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Optimizing Nutritional Content in Fortified Rice Cake: Phytochemical and Sensory Evaluation

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The rising consumer demand for healthier food products poses a significant challenge to the food industry, particularly when trying to balance nutrition with taste. Bakery products, widely consumed globally, are often criticized for being high in calories and low in essential nutrients. Recent innovations focus on fortifying these products with functional ingredients to enhance their nutritional value. This study explores the development of a fortified rice cake that incorporates rice flour, green gram flour, and dry fruit powder to improve both the functional and sensory qualities of the cake. The objective was to analyze the phytochemical composition and conduct an organoleptic evaluation of the fortified cake. Phytochemical analysis revealed the presence of beneficial compounds such as phenolic compounds, glycosides, and flavonoids in some samples. Sensory

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evaluation was carried out by a panel of 30 untrained participants, who rated the samples based on color, texture, flavor, and overall acceptability. Among the samples tested, the cake with equal proportions of refined flour and fortified rice flour (T1) was found to be the most acceptable. The results highlight the potential of using fortified ingredients in bakery products to improve both nutritional quality and consumer satisfaction. This study suggests that incorporating cereals, pulses, and phytochemical-rich ingredients into cakes can create a product that offers both energy and health benefits, paving the way for healthier baked goods in the future.

Keywords: Fortified rice cake; functional food; sensory analysis; phytochemical analysis.

1. INTRODUCTION

Consumers and health professionals have been calling for healthier food products more frequently in recent years. But because customers frequently believe that choosing nutritious food puts pleasure eating in direct conflict with health, food firms have tackled this challenge with relatively little success [1]. Around the world, a lot of bakery products are consumed. This enormous popularity among processed foods can be attributed to a number of factors, such as their affordable pricing, long shelf life, easy availability, and variety of tastes [2]. Their development has gone through several phases of advancement, leading to an increasing diversity in the present [3]. Cakes and other bakery goods are frequently consumed and are high in calories, fats, and carbs but low in fiber, vitamins, and minerals [4]. Providing wholesome food is a viable strategy for the food sector. As a result, meals that are enhanced with antioxidants and dietary fibers have been created, especially in baked goods like cakes, to improve cake quality and make up for the lack of functional and nutritional components, fortified cake goods with a lot of plants and acceptable organoleptic qualities would be required [5]. The purpose of the current study is to evaluate how the functional, nutritional, and sensory qualities of the sponge cake are affected when jujube powder is substituted for wheat flour [6].

Numerous scientific studies have examined the beneficial association between diet and health in order to determine the impact of individual foods or dietary elements on various bodily processes. Foods with beneficial qualities are referred to as "functional food" [3]. When looking at sustainable protein sources, pulses have garnered attention due to their high protein concentration (20–40%). Pulses are a great ingredient for gluten-free cooking and have been used to enhance the protein content of bread and pasta [7]. Methods of wet and dry fractionation, along with bioprocessing techniques like germination and fermentation, offer valuable resources for creating novel functional pulse components [8]. Pulses will undoubtedly be used more in the future. Particularly when combined with cereal raw materials, they may find new uses that satisfy the dietary and sensory requirements of people on every continent [9].

Over the previous few decades, the food industry has undergone tremendous change, mostly due to the development and use of new technology to meet consumers' rising demands for convenience foods [10]. A growing number of bread products with high protein content are made with bean flours. Because the proteins found in legumes have a balanced amino acid composition and provide nutritional benefits, they are the ideal ingredient to increase the nutritional value of baked foods [11]. A growing number of bread products with high protein content are made with bean flours [12]. Because legume proteins have a balanced amino acid content and provide nutritional benefits, they are the ideal ingredient to increase the nutritional value of baked foods [13].

Developing a cake which is fusion of cereals and pulses and provide energy as well as health benefits. The objective of this study is to develop a fortified rice cake enriched with protein-rich green gram flour and dried fruits, aiming to enhance both the nutritional quality and sensory appeal of the product. By utilizing a combination of fortified rice flour and green gram flour, this research seeks to improve the protein content and overall nutrient profile of the cake while maintaining its texture and flavor. The study also intends to assess the phytochemical composition and conduct sensory evaluation to determine the acceptability of the fortified rice cake among consumers.

