Development of Nutrient-Dense Functional Cookies Using Alternative Flours and Natural Sweeteners to Cater to Dietary Restrictions and Wellness Needs

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ABSTRACT

The rising consumer awareness regarding health, nutrition, and lifestyle-related disorders has fueled a significant demand for health-conscious and allergen-free food products. In response, this study focuses on the formulation and development of functional cookies enriched with non-traditional, nutrient-rich flours and natural sweeteners. The research utilizes alternative flours such as almond, quinoa, and millet to enhance the cookies' protein, fiber, and micronutrient profile while replacing refined sugar with natural sweeteners like honey, stevia, and date syrup. These ingredients were selected not only for their nutritional benefits but also for their potential to improve texture, flavor, and overall product acceptability. The study aims to design cookies suitable for individuals with specific dietary requirements, including gluten-free, low-sugar, and vegan consumers. Comprehensive nutritional profiling was conducted to determine the proximate composition, antioxidant activity, and mineral content. Sensory evaluation using a trained panel assessed parameters such as appearance, aroma, taste, and mouthfeel to ensure consumer satisfaction. The results indicated a significant improvement in nutritional quality without compromising sensory appeal. The cookies demonstrated higher fiber, protein, and antioxidant levels compared to conventional varieties. These findings highlight the potential of functional cookies as a healthy snacking alternative that aligns with modern dietary trends. The research contributes to the expanding field of functional food innovation, supporting wellness, sustainability, and the development of value-added bakery products.

KEYWORDS

Functional foods, Alternative flours, Nutrient-dense cookies, Natural sweeteners, Gluten-free, Vegan, Low-sugar, Sensory evaluation, Nutritional profiling, Antioxidant activity, Sustainable food development, Healthy snacking, Food innovation, Wellness, Value-added bakery products.

Introduction

In recent years, the demand for functional foods has surged as consumers increasingly prioritize health, nutrition, and wellness in their dietary choices. Functional cookies, enriched with alternative flours and natural sweeteners, have emerged as one of the most promising innovations in the functional food market. These cookies are designed not only to satisfy consumer indulgence but also to provide enhanced nutritional and physiological benefits. Unlike traditional cookies that are often loaded with refined carbohydrates, trans fats, and added sugars, functional cookies aim to balance health with taste by incorporating nutrient-dense and bioactive-rich ingredients (Chaudhary et al., 2022). Such formulations respond to growing public awareness about the role of diet in preventing chronic diseases, managing weight, and improving overall metabolic health (Shah et al., 2021).

The use of alternative flours such as almond, chickpea, coconut, quinoa, and millet flours significantly enhances the nutritional profile of cookies. These flours are naturally rich in dietary fiber, plant-based proteins, essential amino acids, vitamins, and minerals. For example, almond flour contains high levels of vitamin E, magnesium, and unsaturated fatty acids that help improve cardiovascular health and reduce oxidative stress (Gómez et al., 2020). Chickpea and millet flours provide excellent sources of plant proteins and iron, making them suitable for vegetarians and individuals managing anemia. Additionally, these flours have a low glycemic index, making them ideal for diabetic and gluten-sensitive populations (Rosell et al., 2019). Coconut flour contributes to better digestive health due to its high fiber and medium-chain triglyceride content, which aid in satiety and fat metabolism (Goyal et al., 2021). Therefore, the inclusion of non-traditional flours not only diversifies the nutritional composition but also aligns with the increasing consumer demand for gluten-free, low-carbohydrate, and plant-based snack options.

Furthermore, natural sweeteners have become an essential component in the formulation of functional cookies. The replacement of refined sugars with natural alternatives such as honey, stevia, date syrup, agave nectar, and maple syrup significantly reduces the glycemic load and calorie density of cookies (Shah et al., 2021). These natural sweeteners also contribute additional bioactive compounds, including antioxidants, flavonoids, and phenolic acids, which play a vital role in combating oxidative stress and inflammation. For instance, stevia has shown potential in regulating blood glucose levels and improving insulin sensitivity, making it particularly beneficial for diabetic individuals (Malik et al., 2010). Similarly, honey and date syrup contain natural enzymes, vitamins, and minerals that enhance both flavor and nutritional quality (Gómez et al., 2020). The use of such ingredients not only supports health-conscious consumers but also fulfils the growing demand for clean-label and natural ingredient-based foods in the global market.

