DEVELOPMENT OF GLUTEN FREE COOKIE USING TAPIOCA FLOUR INCORPORATED WITH PALMYRAH TUBER (*Borassus flabellifer* L.) FLOUR

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https://doi.org/10.5281/zenodo.16991606

Abstract. *"Miracle tree" palm tree (Borassus flabellifer) is a traditional plant known for its numerous health benefits. Its tubers are rich in dietary fiber, which supports digestive health, and contain a significant amount of enzymes that are typically not obtained from regular food. A study was conducted to develop gluten-free cookies using locally available raw materials, specifically by incorporating tapioca flour with palmyra tuber flour. The production of gluten-free cookies involved mixing tapioca flour and palmyra tuber flour at a ratio of 95:05 (T_2), 90:10 (T_3), 85:15 (T_4), 80:20 (T_5) and control (T_1) with 100% wheat flour. The other ingredients, such as margarine (50g), sugar (45g), eggs (50g), baking powder (2.5g), milk powder (10g), and vanilla (2.5g), were kept constant for all five-treatment combinations. Cookie dough relevant to the five treatment combinations was prepared and baked using a hot air oven at 180^{0}C for 20 minutes. The gluten-free cookie containing 90% tapioca flour and 10% palmyra tuber flour (T_3) received the highest acceptability in sensory evaluation (7-point hedonic scale), as assessed by 10 untrained panelists. T_3 was selected for further analysis with the control sample. The proximate composition of the selected gluten-free cookie (T_3) was determined as follows: moisture content (9.36 ± 0.13%), ash content (1.43 ± 0.45%), crude fiber (3.56 ± 0.62%), crude protein (4.4 ± 0.03%), crude fat (3.19 ± 0.06%), and carbohydrate (78.05 ± 0.32%). Shelf-life evaluation revealed that TPC and YMC were remained within safety limits, suggesting that the selected cookies can be stored in an airtight container for approximately two weeks.*

Keywords: *cookies, Gluten, Gluten-Free Cookies, Palmyra Tuber Flour, Tapioca Flour.*

Introduction

The increasing prevalence of gluten-related disorders, such as celiac disease and non-celiac gluten sensitivity, has improved the demand for nutritious, affordable gluten-free products (Cabanillas, 2020). However, many existing gluten-free baked products are nutritionally inadequate and expensive (Singh & Whelan, 2011). The present study aims to address this gap by developing gluten-free cookies using tapioca flour and palmyra tuber flour, two underutilized and locally available ingredients.

Tapioca, a long, tuberous, starchy root crop, belongs to the Euphorbiaceae family (Uthpala *et al.*, 2021). Tapioca flour has benefits for people who have celiac disease, an autoimmune disorder caused by gluten ingestion. Tapioca flour is inherently gluten-free, which allows celiac disease patients to incorporate gluten-free alternatives into their diets. The inclusion of tapioca flour in gluten-free formulations tries to emulate the beneficial qualities of wheat dough, resulting in food products (Dini *et al.*, 2014). "Miracle tree" (*Borassus flabellifer* - palm tree), is known for its numerous health benefits. Its tubers are inherently gluten-free, rich in dietary fiber, which supports digestive health, and contain a significant amount of enzymes that are typically not obtained from regular food. (Khatri *et al.*, 2020)

The novelty of this research is the formulation of cookies combining tapioca and palmyra tuber flours to enhance nutritional value and sensory appeal while promoting sustainable use of local resources. The objective was to create a gluten-free cookie with improved nutritional content, acceptable sensory properties, and good shelf stability.

Materials and Methods

Materials

Wheat flour, tapioca flour, palmyra tuber flour, margarine, sugar, eggs, baking powder, milk powder, vanilla powder, hot air oven.

Good quality tapioca flour and palmyra tuber flour were procured from the market in the Colombo area. Other ingredients are wheat flour, sugar, baking powder, eggs, margarine, milk powder and vanilla were purchased from the supermarket in the Gampaha area.

Method

The study employed an experimental design with five treatments: T1 (100% wheat flour - control), T2 (95% tapioca flour, 5% palmyra tuber flour), T3 (90% tapioca flour, 10% palmyra tuber flour), T4 (85% tapioca flour, 15% palmyra tuber flour), and T5 (80% tapioca flour, 20% palmyra tuber flour). Other ingredients (margarine, sugar, egg, milk powder, baking powder, vanilla) were kept constant.