2. MATERIALS AND METHODS

The Food Science and Technology Laboratory (FSTL) of Babasaheb Bhimrao Ambedkar

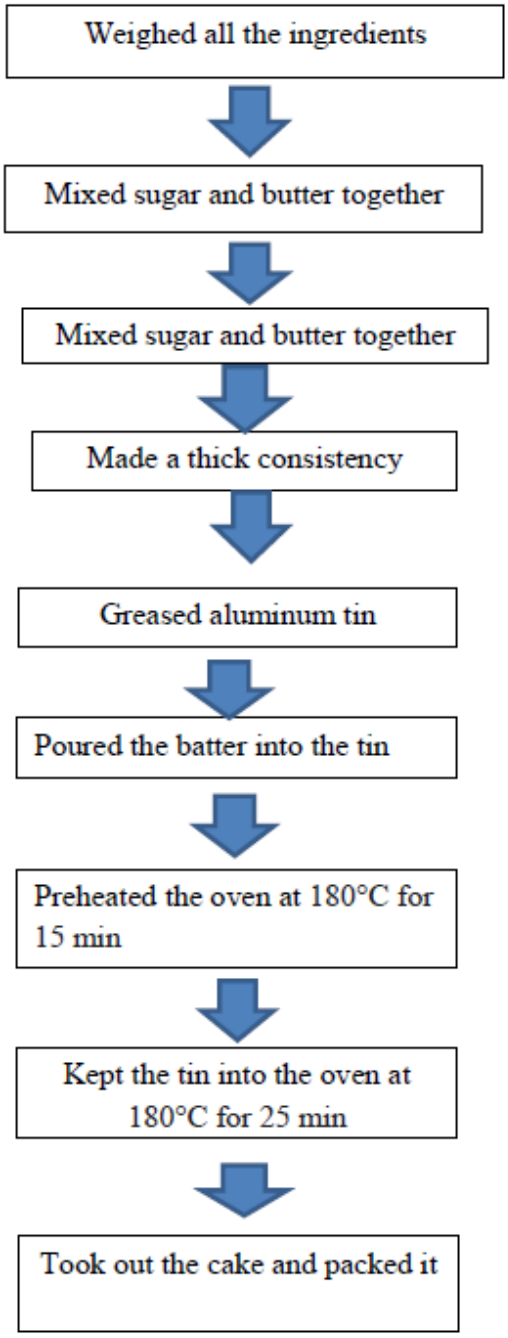

Fig. 1. Flow chart of making Fortified rice cake

University in Lucknow successfully finished the research in nine months. Following the planning of a realistic meal that precisely reflects the desired measures, the primary school and an internet platform were used to gather and choose the ingredients (blink it).

The proportions of each component were chosen to ensure that the final product would have an adequate amount of nutrients without sacrificing texture or flavor.

2.1 Quantity of Ingredients used in Different Sample

We created three formulations with varying weights of fortified rice flour (FRF), as shown in Table 1, taking into account the results of previous laboratory tests.

2.2 Preparation of Product

Utilizing an electronic weighing balance, each ingredient was measured. After whisking butter and sugar to make a homogeneous batter, add one teaspoon of vanilla extract. The prepared batter is mixed with refined flour, fortified rice flour, green gram flour, dry fruit powder, cocoa powder, baking powder, and baking soda, sifted two or three times in total. After preparing the batter and lining a cake tin, butter paper was greased and the oven was preheated to 180°C for 15 minutes, followed by 25 minutes of baking at that temperature.