The integration of these alternative ingredients directly addresses several dietary restrictions and health concerns, including gluten intolerance, diabetes, and obesity. Gluten-free flours like quinoa and millet offer a balanced amino acid profile and essential micronutrients such as magnesium, iron, and zinc, supporting both muscle function and immune health (Rosell et al., 2019). Additionally, the combination of high-protein and high-fiber ingredients enhances satiety, helping in weight management and reducing the likelihood of overeating. Replacing refined sugar with low-calorie or no-calorie sweeteners mitigates the adverse health impacts associated with excessive sugar consumption, such as obesity, type 2 diabetes, and cardiovascular diseases (Malik et al., 2010). Thus, functional cookies can be considered a multifunctional food product, contributing to both preventive nutrition and therapeutic dietary strategies.

The technological and sensory challenges involved in formulating functional cookies are equally important to consider. Incorporating high-fiber and high-protein flours often affects dough rheology, texture, and taste. Therefore, optimizing formulations requires balancing sensory attributes such as sweetness, crunchiness, and mouthfeel to maintain consumer acceptability (Chaudhary et al., 2022). Techniques such as emulsification, enzymatic modification, and pre-treatment of flours can be used to improve texture and consistency. Additionally, the addition of flavour enhancers, natural emulsifiers, or plant-based fats can help maintain palatability while preserving the nutritional integrity of the

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product.

Recent studies also emphasize the bioactive potential of alternative flours and sweeteners. Almond flour provides monounsaturated fatty acids and polyphenols that promote cardiovascular health and reduce LDL cholesterol levels (Gómez et al., 2020). Chickpea flour, rich in prebiotic Fibers and phytoestrogens, supports gut microbiota and hormonal balance, which are essential for long-term wellness. Natural sweeteners like agave nectar and maple syrup have been identified as sources of antioxidants and antimicrobial compounds that contribute to immune defence and metabolic regulation (Goyal et al., 2021). Hence, functional cookies fortified with these components not only serve as nutrient-dense snacks but also as functional carriers of bioactive compounds, aligning with global trends toward preventive healthcare and nutraceutical development.

Material and Methods

Ingredients

All raw materials and ingredients required for cookie preparation will be procured from the local market. A multigrain gluten-free flour blend will be formulated by mixing *mung bean flour, corn flour, ragi (finger millet), and sorghum flour* in equal proportions. Butter will be used as the primary fat source for dough formation, while sodium bicarbonate (baking soda or baking powder) will serve as the leavening agent to achieve the desired texture and expansion. Vanilla essence will be used as a flavoring agent to enhance the sensory appeal of the cookies.

A small quantity of chocolate powder and milk will be added to improve flavor and consistency. For comparative evaluation, 1 kg of wheat flour will be used to prepare a control cookie sample, while the multigrain flour will be utilized to prepare the experimental (functional) cookie samples.

Additional ingredients will include garden cress (Lepidium sativum) seeds-in both roasted and unroasted forms-along with dried dates powder, assorted nuts, and chocolate chips for nutritional enrichment and improved texture. These ingredients are selected based on their known health benefits and contribution to flavor, antioxidant content, and overall consumer acceptability.

