



Quality Improvement of Cakes with Buckwheat Flour, and its Comparison with Local Branded Cakes

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Abstract

Buckwheat is one of the potential food ingredients for the functional food industry. A growing trend for consumer demand highlights the need for the development of composite flour-based bakery products like cookies and cakes. The aim of this study was to analysis the nutrient composition, and microbiological safety examination of buckwheat fortified cakes (BFC), as well as comparative evaluation with locally available branded cakes (LBC). BFC was prepared with the incorporation of 10, 20, 30, and 40% buckwheat flour in wheat flour to measure the quality and acceptability of cakes. As the concentration of buckwheat flour was increased up to 30%, BFC got the best quality, and high sensorial acceptability score evaluated by skilled panelists. BFC had the highest protein, fat, fiber, and micronutrients than all other LBC. No significant ($P < 0.05$) changes were found in sensory tests of the tested cakes. On the basis of microbiological point of view, BFC was found acceptable up to 09 days. Therefore, cake prepared with the incorporation of 30% buckwheat in wheat flour is nutritionally more acceptable than other cakes available in Bangladesh.



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Introduction


Buckwheat (*Fagopyrum esculentum* Moench) is traditionally used in Asia and Europe. It can be a major part of our daily diet due to its potential food ingredient, especially for the functional and clinical food industry.¹ Buckwheat flour is abundant in some

nutrients (per 100 g) such as protein (12.0 g), non-fibrous carbohydrate (69.6 g), dietary fiber (4.3 g), vitamins and minerals, as compared with other cereals such as rice and wheat. It also contains relatively less amount of lipid (3.1 g).² The protein of buckwheat flour consists of albumin (18.2%),

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globulin (43.3%), prolamin (0.8%), glutelin (22.7%), and very little or no gluten.³ Therefore, buckwheat may have a beneficial effect on various metabolic disorders like diabetes, coeliac disease, and so on that are closely associated with the gluten-free diet.⁴ Traditionally, the use of buckwheat through incorporating with wheat flour has increased due to its nutritional and physiological excellence. But, ingestion of insufficiently cooked buckwheat products can lead to diarrhea.⁵ Nowadays the consumer demand is increasing for ready-to-eat snacks, cookies, and the development of other composite flour bakery products. Previous study have focused on the incorporation of buckwheat into biscuits,⁶ bread,⁷ noodles,⁸ spaghetti,⁹ and the development of multi-functional products to improve food quality. Therefore, the objectives of this study were to formulate a cake with the incorporation of different percentage of buckwheat flour in wheat flour and evaluate their physicochemical, microbial, and sensory properties with the cakes locally available in Bangladesh.

Methods and Materials

Sample Collection

Cakes and raw materials such as buckwheat flour, wheat flour, sugar, salt, dry yeast, egg, etc. were collected from the groceries of Bangladesh. Pure cultures of the test organisms and culture media were obtained from Bangladesh Council of Scientific & Industrial Research (BCSIR), Bangladesh. All the chemicals and reagents were of analytical grade (Sigma Aldrich).

Product Development

The experimental cakes were formulated by slightly modifying the AACC method No. 10-91.¹⁰ The control and experimental cakes were made by adding wheat flour as well as the incorporation of buckwheat flour (BWF) at different concentrations viz. 0% (B₀), 10% (B₁₀), 20% (B₂₀), 30% (B₃₀), and 40% (B₄₀). Sugar, fat, and other ingredients were constant for all cakes per 100 g flour basis. The shortening, sugar, and other dry ingredients were gently mixed with water through a mixer bowl, followed by the dough was poured into a round cake pan (2 cm height x 2 cm diameter) and baked at 170-180°C for 20-30 min. All experiments were carried out in triplicates, and cakes were allowed to cool at room temperature (20°C to 25°C) for 8-10 min.

Proximate Macro Nutrient Analysis of Buckwheat Cakes, and Locally Available Cakes

The macronutrient contents (i.e., moisture, carbohydrate, protein, fat, fiber, ash) of the experimental and branded cakes were analyzed by following the AOAC (2005) method.¹¹ The total energy value was estimated by taking the sum of their respective energy values of carbohydrate, protein, and fat.¹²

Minerals Analysis of Buckwheat Cake

Sodium, potassium and calcium contents were determined using flame photometer.^{13,14} The standard solutions were prepared by dilution of the appropriate amounts of each mineral (0.5 ppm, 1 ppm, 2 ppm, 4 ppm, 6ppm, 8 ppm and 10 ppm) from the stock solutions (1000 ppm). In this method, about 2g of sample was taken in a crucible for drying followed by burning in a muffle furnace at 550-600°C to obtain greyish ash. After cooling, the ashes were dissolved in conc. HCL (3 ml) and were evaporated to dryness at a low temperature on the water bath. The remaining contents of crucible were further washed with de ionized water several times to evaporate until the liquid turns colorless. The solution was then filtered with ashless filter paper and was made up to 100 ml by de ionized water. Aliquots of this solution were used as working solution to determine Sodium, potassium and calcium.¹³ Iron (Fe) was determined by AOAC method¹⁵ using Flame Atomic Absorption Spectrometer.

