Development and Quality Assessment of Composite Biscuits Fortified with Potato and Corn Flour

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ABSTRACT

Applying composite flour in bread production could provide a healthier alternative to bread made with wheat flour. This study aimed to develop fortified wheat flour bread with improved nutritional properties, thereby enhancing the overall nutritional value of wheat flour bread. This study used potato and corn flour as supplementary components to produce fortified biscuits. Wheat flour contains optimum levels of moisture (13.10%) and protein (9.37%), while potato flour contains the highest levels of ash (1.6%) and total carbohydrates (82.39%). The result shows that corn flour had the maximum fat content at 2.54% and the highest energy content at 360 Kcal/100 g. As the level of supplementation increases, the diameter, thickness, and volume increase significantly while the weight, spread ratio, and density decrease. The control biscuits (F1), composed of 100% wheat flour, exhibited the highest levels of moisture (5.02%) and protein (8.02%) in chemical analysis. In contrast, biscuits containing a blend of 50% potato flour and 50% wheat flour (F2) displayed reduced moisture (4.45%) and protein (7.54) levels, accompanied by the highest ash content of 1.11%.The fat content increased while the protein content decreased as the potato or corn flour percentage increased. Sensory analysis of biscuits revealed that a combination of 50% potato flour and 50% wheat flour (F2) was the most popular among consumers. Based on sensory evaluation and storage studies on the shelf-life of processed biscuits, it is recommended that up to 50% of the wheat flour in fortified biscuits may be replaced with potato flour on an industrial scale.

Keywords: Biscuit, Fortification, Quality, Physical properties, Composite flour, Shelflife.

1. INTRODUCTION

Biscuits are a significant processed food item in the human diet commonly consumed across various socio-economic classes. This bakery is made primarily from flour with a low moisture content. It is also commonly found in the form of confectionery [1]. Baked goods in the form of biscuits are widely consumed worldwide [2]. Typically, they are snacks made from dough (which consists of flour, fat, sugar, and water) that are changed into delectable items by applying heat in an oven at a controlled temperature [3]. These products are ready-to-eat, simple to prepare, and relatively cheap, featuring various shapes and sizes predominantly consumed by individuals of both younger and older age groups [4].

Using composite flour in food has been considered beneficial in developing nations as it promotes the utilization of regionally cultivated crops as flour and decreases dependence on imported wheat flour [5, 6]. This approach is being assessed to determine the viability of

substituting wheat flours with alternative locally accessible flours [7]. Potato flour is a great carbohydrate source, has high dietary fiber & vitamins, a good amount of minerals, 6-12% protein and negligible fat content and helps lower the gluten content. Corn is a major source of carbohydrates, protein, vitamin B, vitamin A (yellow maize) and minerals [8].

In Bangladesh, it is observed that during the production season of potatoes and corn, prices tend to decrease due to inadequate storage and marketing facilities, often resulting in significant losses for the producers. Adding potato and corn flour to wheat flour can improve the sensory attributes of biscuits and may also offer economic benefits in the production of biscuits [1]. This study aimed to determine the proximate composition of wheat, potato and corn flour and establish a uniform procedure for producing fortified biscuits and their subsequent assessment of quality characteristics.

2. MATERIALS AND METHODS

The experimental studies were conducted in the Department of Food Technology & Engineering laboratories under the Faculty of Nutrition and Food Science, Patuakhali Science and Technology University, Dumki, Bangladesh.

2.1 Materials

Wheat flour (fresh), Corn flour, potato, daldah (Pusti brand), salt (Mollah brand), eggs, sugar (ACI brand), vanilla essence, milk powder (Pran brand) and baking

powder (Noor nobi brand) were bought from the local market. Analytical Research (AR) grade chemicals (high-grade chemicals suitable for different analyses) were used to analyze the raw materials and final products.

