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Formulation and nutritional evaluation of calcium enriched *Eleusine coracana* Gaertn. cake to combat mineral deficiencies

Kamla Mahajani, Renu Mogra, Jyoti◆, Vishakha Sharma, Sarita and Yogita Paliwal
Department of Food Science and Nutrition, CCAS, MPUAT, Udaipur-313001, Rajasthan, India

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Abstract

Today's demands require us to improvise a healthy lifestyle. This study aimed to develop a calcium-enriched cake using ragi flour and to evaluate its nutritional composition. Ragi or finger millet is a treasure of calcium, making it a valuable ingredient for fortifying food products. Cake is a visible nutritional base for nutritional replenishment. Convenient, ready-to-eat foods that are simple to prepare and transport are preferred by people of all ages. Because of their possible health benefits, consumers have increasingly focused on ragi grains. In this investigation, we substituted refined wheat flour with ragi flour in cake batter at 50, 60 and 70 per cent. We saw notable variations in the cake's nutritional and sensory attributes. Our findings revealed that incorporating ragi flour significantly enhanced the proximate composition, dietary fiber and mineral content of cake. The cake could be stored at room temperature up to 3 days without any food additive. The developed calcium-enriched cake using ragi flour presents a promising strategy for enhancing the nutritional value of baked goods while offering a palatable and appealing product to consumers. This suggests that cake supplemented with ragi flour could have more market diffusion if awareness is highly created.

1. Introduction

In recent years, more people have become aware of the importance of incorporating nutrient-rich ingredients into everyday foods to combat mineral deficiencies and other nutritional problems. Calcium, an essential mineral for bone development, is often lacking in the diet of many individuals worldwide (Shlisky *et al.,* 2022). To address this nutritional deficiency, researchers and food technologists have been exploring innovative ways to fortify commonly consumed foods with calcium. Because there is a growing demand for convenience food, bakery products are becoming more and more important and well-liked by people of all ages (Nare, 2023). The most common ingredient in baked goods including bread, biscuits and cakes is refined flour (Lenka *et al.,* 2022). Recent outbreaks of COVID-19 have highlighted the significance of a healthy diet to improve immune function and overall well-being (Galankis, 2020). Eating the cake is a symbol of happiness and pleasure since it is a delicious blend of refined wheat flour, sugar, eggs, milk, butter and flavoring. Once more, it is highly nutritious and serves as a great source of energy due to its suitable amounts of proteins, carbs, vitamins and minerals (Zubairuddin *et al.,* 2015). The cake also improves mental health and revitalizes the senses. Therefore, food scientists and biotechnologists constantly pay considerable attention to the composition of this food (Wandhekar *et al.,* 2021; Deshpande *et al.,* 2021; Tayanath *et al.,* 2018). Cake alone does not make for a healthy choice because it is low in calcium, iron and fiber and rich in calories and fat. It cannot meet people nutritional needs. To feed it, which is difficult and demanding, nutritional components such millets like ragi, bajra, jowar, *etc.,* must be added. Iron and calcium are necessary for the human body to function correctly. According to Boite *et al.* (2018), calcium deficiency can cause osteopenia, osteoporosis, cramping in the muscles and a higher risk of bone fractures. Anemia is mostly caused by iron deficiency. Ragi the hub of health which helps in reducing weight. Finger millet (*E. coracana* Gaertn.) also known as ragi, is a millet crop and is mainly chosen as a staple food by people of arid and semi-arid regions (Radha and Padmini, 2019). Still, thousands of people find that millet fulfills their appetite, particularly those who reside in hot and humid settings (Rane *et al.,* 2014). It is a prominent crop in several regions of India and is a staple crop in East and Central Africa (Majumder *et al.,* 2006). Ragi is the food grain with the highest potassium (408 mg) and calcium (344 mg) content among all millets (Gautam and Sati, 2019). According to Shobana *et al.* (2013), it is an adequate source of iron, calcium, phosphorus, proteins, vitamins, fibers and all important amino acids. The ragi is considered as one of the most nutritious millets since it has roughly 7.16 per cent protein, 1.92 per cent fat, 66-67 per cent carbohydrate and 11.18 per cent dietary fiber. Of all the cereals and millets, ragi has the highest concentration of the minerals potassium (443 mg) and calcium (364 mg) (Longvah *et al.,* 2017). Ragi is growth-promoting food for women, senior citizens and children. People with celiac disease and gluten allergy can safely consume ragi because it is non-glutinous (Devi *et al.,* 2014). Ragi contains plenty of amino acids, including valine, isoleucine, methionine, threonine and tryptophan (Nakarani *et al.,* 2021). Furthermore, ragi provides additional health advantages, including the prevention of osteoporosis, regulation of blood sugar due to its low glycemic index, prevention of skin ageing, treatment of anemia and relaxation of the body from stress, anxiety and depression because