Cookies were created according to five treatment combinations, with cookie doughs prepared using the creaming process, piped to a diameter of 5 cm, and baked in a hot air oven. Cookies were sensory evaluated to determine the optimum treatment combination based on sensory features such as taste, color, texture, flavor, scent, and overall acceptability using a 7-point hedonic scale with 10 untrained panelists. The results were examined using the Minitab statistical analysis tool with Tukey Pairwise Comparison. Selected biscuits were put in sealed containers for the subsequence phases in the experiment.

Table 1. Experimental Design

Ingredients (g)	**Formulation**				
	T_1	**T_2**	**T_3**	**T_4**	**T_5**
Wheat flour	100	-	-	-	-
Tapioca flour	-	95	90	85	80
Palmyra tuber flour	-	05	10	15	20
Margarine	50	50	50	50	50
Sugar	45	45	45	45	45
Egg (without shell)	50	50	50	50	50
Milk powder	10	10	10	10	10
Baking powder	2.5	2.5	2.5	2.5	2.5
Vanilla Powder	2.5	2.5	2.5	2.5	2.5

The recommended methods of the Association of Official Analytical Chemists (AOAC, 2000) are adopted to determine the quantity of crude protein, moisture, ash, and fat content and crude fiber content of the prepared cookies. The total carbohydrate content was estimated by subtracting 100 from the sum of the moisture, ash, fat, and crude protein percentages. All samples were measured in triplicate.

For the shelf-life analysis, Total Plate Count (TPC), Yeast and Mold Count (YMC), pH value, and moisture content were evaluated. In addition, organoleptic attributes were assessed to monitor the sensory quality during storage.

Results and Discussion

Among the formulations, T3 (90% tapioca flour, 10% palmyra tuber flour) received the highest acceptability score in sensory evaluation, particularly in taste, texture, and overall acceptability (Figure 1).

Figure 1. Radar plot depicting the sensory characteristics of gluten- free cookies

Proximate analysis of T3 revealed moisture content of 9.36 ± 0.13%, ash 1.43 ± 0.45%, crude fiber 3.56 ± 0.62%, crude protein 4.40 ± 0.03%, crude fat 3.19 ± 0.06%, and carbohydrates 78.05 ± 0.32%. These values indicate improved fiber and comparable protein content relative to conventional cookies.

Table 2. Proximate composition of gluten-free cookie formulated with tapioca flour and palmyra tuber flour

Composition	T1	T3	P value
Moisture (%)	9.36 ± 0.13^{a}	7.76 ± 0.18^{b}	0.001
Ash (%)	1.43 ± 0.45^{b}	1.75 ± 0.03^{a}	0.000
Protein (%)	4.40 ± 0.03^{a}	3.13 ± 0.05^{b}	0.000
Fat (%)	3.19 ± 0.06^{a}	2.30 ± 0.04^{b}	0.000
Fiber (%)	3.56 ± 0.62^{b}	6.32 ± 0.04^{a}	0.000
Carbohydrate (%)	78.05 ± 0.32^{b}	78.72 ± 0.08^{a}	0.025

The cookies also maintained microbiological safety (TPC and YMC within acceptable limits) for two weeks under airtight storage. According to the WHO standard (1994), the safety limit for baked goods including, bread, cakes and cookies are 2.0 x 10^5 CFU/g (Saddozai and Samina, 2009).Total Plate Count (TPC) was reported as 1.19 × 10^2 CFU/g, 1.66 × 10^2 CFU/g, 2.38 × 10^2 CFU/g, and 2.61 × 10^2 CFU/g for the 1st week, 2nd week, 3rd week and 4th week respectively (Figure 2).

