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Original Research Article

Development of gluten free crackers using water chestnut (Trapa natans) and Pearl Millet (*Pennisetum glaucum*)

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ABSTRACT

Background: Baked goods are favored by the public due to their widespread availability, convenience, ready-to-eat nature, and excellent storage capabilities. The study focused on developing high-quality gluten-free crackers by incorporating pearl millet (Bajra) and water chestnut flour which enhances nutritional value and is gluten free, catering to individuals with celiac disease.
Aim & Objective: To Formulate Crackers with Pearl Millet and water chestnut flour. To determine the Sensory quality of the developed product. To Estimate the Proximate composition and cost of the developed product.
Materials and Methods: Pearl millet flour, water chestnut flour, whole wheat flour, salt, jaggery, garlic powder, ajwain, mixed herbs, oil, and baking powder were procured from local grocery stores of Mysore and standard A.O.A.C (2005) methods for Proximate analysis and 9-point hedonic scale was used for sensory analysis.
Results and Discussion: The sensory evaluation revealed that PMC4 was highly acceptable on par with control. Proximate analysis showed that PMC4 had high phosphorous and calcium content.
Conclusion: The study successfully developed superior gluten-free crackers with incorporation of Pearl millet and water chestnut flour. Among all the variations PMC4 was rich in phosphorous and calcium and is gluten free which caters to individuals with celiac disease.

1. Introduction

Crackers are types of crisp baked products, chemically leavened or fermented Bakery is the rapid growing segment of gluten-free products, due to increasing availability of gluten-free flour alternatives.[1] The baking industry faces significant challenges in producing gluten-free products due to concerns over gluten intolerance and sensitivity. To address this, various underutilized food sources like buckwheat, amaranth, quinoa, and water chestnut, which are rich in starch and antioxidants, have been studied for incorporation into bakery products. Additionally, there's a growing demand for low glycemic index (GI) bakery products, especially among diabetic individuals, hence exploration of low GI food sources and innovative ingredients, along with modifications to baking and post-baking processes, is necessary. Some authors have suggested freezing and frozen storage as a method to potentially reduce GI in baked goods.[2]

Water chestnut, abundant in South East Asia, China, and Northern India cultivated from November to March, offers a rich source of gluten-free starch. Its flour can replace wheat flour in producing gluten-free products, with the potential

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for novel applications due to alterations in structure and functional properties during flour production. Extracts from water chestnut have shown high inhibitory activity against glycolytic enzymes, making them effective in managing type-2 diabetes by reducing blood glucose elevation and insulin secretion. Water chestnut flour is promising for developing low glycemic index bakery products.[3–5]

Pearl millet, originating from the West African grass and domesticated in the Saharan Desert, expanded its cultivation to East Africa and later to India. India's substantial contribution to pearl millet production, amounting to 44% of global millet production, highlights its importance. This grain, rich in iron and zinc, presents a cost-effective solution to address micronutrient deficiencies in regions where millet consumption is prevalent. Moreover, pearl millet's protein content, ranging from 9 to 21%, is comparable to wheat but surpasses that of sorghum, rice, and maize. Furthermore, pearl millet stands out as a mineral powerhouse, boasting significant amounts of iron, zinc, magnesium, copper, manganese, potassium, and phosphorus. While mature kernels are abundant in vitamin A, they lack vitamins B and C, yet contain valuable bioactive compounds such as phenolics. Recognizing the pivotal role of nutrition in both preventing communicable and non-communicable diseases underscores the significance of harnessing pearl millet's nutritional potential for the preparation of nutrient-dense foods.[6–10]

2. Objectives

1. To Formulate crackers using Pearl millet
2. To enrich the product by incorporating water chestnut flour
3. To determine the Sensory quality of the developed product
4. To Estimate the Proximate composition and cost of the developed product

2.1. Raw materials

The study was conducted in the Department of Food Processing and Engineering, JSS College of Arts, Commerce & Science, Mysore, focused on developing Pearl millet-based crackers. The main ingredients used were water chestnut flour and Bajra flour, obtained locally in Mysore. Additional ingredients such as salt, jaggery, garlic powder, ajwain, mixed herbs, oil, and baking powder were also sourced locally.

2.2. Formulation of the product

In standard, whole wheat flour and garlic powder was used as major ingredient. In four variations, the Bajra flour was replaced with whole wheat flour and value addition with water chestnut flour.