Corresponding author: Ms. Jyoti
Department of Food Science and Nutrition, CCAS, MPUAT, Udaipur-313001, Rajasthan, India
E-mail: jyotirao12362@gmail.com
Tel.: +91-8901192744

of its tryptophan and antioxidant content (Kokani *et al.,* 2018). Because of this, grain's high fiber content, weight loss has also been linked to its eating (Gunashree *et al*., 2014; Amubhashukla *et al.,* 2015). Notwithstanding the huge nutritional and health benefits discussed above, urbanization, recent changes in eating patterns and food shortages have resulted in a considerable decline in the use of ragi-based products among both urban and rural population. Our long-term goal is to develop ready-to-use products made from ragi that will benefit people's health and satisfy consumers of all ages. In order to develop ragi millet-supplemented cakes with formulation, balancing and sustaining characteristics, the current study was conducted.

2. Materials and Methods

In 2024, the experimental work was carried out in the Food Science and Nutrition Department at CCAS, MPUAT, Udaipur.

2.1 Procurement of raw materials

For the purpose of making the ragi-refined wheat flour composite cake, we selected refined wheat flour, ragi flour, cashew nuts, cooking oil, baking powder, baking soda, milk and vanilla essence as the basic ingredients. These ingredients were purchased at the Udaipur local market.

2.2 Formulating ragi based cakes

The formulation of ragi cake has been presented in Figure 1. Flours were divided into the ratios refined wheat flour : ragi flour (100:0, 50:50, 40:60 and 30:70, respectively, for control and experimental sample), creamed refined oil (100 ml), condensed milk (200 ml), vanilla essence (3-4 drops) and water were added and blended well with electric beater. We mixed baking soda and baking powder as leavening agents to improve the product and make the cake easier to digest. After mixing in the refined/ragi flour, pour the batter into the oiled cake tin, and bake for 30 min at 180°C in a preheated oven. The steps for the cake formulation process are illustrated in (Figure 1).

2.3 Sensory evaluation

The 9-point Hedonic rating scale was employed to measure the food products' level of consumer acceptability. The panelists were given six samples in a single session and we asked them to score the acceptability using a 9-point Hedonic rating scale that went from "like extremely" to "dislike extremely." We selected 10 semi-trained panelists to score the products for consumer preference studies, utilizing different cards for each product (Srilakshmi, 2015; Verma *et al.,* 2021; Thakur *et al.*, 2021).

