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Development and evaluation of nutritious gluten-free cookies enriched with black rice and Kimia dates

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Abstract
Cookies are a popular bakery item enjoyed by people of all ages as a timeless snack choice. The current study aims to develop cookies by incorporating black rice flour and Kimia dates. The nutritious snack has beneficial nutrients and it also serves as a ready-to-eat baked product for people who want to eat nutritious food anytime and anywhere at an affordable price. The primary focus of the study was to develop cookies that are rich in protein, fibre, iron, antioxidant and anthocyanin content and prepared without adding refined flour, white sugar, and the product was gluten-free cookies. The development process in the study consists of several important stages: formulation and standardization of the cookie, evaluation of the cookies involving the sensory analysis, nutrient analysis, microbial analysis, shelf-life study and the research design used in the study was "mixed research approach" and commercialization of the cookies involves packaging, labeling and commercializing. Consumer testing provides critical feedback, ensuring the final product meets market expectations and dietary requirements. Hence the development of nutritious cookies not only satisfy cravings but also support a healthy lifestyle.

Keywords: Black rice, anthocyanin, Kimia dates, cookies

Introduction

Food product development offers an innovative approach to creating more nutritious and consumer-focused products, going beyond the profit-driven motives of the food industry. The core objective of food innovation is to produce commercially viable and technically feasible products that address consumer needs. This process involves idea generation, feasibility assessment, and the creation of standardized, nutrient-dense products tailored to market demands.

Globally, the demand for bakery products has surged due to factors like affordability, convenience, and longer shelf life compared to other ready-to-eat options. The bakery segment, encompassing items such as cakes, biscuits, buns, and puffs, has evolved to align with the growing health consciousness of consumers. This shift has driven industries to fortify baked goods with nutritious ingredients, blending traditional flavors with healthier alternatives to meet the expectations of health-focused consumers (Das *et al.*, 2023) [2].

Rice (*Oryza sativa* L.) plays a pivotal role as the second most important cereal globally, serving as a staple for the majority of the Asian population. India, a significant contributor to global rice production, is instrumental in addressing the dietary protein and calorie needs of its population. Among various rice types, colored rice varieties such as black rice stand out for their unique nutritional benefits. Known for its rich antioxidant and phenolic content, black rice offers health-promoting properties and is gaining popularity in global markets due to its exceptional nutritional profile (Saha *et al.*, 2022) [10].

Black rice, often reserved for special occasions in Asia, is cultivated predominantly in regions like Manipur, Odisha, West Bengal, and Tamil Nadu. This medium-grain, non-glutinous heirloom rice, distinguished by its deep purple hue and nutty-sweet flavor, is packed with anthocyanins, amino acids like lysine and tryptophan, and potent antioxidants. Its versatile applications range from porridge and desserts to cakes and noodles, making it increasingly accessible in mainstream markets (Kumari, 2020) [5].

Dates (*Phoenix dactylifera* L.) hold historical and cultural significance, particularly in the Middle East and Arab countries, where they have been consumed for over 6,000 years. Beyond their role as a staple food, dates are celebrated for their energy-rich composition and health-promoting properties, including anti-inflammatory, antibacterial, and antioxidant effects (Mirghani, 2021) [7].

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Kimia dates, known for their distinct flavor and exceptional nutritional value, further enhance the appeal of date-based food products (Hurzuk *et al.*, 2023) [3].

Traditionally, the primary ingredients for bakery items include refined flour, eggs, sugar, and fat. However, recent studies have explored alternative ingredients like black rice flour for its functional and nutritional properties. Rich in dietary fibers, phenolic acids, and anthocyanins, black rice has been linked to health benefits such as reduced risks of diabetes, obesity, cancer, and heart disease. Research indicates that incorporating black rice flour in bakery formulations improves the product's textural and functional properties while enhancing its economic and nutritional value (Das *et al.*, 2023) [2].

The increasing global interest in healthier and functional bakery products underscores the potential of using black rice flour as a key ingredient. This study aims to investigate the development of innovative cookies incorporating black rice flour and Kimia dates, providing a nutritious, consumer-focused, and commercially viable bakery product.

Methodology
The study aimed to develop black rice and dates-enriched cookies, focusing on formulating a nutritious snack with desirable taste, texture, and nutritional value. A mixed research approach, combining qualitative and quantitative methodologies, was employed. The required ingredients, including black rice flour(375g), unsalted butter(250g), jaggery powder(200g), Kimia dates(100g), and eggs(1), were procured from local stores in Perambur, Chennai, while additional ingredients such as dates essence, vanilla essence, and baking powder were sourced from supermarkets. The standardized recipe included specific proportions of these ingredients to ensure consistency in product quality.

The sensory evaluation of the cookies was conducted, using a 5-point hedonic scale. A panel of 15 faculty members assessed the appearance, texture, taste, color, and overall acceptability of the cookies. Nutritional analysis, including parameters such as energy, carbohydrates, protein, fat, fiber, and iron content, was performed by using established methods such as the Atwater general factor system, Kjeldahl method, and Soxhlet extraction. The antioxidant and anthocyanin contents were analyzed by the Phosphomolybdenum assay.