2.2 Potato flour preparation

Potato flour was prepared using the method described by [9]. Selected potatoes were first cleaned with potable water. Then peel and slice into 2-3 mm thickness and steam blanched for 10 minutes. After overnight drying (80 -85°C), the slices were milled and passed through a 30-mesh standard sieve. Subsequently, the flour was enclosed in high-density polyethylene bags for further utilization.

2.3 Experimental Plan

In this study, a certain percentage of wheat flour, potato flour, and corn flour were used, as shown in Table 1. Table 2 shows the different combinations of ingredients used to prepare 100g dough.

Table 1. Experimental Plan for the preparation of fortified biscuits

Sample	Wheat flour (%)	Potato flour (%)	Corn flour (%)
F1	100	00	00
F2	50	50	00
F3	50	00	50

Table 2. Ingredients used in the preparation of Biscuits (total 100 g)

Sl. No.	Ingredients	Sample		
		F1	F2	F3
1.	Wheat flour (g)	50	25	25
2.	Potato flour (g)	0	25	0
3.	Corn flour (g)	0	0	25
4.	Sugar (g)	15	15	15
5.	Fat (daldah) (g)	12	12	12
6.	Milk powder (g)	2	2	2
7.	Egg (g)	20	20	20
8.	Baking powder (g)	1	1	1
9.	Vanilla flavor (drops)	1-2	1-2	1-2
10.	Salt (g)	0.5	0.5	0.5

F1= 100% wheat flour; F2= 50% wheat flour + 50% potato flour; F3= 50% wheat flour + 50% corn flour.

2.4 Composite biscuits formulation

The method described by [11] was adapted to make biscuits with slight modification. Firstly, finely meshed fat was mixed with sugar powder, egg, salt, milk powder and vanilla essence. Subsequently, the flour and baking powder were incorporated and thoroughly blended to yield a cohesive dough, flattened into a uniform sheet measuring 3 millimeters in thickness. After cutting a 3 cm round shape, the biscuits were baked at 170°C for 20 minutes using the baking oven.

2.5 Quality analysis of flour and fortified biscuits

In this study, the Moisture content [11], Ash content [12], protein content [12], fat content [12], total carbohydrate content and energy content [13], and gluten content [14] of fortified biscuits and flours (wheat, potato and corn) were determined.

2.6 Physical properties determination

The weight, thickness, spread ratio, volume, and density of fortified biscuits were determined by the method described by [15].

2.6.1 Weight: The weight of the biscuits was determined by calculating the mean of four individual measurements using a digital weighing balance.

2.6.2 Thickness: It was measured by stacking four biscuits on each other and taking the average thickness (cm).

2.6.3 Sread ratio: The spread ratio was determined by using this formula.

$$\text{Spread ratio} = \frac{\text{diameter (mm)}}{\text{thickness (mm)}}$$

2.6.4 Volume: Volume of biscuit is defined as the area of the biscuit multiplied by thickness.

$$\text{Volume (cm}^3\text{)} = \frac{\pi D^2}{4} \times T$$

Where, D= average diameter of biscuits (mm) and T = average thickness of biscuits (mm).

2.6.5 Density: After calculating volume, density was obtained from the ratio between weight and volume [15].

$$\text{Density (g/cm}^3\text{)} = \frac{\text{Weight(g)}}{\text{Volume(cm}^3\text{)}}$$

2.7 Sensory evaluation of developed biscuits

The samples were evaluated based on color, taste, flavor, texture and overall acceptability by a panel of judges (12) using a 9-point hedonic scale according to [16]. A 9-point hedonic rating scale [10] was used for statistical analysis of sensory data to determine the extent of acceptance. The tasters were given a hedonic rating scale from 1 to 9 with the following options: 9 for "extremely like," 8 for "very much like," 7 for "moderately like," 6 for "slightly like," 5 for "neither like nor dislike," 4 for "dislike slightly," 2 for "dislike moderately," 1 for "extremely dislike".

3. RESULTS AND DISCUSSION

This section reflects the results and the findings of the studies and their interpretation.