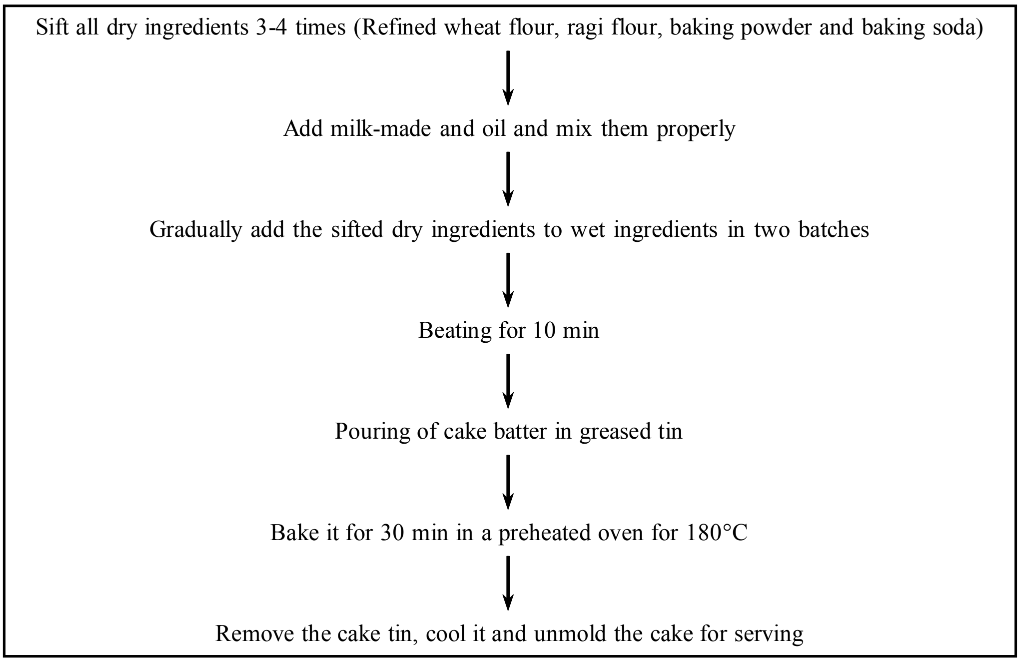

Figure 1: Flow chart of cake formulation.

2.4 Devised cake were chemically analyzed for following parameters

2.4.1 Proximate analysis

The proximate composition of the developed cakes was examined using AOAC, 2010 method. The hot-air oven drying method was used to calculate the moisture content. To determine the sample's moisture content, it was heated to a certain temperature and its weight loss was recorded. To determine the amount of ash present, the samples were burned in a muffle furnace for six hours at 550°C. The total protein content was calculated using the Micro Kjeldahl method, while the fat content was determined using the Soxhlet apparatus. The AOAC protocol was followed in each case (AOAC, 2010; Biswal *et al.,* 2020; Khan and Das, 2019).

2.4.2 Dietary fibre and total mineral content

To determine the amount of dietary fiber in the sample, the water-soluble components were extracted using a Soxhlet apparatus. The insoluble residue was collected and cleaned after the resulting suspension was filtered, and it was then dried to create the insoluble dietary fiber (IDF). Concurrently, a specific procedure was implemented on the leftover filtrate to separate and precipitate the soluble dietary fiber (SDF). In this approach, polysaccharides precipitated as a result of the addition of ethanol following acidification. We collected the soluble fraction of dietary fiber by filtering, cleaning and drying it. The processing of both fiber fractions involved co-precipitated protein and ash modifications, following the methods previously described by Rani *et al.* (2022); Khare *et al.* (2021). The complete mineral composition was analyzed by applying the methods described by Lindsey and Norwell (1969). 2 g of material were contained in a 150 ml conical flask. This should be combined with 20 milliliters of a diacid mixture (HNO_3:$HClO_4$: 5:1, v/v), left to sit overnight and then digested to yield white precipitates. Using double-distilled water to dissolve the precipitates, Whatman No. 42 was employed as a filter. After that, the filtrate was diluted with 100 milliliters of double-distilled water to determine the concentrations of iron, zinc, calcium and phosphorus.

2.4.3 Shelf-life

2.4.3.1 Fat acidity

The AOAC (2010) technique was used to determine the fat acidity. On a Soxhlet apparatus, 10 g sample was extracted using petroleum ether and combined with a 50 milliliter solution of benzene, alcohol and phenolphthalein. Titrated to an orange-pink color against 1 g/lt of potassium hydroxide. In addition, a blank was titrated, and the outcome was subtracted from the titration value of the sample. The fat acidity value was computed as:

Fat acidity = 10 × (T–B)

where,

T = ml of KOH needed to titrate the sample extract

B = the volume of KOH needed to titrate the blank

2.4.4 Statistical analysis

The statistical package for social science (SPSS) 2.0 was used to do statistical analysis on the data, which were collected in triplicate. The five and one per cent significance level was used to verify the significant difference.

3. Results

3.1 Sensory evaluation

Figure 2 summarizes the sensory evaluation of cakes and shows how ragi supplementation affects cake sensory evaluation. When compared to the control cake, Type-I (50:50) cake has the highest overall acceptance and scores higher on most criteria.