2.3 Proximate Composition Analysis

Analysis of samples was carried out according to the standard analytical methods outlined by the AOAC protocols. This included determining the proximate composition, moisture, fat, ash, and protein levels. In accordance with the AOAC procedures 925.40, the samples were dried in an oven at 105 ± 2 °C until they reached a constant weight in order to measure the moisture content. In accordance with the AOAC protocols 942.05, the sample was incinerated for 20 hours at 550°C to determine the ash concentration. Following AOAC protocols 984.13, the micro-Kjeldahl method was used to assess the nitrogen (N) content, and the protein content was determined as N × 6.25. The Soxhlet method, in accordance with the AOAC 963.15 standard, was used to determine the lipid content. Following the methodology described by Onyeike et al. [14], the total carbohydrate content was calculated using the difference method. We performed triple analyses on all samples.

Table 1. Quantity of ingredients used in different sample

Ingredient	Sample		
	To	T1	T2
Refined Flour	70g	35g	45g
Fortified rice flour	0	35g	25g
Green gram flour	10g	10g	10g
Dry fruit powder	10g	10g	10g
Sugar	40g	40g	40g
Cocoa powder	5g	5g	5g
Vanilla essence	2tsp	2tsp	2tsp
Butter	10g	10g	10g
salt	0.30g	0.30g	0.30g
Baking powder	5g	5g	5g
Total	150g	150g	150g

2.4 Phytochemical Analysis

Table 2. Phytochemical Analysis

Phytochemical	Test performed	Methodology and expected observation
Phenolic Compounds	$FeCl_3$ test	In 1 ml of sample, added 2 ml distilled water followed by 3–4 drops of ferric chloride solution. Formation of blue-green color will give a positive result [15]
Tannins	Braemer's test	Added 2 ml of 10% alcoholic ferric chloride to 2 ml of sample. Dark blue color will indicate its presence [16].
Glycosides	Keller–Kiliani test	In 1 ml of sample, added 3 ml of chloroform and H_2SO_4 to form a layer. Brown ring at interphase indicates positive result [17].
Saponins	Foam test	Took 1 ml of sample and added few drops of water, followed by vigorous shaking. Observed for the presence and persistence of froth for few minutes [15].
Flavonoids	NaOH test	To 1 ml of sample added few drops of 2N NaOH solution. Occurrence of yellow color will indicate a positive result [15].
Quinones	$H_2 SO_4$	To 1 ml of sample added 1 ml of conc. H_2SO_4. Presence of red color will indicate a positive test [15].

Composite Scoring Test

Name : ..... Date: .....

Product: .....

Quality	Possible scores	Sample scores		
		Reference sample	Test sample 1	Test sample 2
Colour	20	_____	_____	_____
Consistency	20	_____	_____	_____
Flavour	40	_____	_____	_____
Absence of defects	20	_____	_____	_____
Total score	100			

Comments:

Signature

Fig. 2. Composite score card

2.5 Sensory Evaluation

2.5.1 Participant selection

Inclusion Criteria: Participants were selected based on their availability and willingness to participate in the sensory evaluation. All participants were required to be in good general health with no known food allergies, ensuring safety during the evaluation process. Both male and female participants aged between 18 to 60 years were included.

Exclusion criteria: Individuals with known food allergies or sensitivities to any ingredients used in the test samples were excluded. Participants who had previously participated in similar studies within the last six months were excluded to prevent bias. Any individuals with impaired taste or smell, due to either temporary illness or medical conditions, were excluded.

Sensory evaluation procedure: The sensory evaluation was conducted in the Food Sensory Lab of the Department of Food and Nutrition, Babasaheb Bhimrao Ambedkar University, Lucknow. A total of 30 untrained participants were involved in the sensory evaluation, which was designed to assess the appearance, texture, taste, aroma, and overall acceptability of the fortified rice cake samples [18,19]. The sensory evaluation utilized a composite scoring system, with participants scoring each sample based on key parameters such as color, consistency, flavor, and absence of defects. The evaluation took place in a controlled environment, with samples presented in a randomized order to reduce bias.

Data collection and analysis: The scores given by the participants were recorded and analyzed to determine the overall acceptability of the samples. Statistical analysis was performed to compare the sensory attributes of the different samples, with the results discussed in the context of the study's objectives. This protocol ensures transparency in the participant selection process, ethical conduct through informed consent, and the use of a systematic approach to sensory evaluation.