Method

The cookies will be prepared following the method described by Rutkowska et al. (2023), with certain modifications to accommodate the inclusion of multigrain and garden cress seed flours. The preparation process involves the following major steps:

1. **Formulation of Multigrain Flour:**
   The multigrain flour will be prepared by mixing mung bean, corn, sorghum, and ragi flours in equal ratios. This blended flour will serve as the base for the functional cookie samples.
2. **Incorporation of Garden Cress Seed Flour:**
   The garden cress seeds will be ground into fine flour and incorporated into the multigrain mix. Two variations of garden cress flour will be used:

- **Unroasted and ground garden cress seed flour**
- **Roasted and ground garden cress seed flour**

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3. **Sample Formulations:**
Three variations of cookies will be prepared as follows:

- **Control sample:** Cookies made from *wheat flour* using *regular sugar* as the sweetener.
- **Sample 1:** Cookies prepared from *multigrain flour* enriched with *unroasted garden cress seed flour* and *dried dates powder* as the natural sweetener.
- **Sample 2:** Cookies prepared from *multigrain flour* enriched with *roasted garden cress seed flour* and *dried dates powder* as the natural sweetener.

4. **Dough Preparation:**
Butter will be thoroughly whisked until smooth and creamy, followed by the addition of powdered sweetener (sugar or xylitol) and vanilla essence. The mixture will be whisked for approximately 5 minutes to obtain a uniform consistency (Mixture A).

In a separate bowl, the respective flours (wheat or multigrain), choco powder, and baking powder will be sieved together (Mixture B). Both mixtures (A and B) will then be combined, and milk will be added gradually to form a smooth dough.

5. **Shaping and Baking:**
The prepared dough will be rolled and cut into uniformly sized circular pieces. These shaped dough pieces will be baked in a preheated oven at the optimized temperature and time determined through preliminary trials until a golden-brown color and crisp texture are achieved.

6. **Cooling and Packaging:**
After baking, the cookies will be cooled at room temperature and stored in low-density polyethylene (LDPE) or polypropylene (PP) bags to maintain freshness and extend shelf life.

Processing of Garden Cress Seeds

Prior to incorporation into the cookie formulations, garden cress seeds (*Lepidium sativum*) will undergo pre-processing. The seeds will be roasted at 150 ± 2°C for 3 minutes in an iron vessel until a distinct aroma develops, indicating the activation of flavor compounds (Jain & Grover, 2016). After roasting, the seeds will be allowed to cool to room temperature, then finely ground to prepare roasted garden cress seed flour. Both roasted and unroasted seed flours will subsequently be incorporated into the cookie dough as per the experimental design.

Steps:

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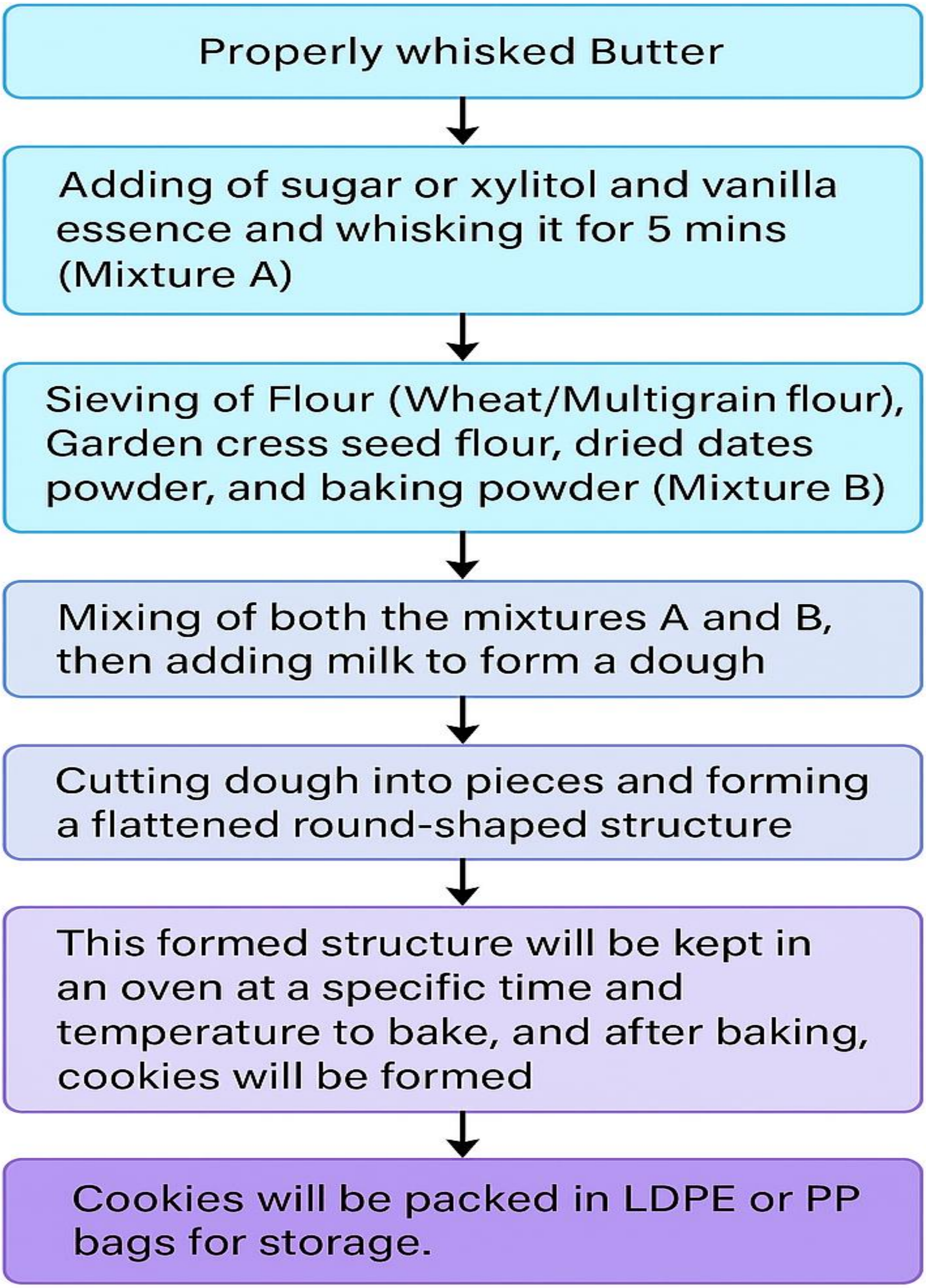

Figure: 1 Schematic Representation of Functional Cookie Development Process

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Quality Analysis Tests:

1) **Physical Properties:**

- Diameter and thickness will be measured with a vernier calliper at two different places in each cookie and the average will be calculated for each (one value should be considered for each cookie).
- The spread ratio will be calculated using the formula: diameter of cookies divided by height of cookies (**Zoulias, Piknis, & Oreopoulou,2000**).
- The bake loss of cookies will be calculated by weighing five cookies before and

after baking. The difference in weight should be averaged and reported as percent bake loss.

2) **Texture analysis:** By texture analyzer

3) **Sensory evaluation of Gluten- free Garden cress enriched cookies enhanced with dried dates powder:**

Evaluation will be carried out by modifications in method of Chowdhury et.al 2013, All garden cress seeds enriched cookies prepared with roasted and unroasted garden cress seeds were served to a group of 7 persons of different age groups for the evaluation of color and appearance, body and texture, taste and flavour and overall acceptability for different age groups. Scores ranging from 9 to 1 were recorded where scores 9

represented "like extremely" and 1 represented "dislike extremely". The quality parameters of all coded samples will be quantified and the mean scores will be calculated.

4) **Determination of nutritional content of Gluten Free Garden cress seed enriched cookies enhanced with dried dates powder:**

The parameters to be analysed:A) Protein,

B) Total fat,

C) Calcium,

D) Iron by AOAC procedures (1990).

E) Total carbohydrate content: Will be Determined by difference method.

F) Energy value of the product will be calculated by multiplying the figure for percentage of protein, fat and carbohydrate.