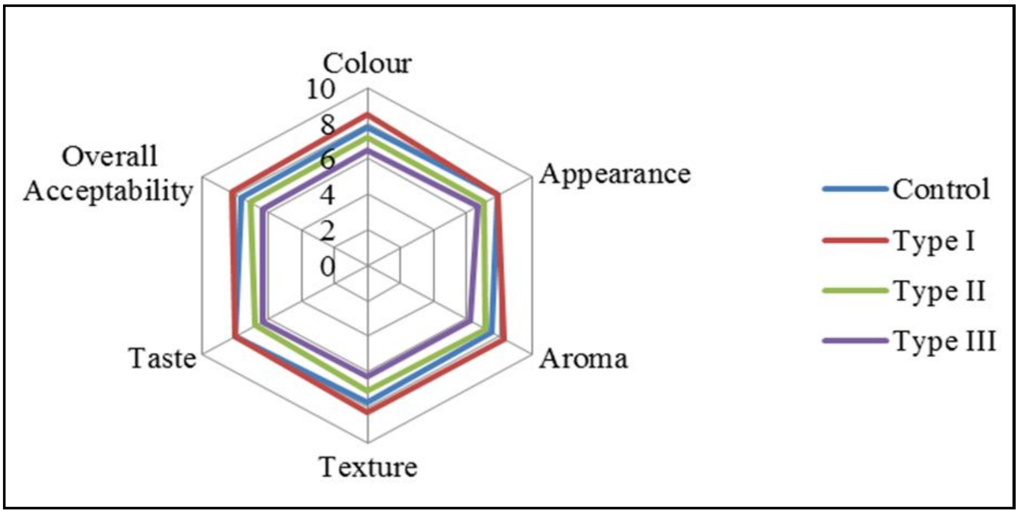

Figure 2: Sensory evaluation.

Table 1: Proximate composition of ragi flour based cake (g/100 g, on dry matter basis)

Cakes	Moisture*	Crude protein	Crude fat	Crude fibre	Ash	CHO
Control RWF (100 %)	24.22 ± 0.39	6.14 ± 0.13	20.48 ± 0.09	0.36 ± 0.03	1.18 ± 0.03	47.62 ± 0.01
Type-I (RWF:RF::50:50)	23.32 ± 0.25	6.44 ± 0.19	21.69 ± 0.19	1.95 ± 0.52	1.99 ± 0.01	44.61 ± 0.01
Type-II (RWF:RF::40:60)	24.14 ± 0.19	7.32 ± 0.06	22.55 ± 0.29	2.37 ± 0.13	2.29 ± 0.03	41.33 ± 0.02
Type-III (RWF:RF::30:70)	25.58 ± 0.15	7.80 ± 0.09	23.18 ± 0.06	3.23 ± 0.12	2.91 ± 0.07	37.03 ± 0.01
CD (p<0.05)	0.88	0.43	0.62	0.91	0.14	0.01

Values are average of triplicate of observations (Mean ± SE) *Moisture was analysed on fresh weight basis

RWF = Refined wheat flour

RF = Ragi flour

3.2 Proximate composition

The analysis of ragi cakes proximate composition, as shown in Table 1. This result demonstrates how ragi supplementation affects the nutritional profile of cakes. Maximum moisture content (25.58 %) was observed in cakes made with 30:70 ratios of Ragi flour to wheat refined flour. Ragi cakes were found to have ash concentration ranging from 1.99 to 2.91 per cent. It was found to be lowest (1.18 %) in the control sample and highest (2.91 %) in the cakes made with 30:70 ragi proportions. The cakes added with ragi had higher crude fiber content (1.95-3.23 %) than the cake without ragi (0.36 %). It was observed that fat levels in cake increased with addition of ragi flour.

The cakes with 30:70 ratio of refined wheat flour to ragi flour had the highest fat content (23.18 %) while the control cake had the lowest fat content (20.48 %). The protein composition of cakes showed a notable impact due to ragi addition. It was observed to be highest (7.80 %) in cakes made with 30:70 ratio of refined wheat flour to ragi and lowest (6.14 %) in control cake. The ragi cakes' carbohydrate content was discovered to be between 37.03 and 44.61 per cent. The cakes made with refined wheat flour (control) had highest carbohydrate content (47.62 %) (Table 1).

