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Research Article

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Formulation of Calcium Enriched Finger Millet (*Eleusine coracana*) based Muffin Fortified with Nutri Seeds

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Abstract

Muffins are sweet baked products highly appreciated by consumers because of their soft texture and characteristic taste. However, traditionally muffins are made up of refined wheat flour (RWF) and contain high amounts of sugar and fat which oppose the consumers today's needs. The increasing interest of consumers in health regimes, fitness and body appearance leads to a rise in the demand for health products. Therefore, the present study was undertaken to develop a value-added muffin type product using finger millet (*Eleusine coracana*), nutri seeds (pumpkin, poppy, and chia seeds) and molasses as a sugar substitute to enhance the desired mineral composition as well as nutritive values. The concentration of ingredients and processing conditions were optimized based on multiple trials and the product quality was evaluated based on sensory evaluation. A 9-points hedonic scale was used to evaluate the color, texture, aroma, taste, and overall acceptability of the developed product. The muffin with higher sensory acceptability was selected for the physico-chemical and nutritional evaluation and compared with the control. The results showed that the products incorporated with nutri seeds powder had higher sensory acceptability score and nutrition content. Moisture content was higher in control muffin i.e., 13.39 g, whereas protein (8.28 g), fat (21.37), ash (1.15 g) and fiber (2.88 g) were found higher in muffins incorporated with nutri seeds powder. Moreover, calcium and phosphorus content were found 150.2 mg and 7.59 mg/100 g, respectively along with the DPPH scavenging ability (IC_{50} value 14.14), total phenolic content (14.86 ppm gallic acid equivalent (GAE), and total flavonoid content (34.24 ppm quercetin equivalent (QE) in nutri seeds fortified finger millet muffin which was significantly ($p < 0.05$) higher as compared to control muffin.

Keywords

Muffin, Millet, Seed, Molasses, Fortification, Baking

Introduction

Muffins are small, round breads with a sweet taste and best served warm. The word muffin comes from the word 'moufflet' which is French. The word is often used for bread and other soft foods that are baked. However, the origin of the muffins is not from France. Muffins are British and American specialties. Muffins are made-up of four main components flour, sugar, fat, and egg which have a significant impact on its structure, appearance and eating quality [1].

Pumpkin (*Cucurbita moschata*) is an important Cucurbitaceae vegetable that can be found in tropical and subtropical countries [2]. Pumpkin seeds are considered an agro-industrial waste that serves as a power source of nutrients and nu-

traceutical properties [3]. Its functional properties include anti-inflammation, anti-diabetes, antifungal activity along with others [4]. Additionally, pumpkin seed is abundant in vitamin E (Tocopherols), carotenoids, provitamins, pigments, pyrazine, squalene, saponins, phytosterols, triterpenoids, phenolic compounds, and their derivatives, coumarins, unsaturated fatty acids, flavonoids, and proteins [3]. They are also a good source of magnesium, potassium, phosphorus, as well as other minor minerals such as zinc, manganese, iron, calcium, sodium, and copper [5].

Chia seed (*Salvia hispanica*) is an annual herbaceous plant which belongs to the family Lamiaceae [6]. The Spanish word "chia" is an adaptation of the Nahuati word "chian" or "chien" which means "oily". The herbaceous plant chia has been used for its various therapeutic properties for a very long time [7]. Chia is usually a round fruit that contains many tiny oval seeds of 2 mm in length and 1 mm in width [6]. Clean and dry chia seeds can be kept for years as they contain antioxidants that prevent the deterioration of the essential oils within the seeds, and it also helps in increasing the self-life of fat rich products [8]. Chia seeds are a rich source of riboflavin, niacin, thiamine, and minerals such as calcium, phosphorous, potassium, zinc, magnesium, and copper [9]. Chia seed contains six times more calcium and eleven times more phosphorus and four times more potassium as compared to 100 g milk [8].