Sensory Analysis

The standard method for sensory analysis is a nine-point hedonic-scale scorecard (9= like extremely, 8= like very much, 7= like moderately, 6= like slightly, 5= neither like or dislike, 4= dislike slightly, 3= dislike moderately, 2= dislike very much, 1= dislike extremely).¹⁶ An expert panel, consisted of 10 trained members (aged between 33-45 years old from Bangladesh Council of Scientific & Industrial Research (BCSIR), Bangladesh) participated to evaluate the sensory attributes of the cakes like appearance, color, texture, flavor, taste, mouthfeel, and overall acceptability.

Microbial Quality Analysis

Microbial quality analysis of this ready-to-eat cake was performed following the procedure of the Bacteriological Analytical Manual.^{17,18} Sample

(25 g) was aseptically weighed and properly enriched with 250 ml of sterile Buffer Peptone Water (Hi-Media, India). For total viable count (TVC) an aliquot (1 ml) of the sample was diluted in 9 ml buffered peptone water, thus placed on plate count agar (Hi-Media, India) and incubate at 37°C for 24 h. After the incubation period, the number of colonies was observed and reported as log CFU/g. For Coliforms and *E. coli* most probable number (MPN) test was carried out with Lauryl sulfate tryptose broth (Hi-Media, India), EC broth, and Brilliant green lactose bile broth (Hi-Media, India) on a screw cap tube. The most probable number of coliforms per milliliter or gram of sample was calculated from the number of tubes showing gas formation. A table for the determination of most probable numbers was used according to Feng *et al.*, (2013).¹⁹ Yeast and Mold counts were determined by spreading the plating method with

Dichloran Rose Bengal Chloramphenicol (DRBC) and Dichloran 18% Glycerol (DG18) agar media. The plates were incubated at 37°C for 5-7 days. Numbers of CFU were counted and reported as log CFU/g. Prevalence of *Bacillus sp.* in cake sample were determined by following Maroua *et al.*, (2018).²⁰ Determination of *Salmonella sp.* was carried out according to Saila *et al.*, (2017).²¹ All the analyses were conducted in triplicates.

Statistical Analysis

Data analysis was done using SPSS software (version 15.0, SPSS Inc. Chicago, Illinois, USA), and values were presented as a percentage and mean \pm standard deviation. Significance tests were done by following the one-way ANOVA method. Means were separated using a t-test. Triplicate data were used to analyze these results.

Table 1: Nutritive value of buckwheat fortified cakes (per 100 g)

Nutrients	B ₀	B ₁₀	B ₂₀	B ₃₀	B ₄₀
Moisture (%)	11.53 \pm 0.55	10.40 ^c \pm 0.72	9.42 ^{a**} \pm 0.45	8.33 ^{a**} \pm 0.69	7.26 ^{a**} \pm 0.39
Carbohydrate (g)	41.9 \pm 0.88	40.06 ^a \pm 1.17	38.12 ^{a*} \pm 0.96	36.63 ^{a**} \pm 0.45	34.67 ^{a**} \pm 0.72
Protein (g)	10.62 \pm 0.75	11.92 ^b \pm 0.61	13.12 ^{b*} \pm 0.51	14.06 ^{b**} \pm 0.68	15.26 ^{b**} \pm 0.51
Fat (g)	34.85 \pm 0.57	36.35 ^b \pm 0.58	37.95 ^{b*} \pm 1.07	39.45 ^{b**} \pm 0.77	41.15 ^{b**} \pm 0.59
Fiber (g)	0.27 \pm 0.01	0.32 ^{b*} \pm 0.02	0.35 ^{b**} \pm 0.01	0.38 ^{b**} \pm 0.01	0.41 ^{b**} \pm 0.02
Ash (g)	0.83 \pm 0.02	0.95 ^b \pm 0.03	1.04 ^{b*} \pm 0.04	1.15 ^{b**} \pm 0.06	1.25 ^{b**} \pm 0.07
Sucrose (g)	21.16 \pm 0.52	21.52 ^{b*} \pm 0.49	21.43 ^b \pm 0.57	21.34 ^b \pm 0.23	21.28 ^b \pm 0.27
Energy (kcal)	523.73 \pm 1.67	535.07 ^b \pm 1.68	546.51 ^b \pm 0.76	557.81 ^b \pm 0.85	570.07 ^{b*} \pm 1.18
Sodium (mg)	120.1 \pm 0.61	121.5 ^b \pm 0.51	122.9 ^b \pm 0.69	124.42 ^{b*} \pm 0.54	125.92 ^{b*} \pm 0.58
Potassium (mg)	200.03 \pm 1.37	224.20 ^b \pm 1.34	247.17 ^b \pm 1.68	271.13 ^{b*} \pm 0.94	295.79 ^{b*} \pm 0.78
Calcium (mg)	25.21 \pm 0.65	26.56 ^b \pm 0.75	27.62 ^b \pm 0.45	28.77 ^{b*} \pm 0.66	29.82 ^{b*} \pm 0.69
Iron (mg)	3.61 \pm 0.01	4.09 ^b \pm 0.11	4.59 ^{b*} \pm 0.04	5.09 ^{b**} \pm 0.04	5.59 ^{b**} \pm 0.05

