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RESEARCH ARTICLE

Innovative Development of Ragi-Based Chocolate Ladoo as a Healthy Confectionery Product

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ABSTRACT

Finger Millet (Eleusine coracana),or ragi, is a nutrient-dense millet, rich in calcium, iron, dietary fibre,& antioxidants. This study aimed to develop a novel functional confection, "Ragi Choco Treats", by combining the nutritional merits of ragi with its sensory appeal of chocolate. Three formulations (T1,T2, T3) were developed with various proportions of ragi flour, cocoa powder, jiggery, and ghee. The standardized formulation (T2) was analyzed for its proximate composition and subjected to sensory evaluation using a 9-point hedonic scale. The results indicated that the final product contained 483.8 kcal energy, 10.7g protein, 14.2g fat, 78g carbohydrate, and 4.74g dietary fibre per 100g. Sensory analysis revealed significant differences ($p<0.0001$) among treatments for colour, taste, flavour, and overall acceptability. Treatment with Balanced Composition of ingredients, received the highest sensory scores for taste (8.4), flavour (9.5), and overall acceptability (8.5). It was concluded that Ragi Choco Treats, particularly the T2 Variant, represent a successful innovation: a sensory acceptable and nutritious snack that leverages the functional properties of finger millet and cocoa.

Keywords: *Chocolate confectionery,Finger Millet, Functional food , Proximate composition,Ragi, Sensory evaluation.*

INTRODUCTION

Finger millet (*Eleusine coracana*), commonly knownas ragi, is a staple millet in South Asia and Africa, renowned for its exceptional nutritional profile. It is a rich source of minerals, particularly calcium and iron, dietary fibre, and beneficial phytochemicals with antioxidant properties. Recent systematic reviews have highlighted that ragi contains approximately 364 mg of calcium per 100 g, a concentration several times higher than that of milled rice. Furthermore, its low-to-moderateglycemic index makes it a suitable ingredient for managing blood glucose levels.

Traditional Processing methods like malting, roastingand fermentation have been shown to enhance the nutrient bioavailability and antioxidant potential of ragi while reducing anti-nutritional factors. While ragi has been conventionally used in products like porridges and traditional sweets (e.g.,ladoo, halwa), there is growing interest in developing innovative, hybrid functional foods that combine health benefits with high consumer appeal.

The Concept of Ragi Choco Treats is novel , aiming to merge the mineral and fibre richness of ragi with the palatability and flavour content of cocoa. This study bridges a gap in the literature regarding the development of millet-chocolate hybrid snacks. The objectives were to formulate nt variants of Ragi Choco

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Table 1. Initial formulations for Ragi Choco Treats (g/100g batch)

Parameter	T1	T2	T3
Ingredient			
Ragi Flour (g)	40.0	40 35.0	40
Chickpea Flour	10	5	5
Cocoa Powder	3	8	20
Jaggery Powder	15	15	10
Ghee	15	15	5
Peanuts	5	5	6
Sesame Flour	5	5	12
Dry Coconut Powder	5	5	1
Edible Gum	2	2	1

Treats, analyze their proximate composition, and evaluate their sensory characteristics to identify an optimal, consumer–accepted formulation.

MATERIAL AND METHODS

Raw Materials

High-quality ragi flour, cocoa powder, jaggery, ghee, chickpea flour, peanuts, sesame flour, dry coconut powder, and edible gum were procured for the study.

Product Formulation and Standardization

Three initialformulations (T1, T2, T3) were developed with varying ingredient proportions (Table 1). Based on preliminary sensory feedback, formulation T2 was selected as the standardized final product for detailed analysis (Table 2).

Standardized final formulation (T2) for Ragi Choco Treats (g/100g batch).

Ingredient	T2
Ragi Flour (g)	40
Chickpea Flour	5
Cocoa Powder	8
Jaggery Powder	15
Ghee	15
Peanuts	5
Sesame Flour	5
Dry Coconut Powder	5
Edible Gum	2

Production Process

The production process involved:

1) Selection and weighing of raw materials
2) Cleaning and sieving of ragi flour
3) Roasting of ragi flour and peanuts
4) Powdering of jaggery and coarse grinding of nuts
5) Gentle heating of ghee
6) Uniform mixing of all ingredients
7) Hand-rolling into spherical shapes (ladoos)
8) Cooling at room temperature
9) Packaging in food-grade LDPE pouches.

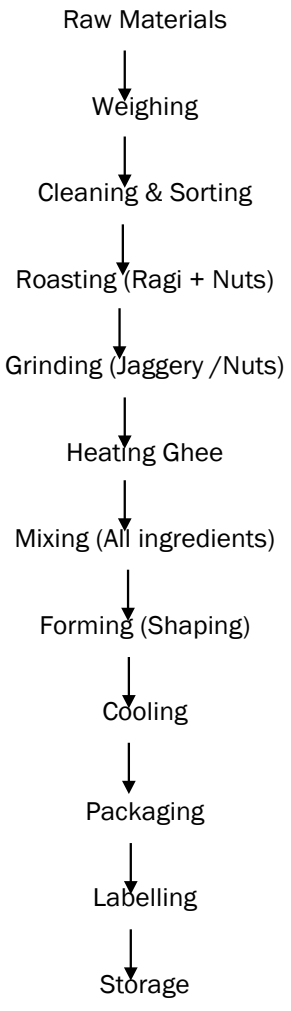

Figure 1: Flow process chart for the preparation of Ragi Choco Treats.