Poppy seed is the dried seed of *Papaver somniferum*, an erect annual herb. *P. somniferum* belongs to the family Papaveraceae. It is grown in temperate and sub-tropical regions. The poppy seeds are very small, less than 1 nm in length. They are white-grey kidney shaped with a pitted surface and an oily endosperm. These seeds are rich in potassium, calcium, and phosphorus ions [10]. They are also a great source of dietary supplements and are used to produce novel food products.

Finger millet (*E. coracana*), which is commonly known as ragi, belongs to the family Poaceae. They are cultivated mostly in India and Africa [11]. The nutritive value of ragi is higher than rice and equal to that of wheat. Ragi is slow in digestion as compared to the RWF which slows down the carbohydrate absorption of the body making it an ideal substitute for people suffering from diabetes and obesity. Ragi shows several functional properties which includes antioxidant, antimicrobial, anti-diabetic, etc. [12]. Additionally, ragi has the highest amount of calcium and potassium. The nutritional composition of finger millet (per 100 g) is: proteins 7.3%, fat 1.3%, total dietary fiber 11.5%, minerals 2.7%, phosphorus 283 mg, and iron 3.9 mg [13]. Due to its fibrous and tough outer layer, which is consumed without dehulling, it is regarded as a coarse grain [14]. Because of its high fiber content and low glycemic index, finger millet is suggested for diabetes [15].

Molasses is a sugar substitute which is made by separating the sucrose crystals that remain after the water has evaporated from clarified juice (made from sugarcane or beets) during the crystal sugar production process. Molasses can be further recycled in this process to maximize sugar production [16]. Blackstrap molasses is a by-product of the refining of sugarcane, which involves crushing the sugar cane to release the sweet juice that is later boiled. Molasses contain considerable amounts of vitamin B6, minerals such as calcium, magnesium, iron, and manganese. They are a good source of potassium. Molasses has several health benefits which includes stabilization of blood sugar levels, menstrual relief, promotes healthy hair, etc. [17].

Materials and Methods

Procurement of ingredients

Refined wheat (*Triticum aestivum*) flour, brown finger millet (*E. coracana*) and nutri seeds (pumpkin, chia and poppy seeds) along with other ingredients such as Blackstrap Molasses (Dhampure speciality sugar Ltd.), cow ghee and double-toned milk (Amul, India), Weikfield's baking powder and baking soda (Weikfield Foods Pvt. Ltd., Pune, India) including vanilla essence were procured for the study from the local market of Jaipur, Rajasthan (india).

Preparation of flour blends

Flour blends of various compositions were prepared for final optimization. A total of 5 blends were prepared which include the control as well as the fortified blends. These blends were later combined with all the other necessary ingredients for the final muffin dough formulation as described below (Table 1).

Table 1: Composition of different flour blend.

Formulation		Seed (g)			Flour (g)	
		Pumpkin	Poppy	Chia	RWF	Ragi
Control (T0)		-	-	-	112	-
T1	A	-	-	-	45	67
	B	-	-	-	56	56
T2	A	17	15	-	35	45
	B	12.5	12.5	7	35	45
	C	15	10	7	35	45

Procedure for muffin making

Set the temperature of the oven to 170 - 180 ˚C and assemble all the required materials and supplies along with a mixer, weighing balance and other calculating utensils. Sieve and mix all the dry ingredients (ragi flour, maida, pumpkin seed powder, chia seeds powder, baking powder and baking soda) in the amount.

In the electric mixer bowl beat the required amount of ghee along with the required amount of molasses for the creaming process. Once the mixture is sufficiently frothy, add the dry ingredients, about 1/3 at a time until fully incorporated, along with a few drops of vanilla essence. When all the dry and wet ingredients have been combined, add enough milk to the muffin dough and knead it gently. After with the help of spoon equal amounts of muffin dough was filled in the muffin cup. Place the muffin cup in baking tray in the oven set at 170 ˚C for 15 min. After the baking is done, remove the muffin from the oven and place them on the tray for 5 - 10 min and store them in an air-tight container at cool and dry place (Table 2).

