. (2019). Shelf-Life of pumpkin fruit slices, flour and blended products. *International Journal of Food Science and Biotechnology*, *4*(1), 14. https://doi.org/10.11648/j.ijfsb.20190401.13.

Li, W., Zhao, Q., & Mao, Q. (2024). Effect of modifying pumpkin preparation on oral processing of breads. *Journal of Texture Studies*, *55*(2). https://doi.org/10.1111/jtxs.12827.

Rahman, M., Islam, R., Hasan, S., Zzaman, W., Rana, M. R., Ahmed, S., Roy, M., Sayem, A., Matin, A., Raposo, A., Zandonadi, R. P., Botelho, R. B. A., & Sunny, A. R. (2022). A Comprehensive Review on Bio-Preservation of Bread: An approach to adopt Wholesome Strategies. *Foods*, *11*(3), 319. https://doi.org/10.3390/foods11030319.

Różyło, R., Gawlik-Dziki, U., Dziki, D., Jakubczyk, A., Karaś, M., & Różyło, K. (2014). Wheat Bread with Pumpkin (Cucurbita maxima L.) Pulp as a Functional Food Product. *Food Technology and Biotechnology*, *52*(4), 430–438. https://doi.org/10.17113/ftb.52.04.14.3587.

RTS - Recycle Track Systems. (2025, January 31). *Food Waste in America in 2025: Statistics & Facts | RTS*. Recycle Track Systems. https://www.rts.com/resources/guides/food-waste-america/.

Taglieri, I., Macaluso, M., Bianchi, A., Sanmartin, C., Quartacci, M. F., Zinnai, A., & Venturi, F. (2020). Overcoming bread quality decay concerns: main issues for bread shelf life as a function of biological leavening agents and different extra ingredients used in formulation. A review. *Journal of the Science of Food and Agriculture*, *101*(5), 1732–1743. https://doi.org/10.1002/jsfa.10816.

U.S. processed pumpkin market size | Industry Report, 2030. (2025). https://www.grandviewresearch.com/industry-analysis/us-processed-pumpkin-market.

Van Bockstaele, F., Debonne, E., De Leyn, I., Wagemans, K., & Eeckhout, M. (2020). Impact of temporary frozen storage on the safety and quality of four typical Belgian bakery products. *LWT*, *137*, 110454. https://doi.org/10.1016/j.lwt.2020.110454