3.3 Dietary fibre

Table 2 unquestionably shows that the enhanced dietary fiber level was a result of the inclusion of ragi flour. The control cake had dietary fiber values of 2.66, 0.66 and 2.00 g/100 g for total, soluble and insoluble fiber, respectively. Total, soluble and insoluble roughage content in cakes made with ragi flour varied from 6.05 to 8.80, 1.87 to 3.06 and 4.17 to 5.74 g/100 g, respectively, the highest was found in cakes made with Type-III ragi flour, while the lowest was found in cakes prepared with control (refined wheat flour) (Table 2). This high level of dietary fiber suggests that ragi flour can support regularity and general intestinal function, which in turn can improve gastrointestinal health. The maintenance of digestive health is known to be significantly influenced by the balance between soluble and insoluble dietary fiber and the observed values highlight the significance of ragi flour as a beneficial dietary supplement.

Table 2: Dietary fibre content of ragi flour based cake (g/100 g, on dry matter basis)

Cakes	Total dietary fibre	Soluble dietary fibre	Insoluble dietary fibre
Control RWF (100 %)	2.66 ± 0.01	0.66 ± 0.06	2.00 ± 0.06
Type-I (RWF:RF::50:50)	6.05 ± 0.14	1.87 ± 0.03	4.17 ± 0.14
Type-II (RWF:RF::40:60)	7.33 ± 0.06	2.08 ± 0.04	5.25 ± 0.04
Type-III (RWF:RF::30:70)	8.80 ± 0.09	3.06 ± 0.07	5.74 ± 0.17
CD (p<0.05)	0.29	0.17	0.36

Values are average of triplicate of observations (Mean ± SE)
RWF = Refined wheat flour
RF = Ragi flour

3.4 Total minerals

Table 3 lists the minerals that are present in ragi cake. The iron content of the control cake was 1.14 mg/100 g this was enhanced by adding more ragi flour. It varied for each of the three variations of ragi flour based cake, ranging from 1.61 to 3.06 mg/100 g. The calcium content of the three types of ragi flour cake ranged from 168.7 to 195.1 mg/100 g, respectively, while the calcium content of the control cake was 135.7 mg/100 g. The calcium content of Type-III was significantly greater (195.1 mg/100 g) than that of the control (135.7 mg/100 g). The zinc concentration of the control cake was 0.77 mg/100 g and it was also seen that this value increased as the amount of ragi flour was combined with refined wheat flour. The values varied between 1.84 and 2.65 mg/100 g. Zinc concentration in Type-III cake was higher (2.65 mg/100 g) (Table 3). These findings provide important insight on the possible nutritional advantages of millets, emphasizing their value as a natural source of vital minerals for a range of biological processes as well as general health.

Table 3: Total mineral content of ragi flour based cakes (mg/100 g, on dry matter basis)

Cakes	Calcium	Iron	Zinc
Control RWF (100 %)	135.7 ± 0.06	1.14 ± 0.01	0.77 ± 0.01
Type-I (RWF:RF:: 50:50)	168.7 ± 0.13	1.61 ± 0.01	1.84 ± 0.09
Type-II (RWF:RF::40:60)	179.4 ± 0.33	2.03 ± 0.02	2.08 ± 0.06
Type-III (RWF:RF::30:70)	195.1 ± 0.35	3.06 ± 0.07	2.65 ± 0.02
CD (p<0.05)	0.84	0.12	0.16

Values are average of triplicate of observations (Mean ± SE)
RWF = Refined wheat flour
RF = Ragi flour

3.5 Shelf-life

3.5.1 Fat acidity

Table 4 presents information on the acidity of fat. This showed that during storage, the fat acidity values of ragi flour cakes varied from 31.74 to 40.54 mg KOH/100 g. In contrast, the control cake values were 42.56 mg KOH/100 g on day zero and increased to 46.16 mg KOH/100 g on third day at room temperature during storage (Table 4). The higher fat acidity of control cake during storage might be due to their higher fat content than ragi supplemented cakes. The development of free fatty acids, moisture gain, and the onset of fat breakdown with time all may have contributed to the increase in fat acidity in baked goods with storage.