Table 2: Ingredients for the preparation of muffin batter (~ 270 g).

Treatments		Seeds (g)			Fat - butter (g)	Flour (g)		Sweetener - molasses (g)	Milk (ml)	Baking powder (tsp)
		Pumpkin	poppy	Chia		RWF	Ragi			
Control (T0)		-	-	-	50	112	-	80	28	1/8th each
T1	A	-	-	-	50	45	67	80	28	1/8th each
	B	-	-	-	50	56	56	80	28	1/8th each
T2	A	13	17	-	50	35	45	80	28	1/8th each
	B	12.5	12.5	7	50	35	45	80	28	1/8th each
	C	15	10	7	50	35	45	80	28	1/8th each

Sensory Analysis

Sensory evaluation of control and fortified muffins was done by semi-trained (30) panelists which included students as well as faculty members of the Amity Institute of Biotechnology and Amity School of Hospitality of Amity University, Rajasthan. Samples were served with coded names and the panelists were requested to rate the likeness on appearance, color, texture, flavor, taste, and overall acceptability of the muffins by using a 9-points hedonic scale, where 9 = like extremely and 1 = dislike extremely [18].

Physico-Chemical Properties

Proximate analysis

According to the formal procedure outlined by AACC [19], the proximate contents of the muffins were evaluated. Whereas total carbohydrate was calculated using following formula:

% Total carbohydrate = 100 - (% Moisture + % Ash + % Crude protein + % Crude fat)

Mineral analysis

For mineral analysis, dissolve the ash content of sample obtained by dry ashing in 250 ml water. Add 10 ml of saturated ammonium oxalate solution and 2 drops of methyl red indicator. Make the solution slightly alkaline by the addition of dilute ammonia and then slightly acid with a few drops of acetic acid until color is faint pink (pH 5.0). Heat the solution to boiling point. Allow you to stand at room temperature overnight. Filter through Whattman No. 42 paper and wash with water, till the filtrate is oxalate free. Break the point of filter paper with platinum wire or pointed glass rod. Wash the precipitate first using hot dilute sulfuric acid from wash bottle into the beaker in which the calcium was precipitated. Then wash with hot water and titrate while still hot (temp 70 to 80 °C) with 0.01 N potassium permanganate to the first permanent pink color. Finally, add filter paper to the solution and complete the titration.

$$Calcium\left(\frac{mg}{100\ g}\right) = \frac{Titre\ value \times Volume\ of\ Ash \times 100}{Volume\ taken\ for\ estimation \times Weight\ of\ sample}$$

Texture analysis

The texture profile analysis of the cookie was carried out with TA. HD plus Texture Analyzer. For the texture profile analysis the cookie penetration was done with a 5 kg load capacity. The cookie sample was positioned on the platform with a holed plate, and a 2 mm cylinder probe punctured the sample five times in an "X" pattern at a speed of 0.5 mm/s speed. From the penetration curve, cookie hardness and distance (fractur ability) were calculated. For each variety of cookies, four samples were perforated, and the average value was reported here [20].

Preparation of bioactive extract

Bioactive extracts were prepared by dissolving 5 g of sample in 100 ml of methanol (80%) and incubated for 2.5 h in the orbital shaking incubator. After the incubation period the sample was transferred into a falcon tube and incubated in the refrigerated centrifuge for 15 min at 2000 rpm at 4 °C. After 15 min the supernatant was collected for further processing and the residue was discarded.

Antioxidant activity

The antioxidant activity of muffin samples was measured by using 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay using the method described by Pandey et al. [18]. In the reaction mixture 0.5 - 3.0 ml of sample methanolic extract was mixed with 0.5 ml of methanolic DPPH (0.5 mm). The absorbance of the samples was taken at against blank at 517 nm using spectrophotometer (Thermo fisher scientific make) once the 30 min incubation period got over. The inhibition percentage of DPPH was analyzed by comparing with methanol treated control group using following formula:

$$\%\,Antioxidant\ activity = \frac{OD_{control} - OD_{sample}}{OD_{control}} \times 100$$

The potential of sample extract producing 50% inhibition (IC_{50} value) was calculated by plotting the graph between sample concentration and percentage of DPPH inhibition.