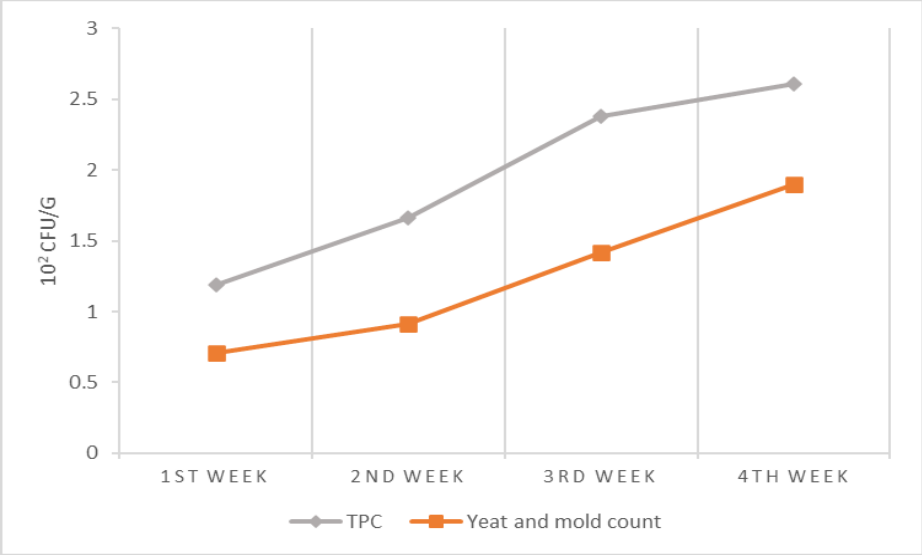

Figure 2. Variation in Total Plate Count and Yeast & Mold Count

According to Figure 2, during the 4-week storage period at 35^0C, a gradual increase in yeast and mold count was observed. Yeast & Mold Count (YMC) was reported as 0.71 × 10^2 CFU/g, 0.91 × 10^2 CFU/g, 1.42 × 10^2 CFU/g, and 1.90 × 10^2 CFU/g for the 1st week, 2nd week, 3rd week and 4th week respectively. All recorded YMC values were within the safety limits. According to the WHO standard (1994), the safety limit for YMC is <1.0x10^4. The cookie's pH decreased

from 6.3 during storage, likely due to microbial and enzymatic activity producing acidic byproducts. While moisture increased over time due to environmental absorption and microbial activity, supporting spoilage. The cookie remained acceptable for up to two weeks in airtight storage (Figure 3).

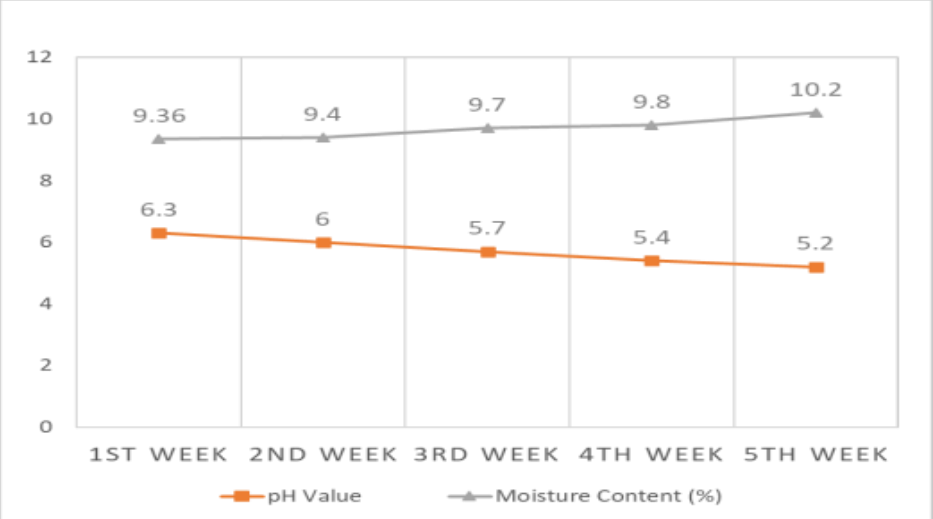

Figure 3. Variation in pH Value and Moisture Content

Conclusion

The study aimed to develop a nutritious gluten-free cookie by incorporating palmyra tuber flour, an underutilized ingredient, with tapioca flour, a surplus crop in Sri Lanka. Cookies were prepared with varying ratios of tapioca and palmyra tuber flour (95:5, 90:10, 85:15, 80:20) alongside a wheat flour control. The formulation with 90% tapioca flour and 10% palmyra tuber flour (T3) showed the highest sensory acceptability. T3 cookies had moisture 9.36%, ash 1.43%, crude fiber 3.56%, protein 4.4%, fat 3.19%, and carbohydrate 78.05%. Shelf-life analysis confirmed safe microbial levels, with cookies remaining acceptable for up to two weeks in airtight storage. The findings highlight the potential of palmyra tuber flour in gluten-free bakery applications.

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Advances in Agricultural and Life Sciences,(7), 57-78.