Table 5: Statistical analysis (ANOVA) of sensory data

Attribute	Treatment Means			F-value	p-value	Significant Differences
	T1	T2	T3			
Colour	8.40	9.60	5.60	965.6	<0.0001	T2 > T1 > T3
Texture	7.60	7.60	7.50	0.78	0.528	No Significant Diff.
Taste	4.52	8.40	4.60	1125.6	<0.0001	T2 > T1, T3
Flavour	6.50	9.50	8.40	489.6	<0.0001	T2 > T3 > T1
Overall Acceptability	7.60	8.50	6.60	193.6	<0.0001	T2 > T1 > T3

Sensory Evaluation

The three formulations (T1, T2, T3) and the control (T0) were evaluated sensorially by a panel of untrained judges. Attributes including colour &appearance, texture, taste, flavour, and overall acceptability were scored using a 9-point hedonic scale.

Statistical Analysis

Sensory data were analyzed using one-way analysis of variance (ANOVA). Where significant differences were ($p<0.05$), post hoc tests were conducted to identify specific differences between treatment means.

RESULTS AND DISCUSSION

Proximate Composition

The proximate composition ofstandardized Ragi Choco Treats (T2) is presented in Table 3. The product provided 483.8 kcal per 100 g, with 10.7g protein, 14.2g fat, and 78g carbohydrates. The dietary fibre content was 4.74g, and the ash content (indicative of mineral matter) was 2.96g. This composition is favourable compared to many conventional sweets, offering a balance of energy and nutrients, including a significant amount of fibre and protein derived from ragi and other ingredients.

Proximate composition of Ragi Choco Treats (T2) per 100g.

Chemical Parameters	RagiChocoTreats
Energy	483.8kcal
Carbohydrate	78g
Fat	14.2g
Protein	10.7g
Ash	2.96g
Fibre	4.74g
Moisture	7.1g

Sensory Evaluation

The mean sensory scores for all treatments are summarized in Table 4. Statistical analysis (Table 5) revealed significant differences ($p<0.0001$) among the treatments for colour, taste, flavour, and overall acceptability. The texture attribute did not show any significant differences ($p=0.528$), indicating a consistent mouth feel across all variants.

T2 consistently received the highest scores for taste (8.4), flavour (9.5), and overall acceptability (8.5). The colour of T2 was also rated highest (9.6), likely due to its appealing brown hue from balanced cocoa content. In contrast T3, with a very high cocoa content (20%), received low scores for taste (4.6) and colour (5.6), suggesting potential bitterness and an overly dark appearance. T1, with low cocoa, scored poorly on taste (4.5) and flavour (6.5), indicating that an insufficient amount of cocoa fails to mask the earthy notes of ragi effectively.

These findings align with previous studies(7.9), which report that optimal incorporation of functional ingredients is crucial for maintaining sensory acceptability. The high overall acceptability of T2 demonstrates that a balanced formulation successfully marries ragi's nutritional profile with the desirable sensory properties of chocolate.

CONCLUSION

The study successfullydeveloped a novel functional confection, ragi choco treats. The optimized formulation (T2) demonstrateda satisfactory nutritional profile, being a source of protein and dietary fibre. Sensory evaluation established that this formulation was the most preferred, achieving high scores for key attributes like taste, flavour, and overall acceptability. The integration of ragi with cocoa proved to be a viable

Mean sensory scores of different Ragi Choco Treat formulations.

Sample	Colour and appearance	Texture	Taste	Flavour	Overall Acceptability
TO(Control Sample)	7	7	7	7	7
T1	8.4	7.6	4.5	6.5	7.6
T2	9.6	7.6	8.4	9.5	8.5
T3	5.6	7.5	4.6	8.4	6.6

strategy for creating a snack that is both nutritious and sensorily appealing. product has significant potential as a healthier alternative to traditional high-calorie, low-nutrient sweets, catering to the growing demand for functional foods. Future work may focus on shelf-life stability, in vivoglycemic index studies, and further mineral and antioxidant profiling.

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Ethics Statement

This study did not involve human participants, animal subjects, or clinical trials. Therefore, ethical approval was not required for this research.

Originality and Plagiarism

The author declare that this manuscript is an original work and has not been published previously nor is it under consideration for publication elsewhere. All sources of information have been properly cited, and the manuscript is free from plagiarism.

Consent for Publication

All author have read and approved the final version of the manuscript and consent to its submission and publication in the journal.

Competing Interests

I declare that there are no competing interests, financial or non-financial, that could have influenced the outcomes or interpretation of this research.

Data Availability

All data generated or analyzed during this study are included within this published article.

For any additional information regarding the research data, readers may contact the author directly.

Author Contributions

Sai Gudekar solely contributed to the conceptualization, methodology development, experimentation, data analysis, manuscript writing, and final approval of the manuscript.

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