Table 1: Formulation of product (g/100gm) for preparation of water chestnut crackers

Ingredients	Control	PMC1	PMC2	PMC3	PMC4
Water Chestnut Flour	-	35	40	45	50
Bajra Flour	-	45	40	35	30
Whole Wheat Flour	80	-	-	-	-
Garlic Powder	10	10	10	10	10
Jaggery	5	5	5	5	5
Salt	2.5	2.5	2.5	2.5	2.5
Baking powder	1.5	1.5	1.5	1.5	1.5
Mixed Herbs	1	1	1	1	1

2.3. Method of preparation

The process involved mixing all ingredients with oil-coated hands to achieve a crumb-like texture. Water was gradually added to form smooth dough, which was then allowed to rest for 30 minutes. The dough was shaped into small balls, flattened evenly, pricked and cut into desired shapes, and baked in a preheated oven at 200°C for 10-12 minutes until light brown and crisp. Once cooled, the crackers were stored in an airtight container.

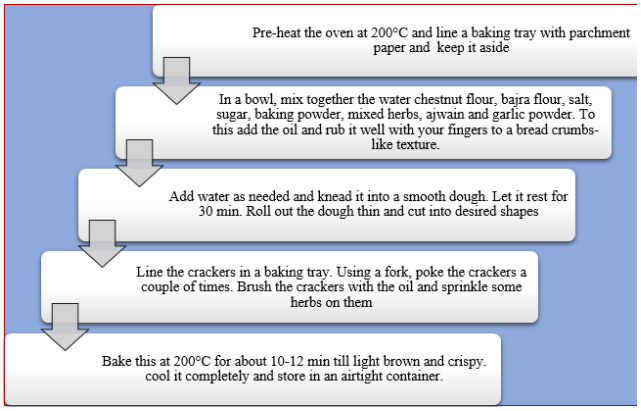

Figure 1: Flow chart of preparation of water chestnut crackers

2.4. Sensory analysis of water chestnut crackers

The developed crackers of all variations with control were subjected analyse and interpret the organoleptic properties with 9-point hedonic scale by semi-trained panelists participated in the assessment, rating the product on the overall score was determined based on average scores.[11]

2.5. Proximate analysis of water chestnut crackers

The nutritional profile of the product underwent analysis following A.O.A.C. (2005) methodologies. Moisture content was determined via hot air oven drying at temperatures ranging from 98 to 100°C. Protein content

was assessed using the Micro-Kjeldhal method to measure total nitrogen. Ash percentage was determined through high-temperature incineration in a muffle furnace, while fat content was estimated using the Soxhlet apparatus. Crude fiber content was analyzed using a crude fiber analyzer. Carbohydrate content was calculated by deducting the sum of moisture, protein, fat, and ash from 100, based on a 100g sample. Additionally, mineral concentrations, including calcium, iron, and phosphorus, were quantified using Atomic Absorption Spectrometry (AAS).[12]

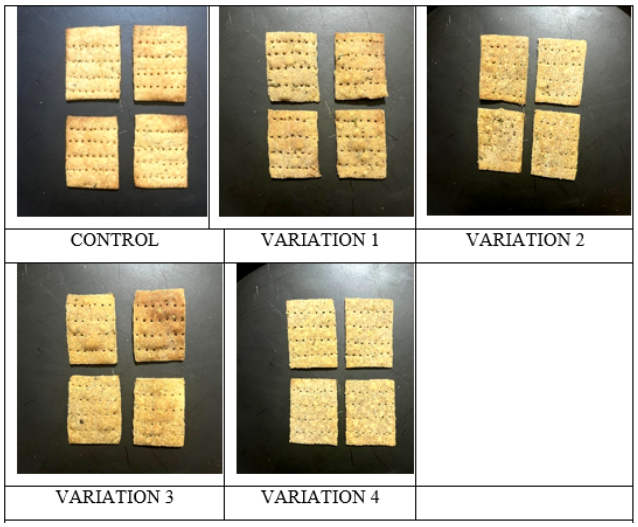

Figure 2: Preparation of water chestnut crackers

2.6. Statistical analysis

The data obtained from this study underwent statistical analysis using the Holm Sidak method to assess significance, with a predetermined level of $p \leq 0.05$. This approach allowed for rigorous examination of the results, ensuring robust conclusions regarding the impact of variables on the outcomes of the study.[13]

3. Results and discussion

3.1. Sensory evaluation of water chestnut crackers

Remarkably, among all variations, PMC4 was equally acceptable as that of control in terms of sensory attributes and is nutrient dense. The sensory scores are highlighted in the Table 2.