Total polyphenols

The total phenolic content was determined by Folin-Ciocalteu assay according to the method described by Hasan et al. [21] with some modifications. 1 ml of sample extract was mixed with 1 ml of Folin-Ciocalteu solution 1 N. Then 10 ml of sodium bicarbonate (7% solution) was added to the mixture and finally adjusted to a volume of 25 ml by adding distilled water. The solutions were left for 1.5 h at 25 °C. Then, the absorbance was measured at 750 nm. Gallic acid (3.125 - 50 ppm) was used for calibration. The calibration curve was linear (R^2 = 0.9991). The results were expressed as mean of the concentration of GAE per gram of dried sample ± standard deviation. All measurements were performed in triplicate.

Total flavonoid content

5 ml of sample (methanolic solution of extract) was added mixed with 0.3 ml of sodium nitrite (5%). After 5 min, 0.3 ml of 10% aluminum chloride was added to the previous mixture and after another 6 min, 2 ml of sodium hydroxide (1 N) was added and the total volume was made up to 10 ml with distilled water. The absorbance of reaction mixture was observed at 510 nm. A volume of 10% aluminum chloride was substituted by same volume of distilled water in blank. Test samples were analyzed in triplicate and the concentration of the sample was determined using calibration curve. The mean value is reported in quercetin equivalent in terms of µg/ml of extract [18].

Results and Discussion

Study on product quality were based on physico-chemical characteristics (such as texture, moisture, ash, fat, protein, crude fiber, total carbohydrates, calcium content, total antioxidant activity, total phenolic content, and total flavonoid content and sensory traits, which were assessed for stored samples. The following section presents and discusses the study's findings.

Sensory analysis

The sensory analysis of the control as well as the other sample was done on the day of their respective preparation. From the given figure 1 it is evident that out of the 2 formulations of ragi and RWF, the 2nd formulation, i.e., T1 (B) containing 50% ragi and 50% RWF secured appreciable scores with an overall acceptability of 8.0 which was greater than the other formulations T1 (A) - 7. Thus, this formulation was selected for further processing. In the final test samples with varied concentrations of various seeds the sample T2 (C) received the highest score in taste (8.2) and flavor (8.1) as some of the panelists like to much the unique flavor of seeds. Its texture (7.7) was found to be a little less than the sample containing 40% RWF and 60% ragi (texture - 7.9) due to the slight increase in concentration of ragi flour. As for T1 (no chia seed), the taste and flavor profile were still at an acceptable value, but both received very low ratings for their respective color, texture, and overall acceptability. Overall, it was observed that the presence of higher concentration of ragi flour as well as various seeds affected the color and textures the most. The control sample received the greatest scores since there was no presence of either ragi or other seeds.

Textural analysis

The textural parameters analyzed were the firmness and elasticity of the muffin samples. The variation in both these properties of the three samples (control (T0), T1 and T2) was as follows (Table 3).

The decrease in firmness and elasticity observed in sample T1 was due to the addition of ragi flour causing a subsequent decrease in the protein (gluten). Similar results have been observed by Hussain et al. [22] in the formulation of wheat-millet flour blend cookies where the hardness of the cookies decreased with increasing millet flour concentration. In the T2 sample, the elasticity was regained by the incorporation of seeds rich in protein. The addition of proteins can improve the elasticity of the final product. In a study performed by Sharma et al. [23] it was observed that due to the incorporation of chia seeds in the muffin mix, there was a significant decrease in the hardness and firmness in the muffins made from that mix [24] stated that the high protein content of chia seeds contributes excellent emulsifying properties in bakery products (Figure 2).