Microbial analysis, including total plate and yeast & mold counts, was carried out at Biogrowth Lab Services on days 1, 7, 14, and 21 to monitor the microbial growth and evaluate the shelf life of the cookies. The shelf life was determined to be 22 days at room temperature. The cookies were packaged in 13.5×22 cm plastic Ziploc pouches, with labels providing details such as product name, net quantity, price, and manufacturing and expiry dates. Commercialization was conducted accompanied by a cost analysis to evaluate ingredient expenses and profit margins. Feedback was gathered from 25 panel members through a structured form, assessing attributes such as appearance, texture, taste, packaging, quantity, price, and overall acceptance. This comprehensive methodology ensured a thorough evaluation of the cookies, from formulation to commercialization.

Results and Discussion

Table 1: Overall likes and dislikes analysis

Rating	Black rice & dates (jaggery powder)	Black rice& dates (icing sugar & white Sesame seeds)	Black rice & dates (icing sugar & cashews)
Dislike very much	-	-	-
Dislike slightly	1	-	2
Neither like nor dislike	-	-	1
Like slightly	23	33	14
Like very much	51	42	58

Table.1 represents the overall likes and dislikes analysis for three different variations of a cookie made with black rice and dates: one with jaggery powder, one with icing sugar and white sesame seeds and one with icing sugar and cashews. The "Black rice & dates (Jaggery powder)" cookie received the highest number of "Like very much" scores (51) and "Like slightly" scores (23), with only one "Dislike slightly" score, indicating a strong preference among the respondents. The "Black rice & dates (Icing sugar & white sesame seeds)" cookie also performed well, with (42) respondents liking it very much and (33) liking it slightly, and no negative responses. The "Black rice & dates (Icing sugar & cashews)" variation received the highest number of "Like very much" scores (58), but had a few respondents disliking it slightly (2) or neither liking nor disliking it (1), along with the lowest number of "Like slightly" scores (14).According to the above data, "Black rice & dates (Jaggery powder)" cookie received the highest number of "Like very much" and strongly preferred among the respondents. Hence the investigator has standardized product-A (black rice and dates with jaggery powder cookies) for the further analysis

Table 2: Nutrient analysis of black rice and dates cookies

Parameter (kcal/g/mg/kg)	Value/100g
Energy (kcal)	467.4
Protein (g)	6.9
Fat (g)	19.08
Carbohydrates (g)	67
Sugar (g)	11.12
Fibre (g)	2.1
Iron (mg)	2.33
Total antioxidant (mg/kg	400
Total anthocyanin (mg/kg)	354

The total energy content of the cookies was 467.4kcal/100g, the total protein content of the cookies was 6.9g/100g, the total fat content of the cookies was 19.08g/100g, the total carbohydrate content of the cookies was 67g/100g, the sugar content of the cookies was11.12g/100g, the total fibre content of the cookies was 2.1g/100g, the iron content of the cookies was 2.33g/100g, the total antioxidant content of the cookies was 400mg/kg, the total anthocyanin content of the cookies was 354mg/kg.

Table 3: Microbial Analysis

Parameters	Unit	7thday	14thday	21stday
Total plate count	CFU/g	<10	<10	300
Yeast & mould	CFU/g	<10	<10	40

CFU-(Colony Forming Unit)

<10Canbeconsideredasabsent
The presence of total plate count and yeast & mould in black rice and dates cookies. The shelf-life study was observed on the 7ᵗʰday, 14ᵗʰday and on21st day. On the 7th and14th day of the observation, no significant changes of total plate count and yeast & mould count was seen and was mentioned as<10 that it can be considered as absent. Whereas, on the 21st day total plate count was 300CFU/g and yeast & mouldwas40CFU/g. from the shelf-life study we can interpret that the microbial count was seen only after 14th day and microbial count was observed on 21stday.

Table No. 4(A&B) outlines the ingredients and their respective quantities used for making cookies. The cost of the ingredients was as follows: 1.25 kg of black rice flour cost Rs. 275, 700 g of unsalted butter cost Rs. 360, 600 g of jaggery powder cost Rs.40, 600 g of dates cost Rs.50, 3 eggs cost Rs.18, 10 ml of essence cost Rs.6, and 9 g of baking powder cost Rs.2. Additional costs for grinding, packaging, labeling, labor, and electricity were also accounted for.

The total ingredients and associated costs yielded 125 cookies at a total cost of Rs.1150. Consequently, the cost of one cookie was calculated to be Rs.9.20. This price makes the black rice and dates cookies affordable for consumers.

Table 5 presents feedback on the overall acceptance of the commercialized product across different age groups. Among respondents under the age of 18, 30.8% were satisfied, 100% were unsatisfied, and 9.1% were very unsatisfied. For the age group 19-24, 23.1% were satisfied, while 54.5% were very satisfied. Respondents aged 25-44 included 23.1% who were satisfied and 27.3% who were very satisfied. In the age group above 45, 23.1% were satisfied, and 9.1% were very satisfied.