3. RESULTS

3.1 Preparation of Product

The ingredients used for the preparation of three different rice cake samples (To, T1, and T2) were carefully selected to maintain consistent total weights (150g) while varying the proportions of key components to assess their impact on the final product's sensory and nutritional qualities. Within this research, three

distinct products are created, each with a unique composition.

3.2 Proximate Analysis

The proximate composition of the fortified rice cake samples (To, T1, and T2) was analyzed for ash content, moisture, fat, crude fiber, protein, carbohydrate content, and energy value. The results are as follows:

The proximate composition analysis of the fortified rice cake samples revealed distinct differences in their nutritional profiles. Sample To, the control, had the highest moisture content (24%) and moderate levels of protein (1.31%) and fiber (6%). Sample T1, which incorporated fortified rice flour and green gram flour, exhibited the highest protein (2.95%) and fiber content (8%), indicating improved nutritional quality. Sample T2, while having the lowest moisture content (17%), had the highest carbohydrate content (79.87%) and energy value (331.1 kcal). These results suggest that while T1 offers enhanced nutritional benefits, T2 provides higher caloric energy, making it a potential choice for those seeking a higher energy intake.

3.3 Phytochemical Analysis

The naturally occurring compounds known as phytochemicals have demonstrated enormous health benefits for humans due to their high anti-inflammatory and antioxidant properties. The study of phytochemical of fortified rice cake with green gram pea, it revealed the presence and absence of phytochemicals.

Thirty trained panelists were selected from inside the Department to participate in the sensory evaluation of the fortified rice cake. Each panelist received a sample of a fortified rice cake, and they were instructed to rate the rice cake according to its appearance, taste, aroma, and texture. A systematic questionnaire or rating scale was used to solicit feedback from the panelists, and the results were examined to ascertain the overall approval of the fortified rice cake.

Rice is beneficial because large amounts of several chemicals can be found in stabilised rice bran, which may be able to prevent a variety of chronic illnesses. It is thought that RB has a significant role as a functional food. That has anti-tumor action, cardiovascular health advantages, and cholesterol-lowering qualities [20].

Sensory evaluation: The results of all the samples are presented in the form of Table 4 and graph by calculating the mean vale.

The result of sample one is shown below:

Table 3. Proximate composition of fortified rice cake

Sample	Ash	Moisture	Fat	Crude fiber	Protein	Carbohydrate	Energy
To	0.6	24	0.3	6	1.31	78.21	320.78
T1	0.5	23	0.2	8	2.95	73.37	307.08
T2	0.6	17	0.3	5	2.23	79.87	331.1

Table 4. Observation of phytochemicals

Sr. No	Phytochemicals	Observation (To, T1 & T2)
1	Phenolic	+
2	Tannin	-
3	Glycoside	+
4	Saponins	-
5	Flavonoid	+
6	Quinones	-

Where,
"+" shows the presence
"-" shows the absences

Table 5. Average of sensory evaluation of Sample T0

Sr. No	Parameters	Average Score
1	Colour	17.96667
2	Texture	18.86667
3	Flavor	19.86667
4	Absence of defect	20.86667
5	Total Score	77.56667