3.2. Proximate composition of water chestnut crackers

The proximate composition of the chosen PMC4 and the control were undertaken for analysis and the findings are outlined in Table 3. Notably, the moisture content remained constant across all variations of PMC. Intriguingly, PMC4 demonstrated elevated protein content in comparison to the control, accompanied by a slight reduction in carbohydrate fiber content. Additionally, PMC4 exhibited increased levels of essential nutrients, including phosphorus and calcium as well.

Table 2: Organolepticevaluation of water chestnut crackers, values are mean ± SD (n=30), p value ≤ 0.05

Parameter	Control	PMC1	PMC2	PMC3	PMC4
Appearance	8.72± 0.29	8.42± 0.27	8.49± 0.18	8.57± 0.23	8.69± 0.58
Colour	8.62± 0.45	8.12± 0.19	8.47± 0.12	8.31± 0.15	8.57± 0.72
Texture	8.60± 0.38	8.09± 0.17	8.44± 0.34	8.28± 0.26	8.58± 0.74
Flavour	8.68± 0.31	7.77± 0.28	7.21± 0.19	7.90± 0.09	8.55± 0.79
Taste	8.70± 0.38	7.95± 0.14	8.58± 0.26	8.01± 0.18	8.64± 0.69
Overall acceptability	8.65± 0.45	8.27± 0.16	8.42± 0.13	8.29± 0.12	8.58± 0.65

Table 3: Proximate composition of Water Chestnut crackers, values are mean ± SD (n=3) *p value ≤ 0.05 (Holm Sidak method).

Nutrients	Control	Variation 4 (PMC4)
Energy (kcal)	376.19±0.13	384.32±0.12*
Carbohydrate (g)	63.74±0.16	63.31±0.09
Protein (g)	10.35±0.11	11.88±0.05*
Fat (g)	8.87±0.23	9.28±0.14*
Fibre (g)	9.09±0.17*	7.46±0.21
Moisture (%)	5.12±0.10	5.09±0.16
Ash (g)	2.83±0.06	2.98±0.18
Iron (mg)	3.51±0.18	3.36±0.24
Phosphorus (mg)	255.73±0.20	310.53±0.19*
Calcium (mg)	30.1±0.17	48.56±0.23*

3.3. Cost analysis of water chestnut crackers

The cost of chestnut crackers is Rs.45/100g. This calculation involved aggregating the prices of all ingredients sourced from the market, along with the costs associated with labour, gas, taxes, electricity, and packaging.

4. Conclusion

The study aimed to develop nutrient rich, gluten-free crackers for individuals with celiac disease using pearl millet flour and water chestnut flour. Among

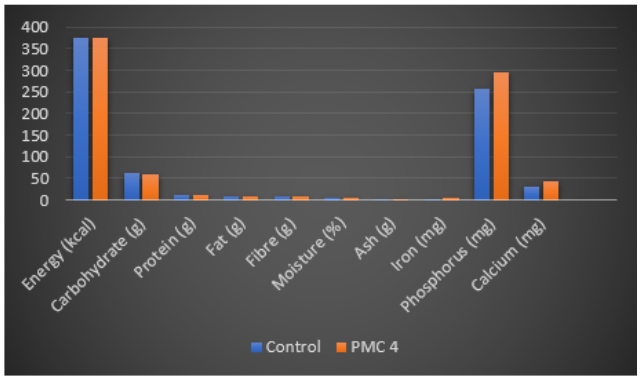

Figure 3: Graphical representation of proximate composition of water chestnut crackers and control

the variations tested, PMC4 emerged as the most preferred interms of sensory properties, showcasing superior nutritional composition. Phosphorus and calcium content was drastically increased with incorporation of water chestnut flour and is gluten free with replacement of wheat flour with pearl millet flour and was also rich in protein content. Overall the development of gluten Free Crackers using Water Chestnut and pearl millet flour was superior in terms of sensory and nutritional aspects on par with the control.

5. Source of Funding

None.

6. Conflict of Interest

None.

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