Table 4: Cost analysis A& B

Cost Analysis (A)					
S. No	**Ingredients**	**Quantity**	**Unit/Price**	**Cost**	
1	Black Rice Flour	1.25 (Kg)	220.00	275.00	
2	Unsalted Butter	700.00(gm)	0.51	360.00	
3	Jaggery Powder	600.00 (gm)	0.07	40.00	
4	Dates	600.00(gm)	0.25	150.00	
5	Egg	3.00(Each)	6.00	18.00	
6	Essence (Vanilla, Dates)	10.00(ml)	0.60	6.00	
7	Baking Powder	9.00 (gm)	0.22	2.00	
8	Grinding	1.00 (Each)	10.00	10.00	
9	Packaging	25.00(Each)	3.50	87.50	
10	Labelling	25.00 (Each)	2.00	50.00	
11	Labour	50	1.00	50.00	
12	Electricity	28.57	3.50	100.00	
			Total	1148.50	
Cost Analysis (B)					
Production Cost		1148.50			
Rounding off		1.50			
Total Cost		1150.00			
Total No. of Cookies		125.00			
Cost of each Cookie		9.20			
No. of Cookies in each Pouch		5.00			
Costof1Pouch		46.00			

Table 5: Distribution of feedback on Overall acceptance

[Overall acceptance]		Age Category				Total	p value
		Below 18 years	19 to24 years	25 to 44 years	Above 45 years		
Satisfied	N	4	3	3	3	13	
	%	30.8%	23.1%	23.1%	23.1%	100.0%	
Unsatisfied	N	1	0	0	0	1	
	%	100.0%	0.0%	0.0%	0.0%	100.0%	0.332
Very satisfied	N	1	6	3	1	11	
	%	9.1%	54.5%	27.3%	9.1%	100.0%	
Total	N	6	9	6	4	25	
	%	24.0%	36.0%	24.0%	16.0%	100.0%	

*Statisticalsignificancewith95%CI

Summary and conclusion

A conventional recipe for cookies enhanced with dates and black rice was created and successfully made. Black rice flour (375g) and dates (100g) were the main ingredients, with the following extras: unsalted butter (250g), jaggery powder (200g), egg (1), essence (5ml), and baking powder (3g). A mixed research strategy was used in the methodology.

A 5-point hedonic scale was used for sensory evaluation, in this examination 15 panelists was involved, in order to rate characteristics such as general acceptance, texture, color, taste, and appearance. Analysis of the cookie's nutritional value: According to the research, 100g of cookies included 400 mg/kg of iron, 6.9g of protein, 19.08g of fat, 67g of carbohydrates, 11.12g of sugar, 2.1g of fiber, and 467.4 kcal of energy.

Microbial count testing was also conducted. Observations on the 7th and 14th days showed no significant microbial growth, with total plate counts and yeast & mold counts recorded as <10, indicating the absence of microbial activity. However, by the 21st day, total plate count reached 300 CFU/g, and yeast & mold count was 40 CFU/g. Based on the shelf-life study, it was concluded that the cookies remain safe for consumption up to 21 days when stored in sterile, airtight containers at room temperature.

A cost analysis revealed that the production cost for one black rice and dates-enriched cookie is approximately ₹9.20. Consumers were provided with a feedback form to fill out regarding the black rice and dates enriched cookies, and the cookies were sold at Ebenezer stores, Perambur, Chennai. The completed feedback forms were collected and the data was analyzed using the chi-square test. Amongst the 25 consumers, the 19-24 age group expressed great satisfaction with the texture of the cookies, while the 25-44 age group expressed satisfaction with the inexpensive price. The taste, packaging, and quantity of the cookies were well-received by all age groups. The appearance of black rice and dates enriched cookies was not much accepted by the consumers.

Black rice, recognized as a functional food, is rich in essential nutrients such as dietary fiber, which supports digestive health and aids in weight management. It also contains essential amino acids that promote normal body functions and enhance immunity, along with antioxidants like anthocyanins (cyanidin-3-glucoside and peonidin-3-glucoside) that combat free radicals. Additionally, black rice is a good source of thiamine and niacin. Similarly, Kimia dates are a rich source of iron, fiber, and various vitamins and minerals, further enhancing their nutritional value.

Despite the decline in black rice cultivation due to the emergence of high-value cash crops, its potential as a nutrient-dense food is increasingly recognized. The Indian variety "Chakhao" stands out for its resilience to insects and drought, making it a viable option for improving grain

quality, yield, and antioxidant properties. Incorporating black rice flour into baked goods, such as cookies, has demonstrated reduced starch digestion rates and improved protein digestibility, making it particularly suitable for individuals with diabetes as a functional food.

This study aimed to develop a nutritionally enriched cookie using black rice and dates, achieving the desired texture, flavor, and nutritional profile. The research included the development of a standard recipe, sensory evaluation, nutritional analysis, microbiological assessment, and shelf-life investigation. The final product was well-received during commercialization, showcasing its potential as a health-oriented food option. In conclusion, products like black rice and dates-enriched cookies address the growing demand for nutrient-dense foods, offering vital nutrients in an appealing and accessible form. This innovative product highlights the importance of leveraging traditional, nutrient-rich ingredients to meet contemporary health needs.

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