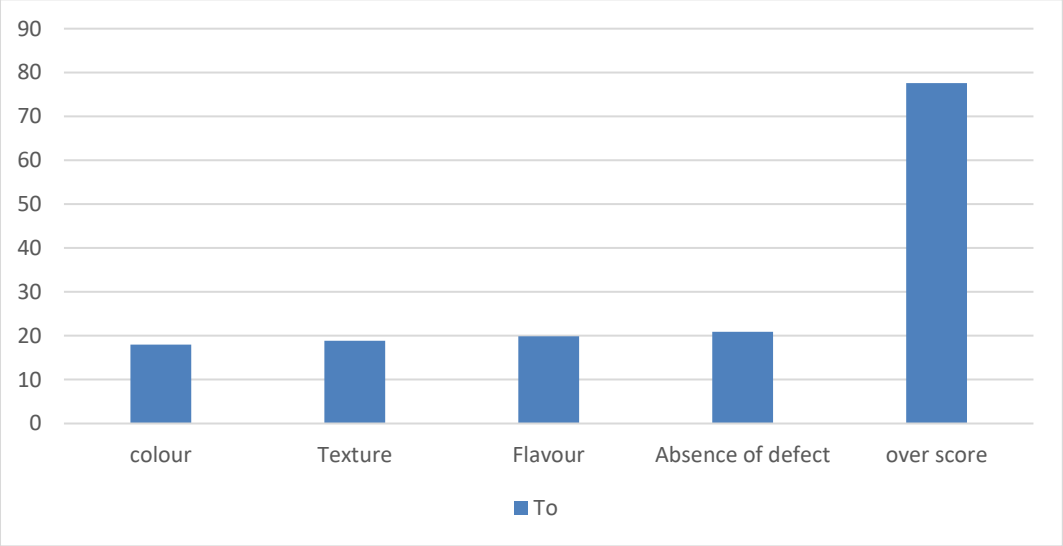

Fig. 3. Mean Value of To

Table 6. Average of sensory Evaluation of sample T1

Sr. No	Parameters	Average
1	Colour	19.33333
2	Texture	19.33333
3	flavor	39.1
4	Absence of defect	19.33333
5	Total score	97.1

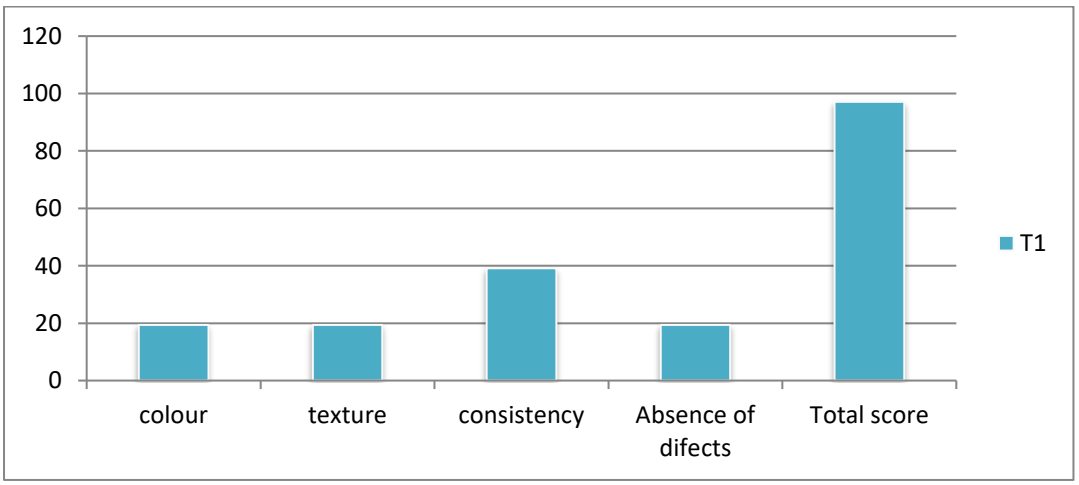

Fig. 4. Mean Value of T1

Table 7. Average of sensory evaluation of sample T2

S.No	Parameter	Average
1	colour	17.66667
2	Texture	17.7
3	Flavor	37.8
4	Absence of defect	18.3
5	Total score	91.46667