Here, B₀, B₁₀, B₂₀, B₃₀, B₄₀ indicates 0, 10, 20, 30, and 40% buckwheat mixed with wheat flour respectively. Values are means of triplicates \pm standard deviation.

Superscript 'a' and 'b' in a row indicates lower & higher values respectively and were compared with that of B₀ (control).

* indicates significantly different (P <0.05) and **indicates highly significant (P <0.001) as determined by Duncan's multiple range test.

Results and Discussion

Nutrient Analysis of Buckwheat Fortified Cake (BFC)

The proximate nutrient composition of cakes in the control group (without buckwheat flour) and the cakes prepared with different percentages of buckwheat flour (B₁₀, B₂₀, B₃₀, and B₄₀) is shown in

Table 1. The moisture content of the cakes fortified with buckwheat (BFC) was reduced (11.5% to 7.3%) with the increment of buckwheat flour (BF). Puwani *et al.* (2006) reported lower moisture content (6.3–10.9%) enhances the product's shelf-life during storage by inhibiting the microbial growth and chemical reactions in foods.²² The amount

of carbohydrate was lower in BFC than the cake without buckwheat (B₀). Non-digestible starch like resistant starch, β-glucans, oligosaccharides, and chitin present in the buckwheat might reduce the carbohydrate content.²³ Addition of BF to cake also significantly (p<0.05) increased the nutritive values of fiber, protein, fat, ash, calcium, and iron. Amounts of protein, fat, and fiber in BFC ranged from 11.9-15.3%, 36.4-41.2%, and 0.3-0.4%, respectively. According to Maeda *et al.* (2004), buckwheat protein is an excellent supplement for cereal grains due to having a high biological value of amino acids.²⁴ Energy values among the cakes did not differ significantly. However, minerals contents were simultaneously increased (P < 0.05) with the augmentation of BF in the cake (Table 1). These trends were also proposed by other studies for the buckwheat flour products like bread,²⁵ biscuit,²⁶ and noodles.⁶ Data in Table 1 showed that BFC prepared with 30% (B₃₀), and 40% (B₄₀) buckwheat flour was nutritionally better (P < 0.001) than the cake made with only wheat flour (B₀).

Sensory Evaluation of BFC

Sensory evaluation is one of the best tools among consumers to judge the product for final acceptance. Sensory attributes of BFC are shown in Table 2. The color and appearance of the product make the first impression in the consumer’s mind to select ones. The mean score for color and appearance for BFC ranged from 8.82 to 8.13. The control cake (B₀)

showed the highest score, and the lowest score was found in B₄₀. The mean score of BFC was reduced with the increment of BF which contains dark color.²⁷ The texture is another important sensory attribute that indicates the feel of an interior part as softness or hardness of the product. In our study, the textural properties of BFC improved with the increasing amount of BF. The mean score of B₀, B₁₀, B₂₀, B₃₀, and B₄₀ were found 8.81, 8.64, 8.38, 8.32, and 7.78 respectively. The texture of BFC up to 30% addition of BF was not significantly (P <0.05) different from the cake made without BF.

Flavor and taste determine the acceptability and market success of the product. This study showed that flavor and taste had the lowest score for the control cake (B₀), and gradually increased with the addition of an increasing amount of BF. The symmetry and evenness of the cake depend on the strength of gluten that forms a network and retains homogeneous vapor production during baking.²⁵ As BF contains lower gluten content, BFC developed a lower innermost network and uniformity than B₀. The overall acceptability for B₀ (8.40), and B₃₀ (8.36) did not differ significantly and showed a higher mean score as compared to B₁₀ (8.02), B₂₀ (8.13), and B₄₀ (7.92). Based on all the sensory attributes, BFC formulated with 30% buckwheat flour (B₃₀) was the best, and above this level, the sensory score was lower, as shown in Table 2.