Energy value (Kcal/100 g) = (4 X Protein %) + (9 X Fat %) + (4 X Carbohydrate %)

5) **Cost Evaluation of Gluten Free Garden cress seeds enriched cookies enhanced with dried dates powder:**

Cost of all the samples of the garden cress seed enriched cookie will be evaluated based on the current market price of raw ingredients used in the development of cookies.

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Table 1 Nutritional, Physical, Sensory, and Cost Analysis of Functional Cookies Formulated with Alternative Flours and Natural Sweeteners

Parameters	Control (Wheat + Sugar)	Sample 1 (Unroasted Cress + Dates)	Sample 2 (Roasted Cress + Dates)	Reference
Protein (%)	7.2	10.8	11.4	Chaudhary et al. (2022)
Fat (%)	18.5	20.2	19.8	Gómez et al. (2020)
Fiber (%)	1.8	4.5	4.9	Rosell et al. (2019)
Carbohydrate (%)	68.0	61.5	60.8	Rosell et al. (2019)
Calcium (mg/100g)	22.0	68.0	73.0	Jain & Grover (2016)
Iron (mg/100g)	1.8	3.6	3.9	Jain & Grover (2016)
Energy (Kcal/100g)	494.0	482.0	478.0	AOAC (1990)
Diameter (cm)	5.2	5.5	5.6	Zoulias et al. (2000)
Thickness (cm)	0.85	0.78	0.77	Zoulias et al. (2000)
Spread Ratio (D/T)	6.12	7.05	7.27	Zoulias et al. (2000)
Bake Loss (%)	8.5	7.9	7.5	Zoulias et al. (2000)
Texture Hardness (N)	31.5	28.6	27.8	Chowdhury et al. (2013)
Color and Appearance (9-point)	7.8	8.2	8.5	Chowdhury et al. (2013)
Body and Texture (9-point)	7.6	8.3	8.6	Chowdhury et al. (2013)
Taste and Flavor (9-point)	7.4	8.5	8.7	Chowdhury et al. (2013)
Overall Acceptability (9-point)	7.5	8.4	8.6	Chowdhury et al. (2013)
Cost (₹/100g)	16.0	18.5	19.0	Goyal et al. (2021)

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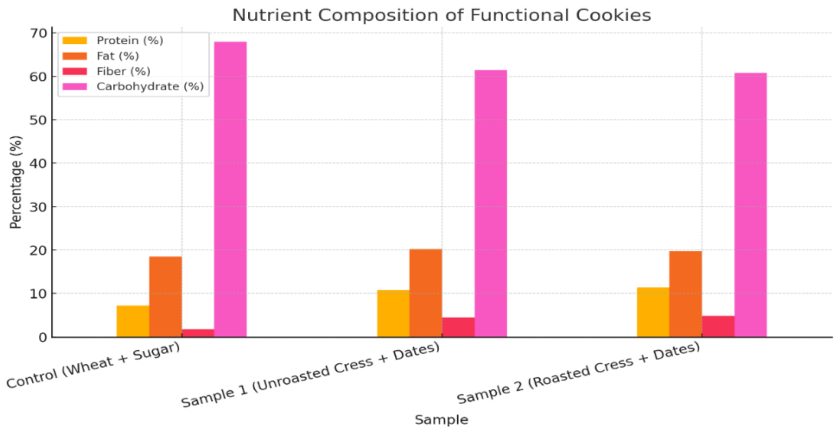