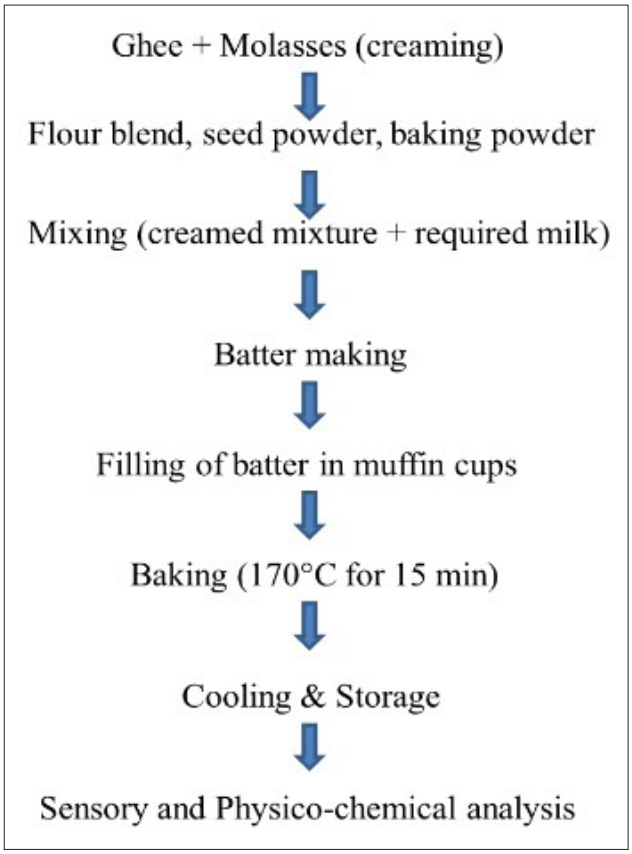


Figure 1: Flow chart for muffin preparation.

Table 3: Texture profiling of control (T0), T1, and T2 samples.

Formulation	Firmness (g)	Elasticity
Control (T0)	3123.14	3436.55
T1	2171.00	2940.96
T2	1447.02	3437.20

Proximate composition of seeds fortified ragi muffin

According to the data displayed, the average moisture content of different samples T0, T1, and T2 of ragi flour muffin were found to be 13.39 g, 13.13 g, and 13.27 g, respectively. The moisture content of T1 was slightly less than that of control muffin sample T0 which might be due to lower protein content of ragi flour. This increase in moisture in bakery products due to increase in protein content has been reported in earlier studies as well [25]. A possible reason for the slight increase in moisture content of T2 could be the mucilage released by chia seeds during baking which improves the water content of the product. These results corroborate with that of Sayed-Ahmad et al. [26] and Steffolani et al. [27] who report-

Table 4: Proximate analysis.

Formulation	Parameter per 100 g of sample						
	Moisture	Ash	Fat	Protein	Carbohydrate	Crude fiber	Calcium (mg)
T0	13.39	0.92	19.21	8.16	58.32	1.32	80
T1	13.13	1.09	19.23	7.56	58.99	2.65	120.8
T2	13.27	1.15	20.37	8.28	53.17	2.88	150.2

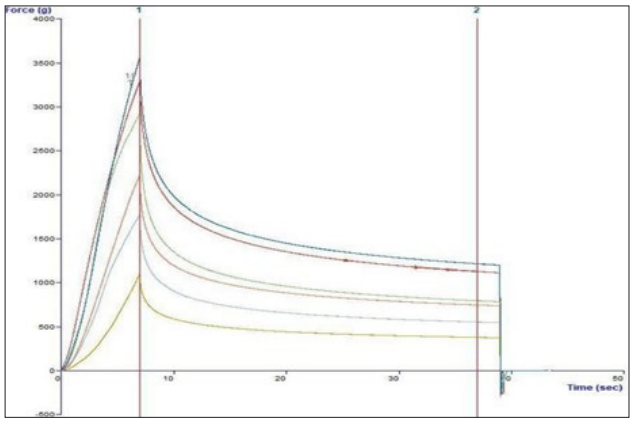


Figure 2: Graphical representation of texture analysis.