Table 4: Effect of storage period on fat acidity (mg KOH/100 g) content of ragi flour based cakes (on dry matter basis)

Cakes	1 Day	2 Days	3 Days	CD (p<0.05)
Control RWF (100 %)	42.56 ± 0.01	44.57 ± 0.01	46.16 ± 0.35	0.71
Type-I (RWF:RF::50:50)	40.54 ± 0.05	39.22 ± 0.45	37.37 ± 0.15	0.97
Type-II (RWF:RF::40:60)	36.70 ± 0.23	35.29 ± 0.21	34.77 ± 0.11	0.67
Type-III (RWF:RF::30:70)	33.63 ± 0.06	32.59 ± 0.14	31.74 ± 0.09	0.37

Values are average of triplicate of observations (Mean ± SE) , RWF= Refined wheat flour, RF = Ragi flour

4. Discussion

The sensory evaluation of the ragi cakes shows that the Type-I formulation had the highest overall acceptability score while the Type-III formulation had the lowest overall acceptability score. The results obtained are consistent with previous research on cookies added with sprouted ragi flour (SRF) by Rana *et al.* (2021). The ragi cakes' moisture, crude fiber and ash content were higher than those of the control cake made with refined wheat flour. Comparable outcomes were stated by Mane and Kadam (2021); Jamale *et al.* (2022) who found that cookies supplemented with 30, 40 and 50 per cent ragi flour had higher levels of protein, crude fiber and ash content than the control. Results of present study also lend support to that of Lenka *et al.* (2022), who reported that cakes enriched with ragi had higher proximates than controls overall with the exception of carbohydrate content. According to Muktar *et al.* (2018), adding ragi flour resulted in an increase in ash, crude protein and crude fat content. Upadhyay (2018) states that ragi flour has higher levels of crude fiber, ash and crude fat than popular grains like wheat. Because of the greater nutritional content of the added ragi, the value-added cake is superior to control in terms of nutrition. The cakes made with ragi flour had higher levels of total iron, calcium, zinc and phosphorus than the control made with 100 per cent refined wheat flour. Goswami *et al.* (2017) found that the control halwa mix had lower iron and zinc concentration than the halwa mix enhanced with ragi flour. According to studies by Longvah *et al.* (2017) and Bhoite *et al.* (2018), ragi flour is also high in minerals, particularly potassium (443 mg/100 g), iron (4.62 mg/100 g), magnesium (146 mg/100 g), calcium (364 mg/100 g) and phosphorus (210 mg/100 g). It is concluded that ragi flour can be utilized in a range of processed foods used for celiac patients because it is gluten free and has more nutrients than other flours (Yousaf *et al.*, 2021; Patel and Thorat, 2019). Cakes with ragi added had higher dietary fiber contents. These findings closely align with those of Suneetha and Rao (2019), who found that cookies fortified with ragi flour had higher levels of dietary fiber than control cookies. A notable rise in the fat acidity content of cakes that were kept was noted. As the storage period lengthens, there may be a rise in fatty acid production as a result of increased triglyceride hydrolysis, which produces free fatty acids and raises the acidity of fat (Jyoti *et al.,* 2022). Increased fat acidity in baked goods during storage may have resulted from moisture absorption, the beginning of fat degradation over time and the production of free fatty acids (Khare *et al.,* 2021). This also explains the decline in (Godase *et al.,* 2020) acceptability scores for stored items. The food industry can use ragi flour to formulate many kinds of nutritious food, meeting the current need for items high in calcium, iron, zinc and dietary fiber. The cakes with ragi added received positive sensory evaluations, suggesting that they might be consumed by a wider population and could be a viable choice for those who are malnourished.

5. Conclusion

The goal of this study is to investigate how ragi flour affects the nutritional value and texture of cake. Based on the research findings, mixing ragi flour with refined wheat flour is the most acceptable way to make sponge cakes with improved nutritional content and acceptable organoleptic features. In the ongoing experiment, cake is being enriched with ragi flour. As a result, three different samples were collected, and the amounts were calculated by replacing refined wheat flour with 50, 60 and 70 per cent ragi flour. A processed food intervention based on ragi may be implemented as a tactic to address the issue of undernourishment and hidden hunger among vulnerable populations. Food companies can use ragi flour to formulate various kinds of nutritious foods that are high in calcium, iron and dietary fiber-nutrients that are desperately needed today.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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