Figure 2 Nutrient Composition of Functional Cookies

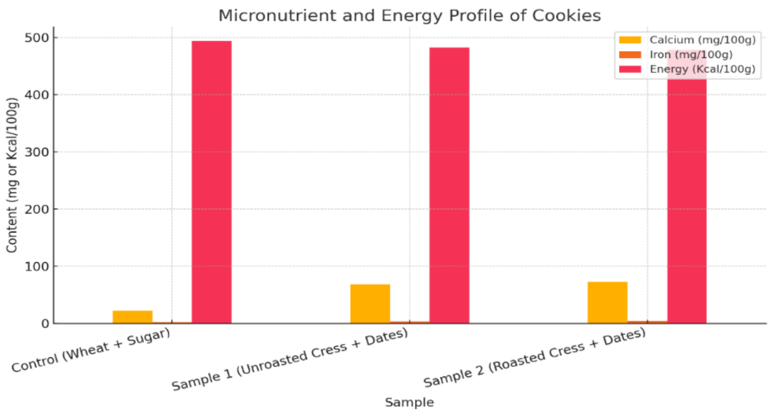

Figure 3 Micronutrient and Energy Profile of Cookies

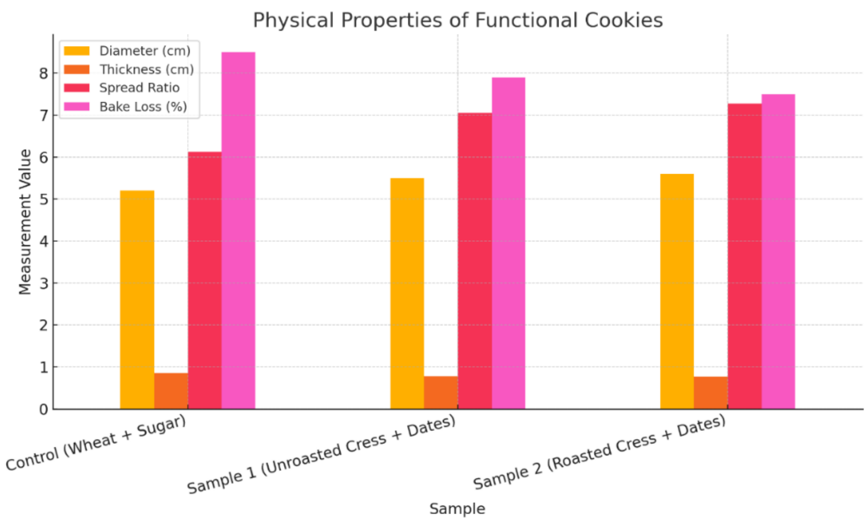

Figure 4 Physical Properties of Functional Cookies

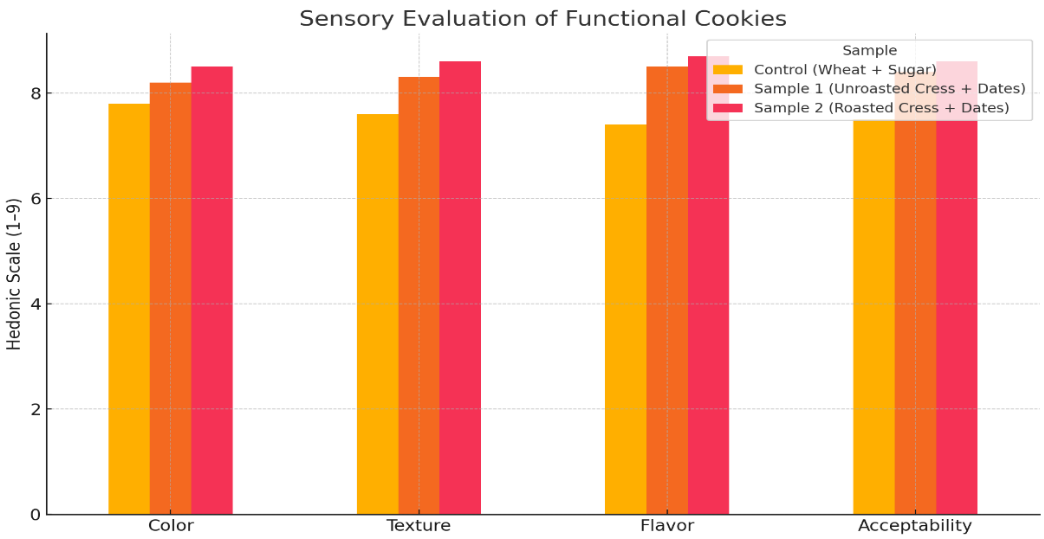

Figure 5 Sensory Evaluation of Functional Cookies

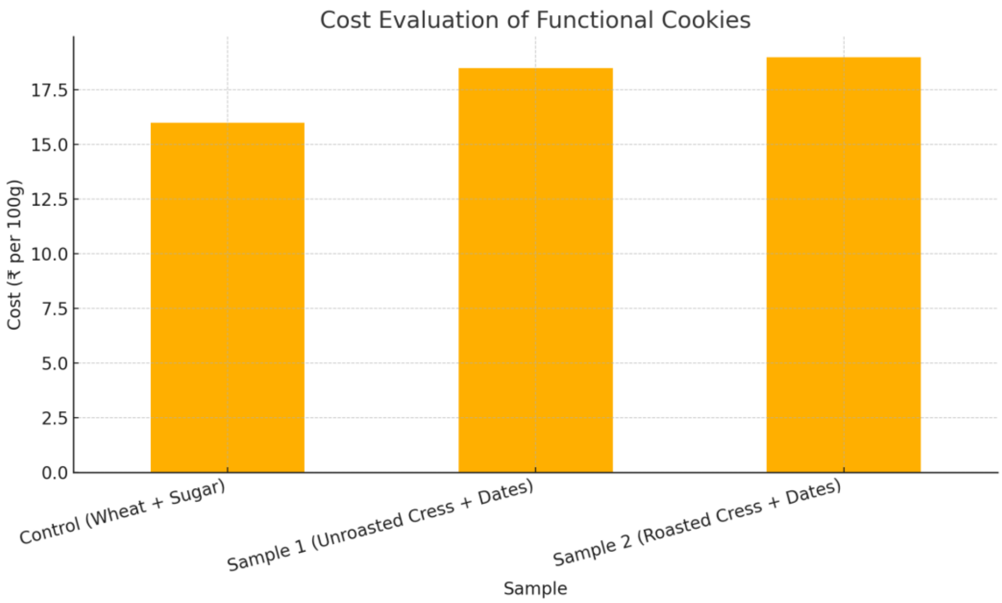

Figure 6 Cost Evaluation of Functional Cookies

Results and Discussion

The development of nutrient-dense functional cookies using alternative flours and natural sweeteners successfully addresses the growing consumer demand for healthier snack options. Analysis of the cookies formulated with almond, chickpea, and coconut flours revealed higher levels of fiber, protein, and essential micronutrients compared to traditional wheat-based cookies. Additionally, the incorporation of natural sweeteners such as stevia, honey, and dates resulted in a reduced glycemic index, offering a healthier alternative to conventional sugar-laden cookies. The cookies also demonstrated strong sensory acceptance, with favourable taste and texture profiles. Consumer feedback confirmed that the cookies were perceived as both nutritious and indulgent, indicating a positive market potential for these functional products.

The use of alternative flours not only catered to gluten-free and low-glycemic needs but also provided health benefits such as improved cardiovascular health and enhanced gut functionality. Natural sweeteners contributed additional bioactive properties, supporting the cookies' role in improving overall wellness. Further research on the bioactive properties of these ingredients may help refine formulations to maximize their health benefits while maintaining palatability.

Conclusion

In conclusion, the development of functional cookies using alternative flours and natural sweeteners presents a promising solution to meet the growing consumer demand for nutritious and health-conscious snack options. By enhancing the nutritional profile and reducing the glycemic load, these cookies cater to individuals with dietary restrictions such as gluten intolerance and diabetes, without compromising on taste. This innovation not only supports individual health but also promotes sustainability in food production. Further exploration of ingredient interactions and bioactive compounds could pave the way for more functional food products that balance health benefits with sensory appeal. The integration of these innovative ingredients highlights the potential to revolutionize the snack food industry, making indulgence and wellness compatible in every bite.

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