Table 2: Sensory properties of BFCs

	B ₀	B ₁₀	B ₂₀	B ₃₀	B ₄₀
Color and appearance	8.82 ^a ±0.02	8.69 ^a ±0.04	8.62 ^a ±0.02	8.47 ^a ±0.01	8.13 ^a ±0.02
Texture	8.81 ^a ±0.01	8.64 ^a ±0.03	8.38 ^a ±0.01	8.32 ^a ±0.01	7.78 ^b ±0.01
Flavor	7.82 ^a ±0.01	7.93 ^a ±0.01	8.07 ^a ±0.02	8.18 ^b ±0.02	8.29 ^b ±0.03
Taste	8.05 ^a ±0.02	8.18 ^a ±0.03	8.86 ^b ±0.03	8.47 ^b ±0.02	7.9 ^a ±0.02
Overall acceptance	8.40 ^a ±0.01	8.02 ^b ±0.03	8.13 ^a ±0.03	8.36 ^a ±0.01	7.92 ^b ±0.04

Values are means of six panelist’s ± standard deviation. Values with the same superscript in a row are not significantly different (P <0.05).

Microbial Analysis

According to WHO standards (1994) the maximum permissible limits in baked products (cake, bread, biscuit and others) for total aerobic bacteria count are 2.0x10⁵ cfu/g, coliform bacteria <200 MPN/g,

E. coli absent, yeast and mold is <1.0x10³ cfu/g.²⁸ Furthermore, good manufacturing practice (GMP) guidelines also comply with the WHO guideline.²⁹ However, the microbial load of the experimental cake was assessed up to 10 days. The findings

demonstrated that the total aerobic bacteria count was within the acceptable limit up to 09 days. Moreover yeast and mold counts were found to be within WHO limits, whereas Coliform, *E. coli*,

Bacillus sp. and *Salmonella sp.* were absent in the tested cake sample (Table 3 and Fig. 1). After 09 days, the microorganisms were increased, and the product quality became deteriorating.

Table 3: Microbiological quality evaluation of buckwheat cake

Microorganisms	0 days	3 days	5 days	7 days	9 days	10 days
Total aerobic bacteria, cfu/g	2.9×10 ²	3.4×10 ²	3.9×10 ²	4.7×10 ³	6. 2×10 ⁴	9. 4×10 ⁵
Total Coliforms, MPN/g	<0.3**	<0.3**	<0.3**	<0.3**	<0.3**	<0.3**
<i>Escherichia coli</i> , MPN/g	<0.3**	<0.3**	<0.3**	<0.3**	<0.3**	<0.3**
Yeasts and Molds, cfu/g	<10*	<10*	<10*	<10*	3.0×10 ²	5.0×10 ³
<i>Bacillus cereus</i> ,/g	Absent	Absent	Absent	Absent	Absent	Absent
<i>Salmonella sp.</i> /25g	Absent	Absent	Absent	Absent	Absent	Absent

* <10 indicate absence of test organisms in 1g of sample.

** As per MPN (most probable number) chart, MPN <0.3 indicates absence of test organism in 1g.

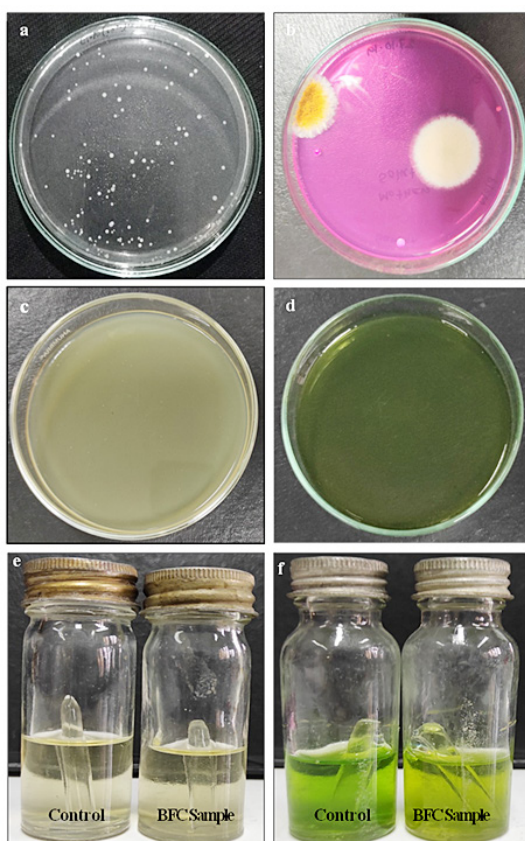


Fig. 1: Microbiological results of BFC after 09 days. (a) Total viable count, (b) Yeast and Mold count, (c) *Bacillus sp.* count, (d) *Salmonella sp.* count, (e) Test of Coliform, (f) Test of *E. coli*.