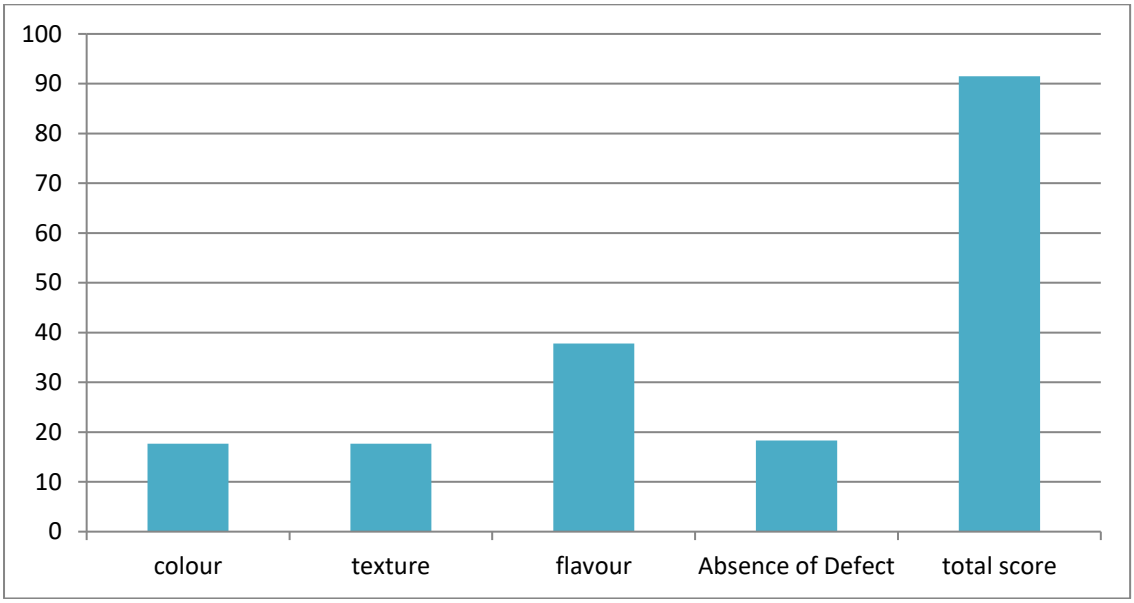

Fig. 5. Mean value of T2

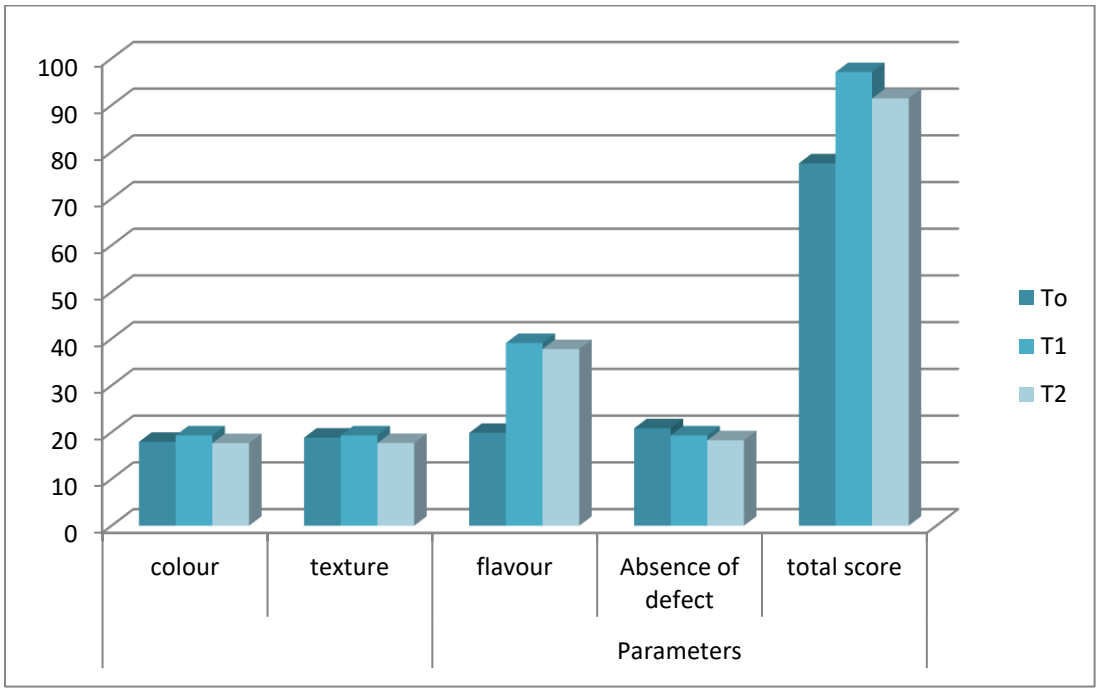

Fig. 6. Overall presentation of all sample

In prepared samples the sample T1 is more acceptable than compare to other two sample (To & T2) by taste, texture, colour. In this study, the taste of the fortified rice cake was evaluated as part of the sensory evaluation conducted by untrained panelists. The results of the taste assessment were included in the sensory evaluation data, specifically in Tables 3, 4 and 5, which summarize the flavor scores for all samples (To, T1, and T2). Based on the panelists' feedback, sample T1 was found to have the most favorable taste profile, with an improved balance of sweetness and overall flavor compared to the other samples.

The overall presentation of samples which one is more acceptable.

4. DISCUSSION

The study aimed to develop a fortified rice cake using fortified rice flour, green gram flour, and dry fruits to enhance its nutritional profile. Rice bran, rich in bioactive compounds like tocopherols, tocotrienols, and oryzanol, has been shown to offer significant health benefits, such as antioxidant, anti-inflammatory, and cholesterol-lowering properties, which may help reduce the risk of chronic diseases, including cardiovascular disorders and cancer [20]. Additionally, the inclusion of green gram flour, which is rich in protein and fiber, further boosts the cake's nutritional value, making it a healthier alternative to conventional cakes that predominantly rely on refined flour and sugar [21].

In comparison to standard cakes, which are often high in simple carbohydrates and low in fiber, the fortified rice cake developed in this study demonstrates superior nutritional attributes. Sample T1, in particular, exhibited a higher protein (2.95%) and fiber content (8%) than typical sponge cakes, which tend to have lower protein and fiber due to the exclusive use of refined flour. The inclusion of dry fruit powder not only enhances the cake's flavor but also contributes additional micronutrients, antioxidants, and natural sweetness, making it a more nutritionally dense product [22].

The fortification of the cake with rice flour and green gram flour significantly improved the protein and fiber content, which are generally lacking in standard cakes. This makes the fortified cake a healthier alternative, particularly for those seeking a balanced diet. The presence of phenolic compounds, glycosides, and flavonoids in the cake highlights its potential health benefits