ed that incorporation of oilseeds such as chia can increase the water retention capacity and the sensory properties of bread due to the release of mucilage. The consequent increase in ash, fat, and protein content of the final (T2) sample was due to the incorporation of mineral rich, high protein containing oil seeds such as poppy, chia and pumpkin seeds. However, a significant decrease in the total carbohydrate content can be observed in the T2 sample. The result of this theory corresponds to the results obtained by Kukade et al. [28] Kaur and Sharma [29], and Rabail et al. [30] in their respective works (Table 4).

The data presented in table 1 indicates that the average crude fiber of different samples T0, T1, T2, of ragi muffin were found to be 1.32 g, 2.65 g, and 2.88 g, respectively. The higher amount of fiber content in T1 and T2 muffins can be attributed to the addition of ragi flour and pumpkin seed powder to the muffin formulation which corresponds to the results obtained by Sharma and Yamer [31] and Białek et al. [32]. The data presented in table 1 indicates that the average calcium of different samples T0, T1, T2, of ragi muffin were found to be 80 mg, 120.8 mg, and 150.2 mg, respectively. The high calcium content of prepared muffins was due to the presence of calcium rich ingredients such as ragi flour, molasses, chia, poppy and seeds. In a study performed by Lončar et al. [33], it was observed that muffins incorporated with frozen dried apple powder osmotically treated with sugar beet molasses showed a higher calcium percentage than the control muffins. Molasses is rich in essential micronutrients, including minerals such as calcium. Similarly, other researchers such as Sharma et al. [23], Kukade et al. [28], Sharma and Yamer [31], in their works on poppy seed flour, chia seed and ragi flour, respectively, have reported an increase in the calcium content of their respective products.

The total antioxidant activity of the sample was found to be DPPH inhibition with IC_{50} value 14.149 g/ml of sample extract. And the total phenolic content and total flavonoid content were found to be 15.015 ppm GAE and 34.426 ppm QE, respectively. Radical scavenging activity in bread supplemented with 5% pumpkin seeds as compared to the control bread. The antioxidant capacity of pumpkin seed flour has also been displayed in the work by Białek et al. [32] where muffins incorporated with pumpkin seed flour showed high DPPH scavenging activity (64%). Along with this the total phenolic content value was found out to be 17.6 mg GAE/100 ml of the sample extract. Study by Hussain et al. [22], comparing cookies made from ordinary wheat flour to cookies made with increased amounts of either water washed, or alkali washed millet flour, it was discovered that the phenolic content of the latter was higher (1.90 ± 0.14 mg GAE/g sample). Chia seeds are also considered as a potential source of antioxidants due to the presence of polyphenols including chlorogenic and caffeic acids, myricetin, quercetin, and kaempherol [26].

Conclusion

The aim of this study was to formulate a millet based baked good (muffin) enriched with various seeds powder with acceptable sensory as well as physicochemical characteristics. Based on the sensory evaluation where different treatments were evaluated for their color, appearance, texture, taste, flavor, and overall acceptability; T0, T1 (B), and T2 (C) received appreciable scores while T1 (A), T2 (A), and T2 (B) received lower scores. Therefore, T0, T1 (B), and T2 (C) were subjected to further analysis. Texture analysis suggested a significant increase in elasticity of nutriseed fortified muffin (3437.20) as compared to that of the control sample (3436.55). A relative increase in moisture and ash content was also observed when the two samples were compared. The fat and protein content of T2 (C) was found to be 20.37% and 8.28, respectively. The quantitative analysis of bioactive compounds such as antioxidants, polyphenols and flavonoids showed appreciable results with the values, 14.14 mg/ml (IC_{50}), 15.015 ppm GAE, and 34.42 ppm QE, respectively. This indicates that incorporation of pumpkin poppy and chia seeds powder is an effective promoter of these bioactive compounds.

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None.

Conflict of Interest

None.

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