Comparison of Buckwheat Fortified Cake (B₃₀) with Locally Available Branded Cakes in Bangladesh

This study also compared the experimental BFC (B₃₀) with the cakes (made with wheat flour) available in the market, as shown in Table 4. The moisture content of the local branded cakes (LBC) was found 13.66 to 20.14%, whereas B₃₀ showed the lowest one (8.33%). The high percentage of moisture inspire microbial growth and also declines food quality.²² This may be explained as a better shelf-life of B₃₀. The lowest carbohydrate content was also found in B₃₀ (36.63%) which indicates a good choice for diabetic, and obese persons.

Protein, fat, fiber and ash contents were found significantly higher in B30 i.e. 14.06%, 39.45%, 0.38%, and 1.15% respectively. In case of LBC, these nutrients ranged from 6.38 to 9.41% (protein), 22.02 to 29.38% (fat), 0.02 to 0.07% (fiber), and 0.07 to 0.72% (ash). These results corroborated the findings of the previous studies, where the potentiality of buckwheat flour has been mentioned as a higher level of protein, fat, fiber, and ash.³⁰ This study also depicted that the highest energy value of cake was found in BFC (557.81 Kcal/100 g), and in the case of LBC, the energy value was ranged from 425 to 489 Kcal/100 g (Table 4).

Table 4: Comparative macronutrient analysis of BFC (B₃₀) with locally available branded cakes in Bangladesh (per 100 g)

Nutrients	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇	C ₈	B ₃₀
Moisture	13.66 ^h	20.14 ^a	18.88 ^b	17.29 ^e	17.50 ^d	18.10 ^c	14.00 ^g	15.95 ^f	8.33 ⁱ
Carbohydrate	50.02 ^b	43.49 ^g	49.16 ^e	49.78 ^d	49.90 ^c	45.63 ^f	52.81 ^a	49.78 ^d	36.63 ^h
Sucrose	17.71 ⁱ	17.75 ^h	19.97 ^g	22.81 ^b	20.81 ^d	20.65 ^e	23.93 ^a	20.03 ^f	21.34 ^c
Protein	6.38 ⁱ	6.40 ^h	7.52 ^f	7.34 ^g	7.97 ^e	9.41 ^b	8.54 ^c	8.05 ^d	14.06 ^a
Fat	29.28 ^c	29.38 ^b	22.02 ⁱ	24.88 ^f	23.89 ^h	26.27 ^d	23.93 ^g	26.08 ^e	39.45 ^a
Ash	0.64 ^f	0.57 ^g	0.70 ^c	0.68 ^d	0.72 ^b	0.54 ^h	0.65 ^e	0.07 ⁱ	1.15 ^a
Fiber	0.02 ^f	0.02 ^f	0.04 ^d	0.03 ^e	0.02 ^f	0.05 ^c	0.07 ^b	0.07 ^b	0.38 ^a
Energy (kcal)	489 ^b	464 ^d	425 ⁱ	452 ^g	446 ^h	457 ^f	461 ^e	466 ^c	557.81 ^a

Values are means of three replicates Superscript 'a' to 'i' in a row indicates higher to lower values respectively and the same superscript were not significantly different (p>0.05).

Conclusions

Buckwheat flour incorporation into wheat flour significantly improved the physicochemical and sensory properties of cake. BFC showed higher protein, fat, and fiber contents than cakes formulated with only wheat flour. Panelists rated the BFC as the best, whereas the cake prepared from wheat flour was found to have lowest sensorial scores. It is also important to note that the BFC cake developed during this study is microbiologically acceptable for up to 09 days. It can, therefore, be concluded that a good quality cake can be prepared by incorporating 30% buckwheat flour. Thus, the present study will encourage the local food industries to develop various traditional and the buckwheat-based food products.

Authors' Contributions

Conceptualization, TF and SSR; Methodology, TF and SA; Formal Analysis, SSR; Investigation

and Data Curation, TF, JF, FBH; Writing-Original Draft Preparation, SSR; Writing-Review and Editing, TF, and SSR. Final manuscript was read and approved by all authors.

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Conflict of Interest

The authors do not have any conflict of interest.

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