due to the antioxidant properties of these compounds. The sensory evaluation revealed that sample T1 was highly acceptable in terms of taste, texture, and appearance, indicating that nutritional enhancement did not compromise the sensory qualities of the cake. There are few limitations of the study. The fortified rice cake had a lower moisture content compared to standard cakes, which may affect its shelf life and texture over time. Future improvements could focus on adjusting the ingredient composition to improve moisture retention without compromising nutritional value. Although the cake is nutritionally superior, the energy value of sample T1 was lower (307.08 kcal) compared to standard cakes. For individuals seeking higher caloric intake, this may be a limitation. Certain phytochemicals, such as tannins and quinones, were absent, which might limit the health benefits typically associated with such compounds.

5. CONCLUSION

This study successfully developed a fortified rice cake by incorporating rice flour, green gram flour, and dry fruit powder, aiming to enhance both its nutritional profile and sensory appeal. The phytochemical analysis confirmed the presence of beneficial compounds such as phenolics, flavonoids, and glycosides, indicating potential health benefits due to their antioxidant properties. Proximate analysis showed that the fortified cake, particularly sample T1, had significantly higher protein and fiber content compared to traditional cakes, making it a healthier alternative. Sensory evaluation revealed that the fortified cake maintained favorable taste, texture, and appearance, with sample T1 emerging as the most acceptable among the test samples. These findings suggest that fortifying bakery products with nutrient-rich ingredients can provide both health benefits and consumer satisfaction, paving the way for healthier baked goods in the future. Further research could explore the long-term stability of these fortified cakes and their potential commercial viability.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image

generators have been used during writing or editing of this manuscript.

CONSENT

Written informed consent was obtained from all participants prior to their involvement in the sensory evaluation. Participants were informed about the nature of the study, the sensory evaluation process, and their right to withdraw from the study at any time without any consequences.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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