3.1 Proximate composition of wheat, potato and corn flours: Table 3 presents the analysis of nutritional quality. The results indicate that wheat flour exhibited the highest moisture content at 13.10%, with corn flour following closely behind at 11.09%. In contrast, potato flour displayed the lowest moisture content at 10.20% among the three types of flour. Potato flour yielded the highest ash content (1.6%) and total carbohydrate content (82.39%), whereas wheat flour exhibited the lowest ash content (0.62%) and fat content (0.85%) but the highest protein content (9.37%). The study results indicate that corn flour exhibited a high-fat content of 2.54% and yielded a maximum energy value of 360 Kcal/100g upon consumption. Conversely, potato flour demonstrated a comparatively lower energy value of 323 Kcal/100g. As per the researcher's findings [17], wheat flour exhibits a moisture content of 12.0%, ash content of 0.60%, protein content of 13.0%, fat content of 1.0%, and total carbohydrate content of 74.7% in wb. On the other hand, corn flour displays a moisture content of 9.3%, protein content of 7.4%, fat content of 2.0%, ash content of 1.2%, crude fiber content of 5.5%, and total carbohydrate content of 80.2%. The compositional dissimilarity observed among authors may be attributed to factors such as varietal diversity, environmental conditions, pre and post-harvest processing, and the degree of drying.

Table 3. Composition of wheat, potato and corn flours

Parameters	Wheat flour	Potato flour	Corn flour
Moisture (%) on dry basis	13.10	10.20	11.09
Ash (%)	0.62	1.60	0.63
Protein (%)	9.37	5.32	6.52
Gluten (%)	15.20	Not detected	Not detected
Fat (%)	0.85	0.49	2.54
Total Carbohydrate (%)	76.06	82.39	79.22
Energy (Kcal/100 g)	332	323	360

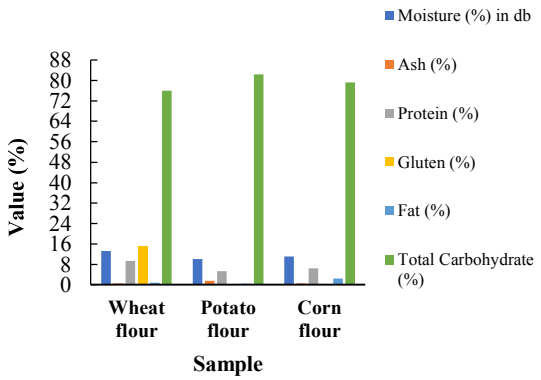

Figure 1. Composition of wheat, potato and corn flour

3.2 Physical properties of biscuits:

Table 4 demonstrates the average findings from the assessment of the biscuits' physical characteristics, including their diameter, thickness, volume, spread ratio, and density. As the level of supplementation increases, there is a noticeable rise in the diameter, thickness, and volume, while a decrease in weight, spread ratio, and density is noted. The F3 sample exhibits the largest values for diameter, thickness, and volume, while the F1 sample displays the highest weight, spread ratio, and density among the three samples. Incorporating potato flour and corn flour impacts a significant impact on the physical characteristics. The thickness of biscuits exhibited a slight increase with the gradual replacement of wheat flour with potato flour by up to 25%. This phenomenon was inversely proportional to the spread ratio, which decreased with the increasing proportion of potato flour. This can be attributed to the higher water-holding capacity of potato flour, as reported in previous studies [18].

Table 4. Effect of potato and corn flour on physical properties of biscuits

Sample	Weight (g)	Diameter D (cm)	Thickness T (cm)	Volume (cm^3)	Spread Ratio	Density (g/cc)
F1	4.61	3.70	0.68	7.31	5.44	0.63
F2	4.32	3.80	0.72	8.16	5.27	0.53
F3	4.55	3.82	0.82	9.40	4.66	0.43

F1= 100% wheat flour; F2= 50% wheat flour + 50% potato flour; F3= 50% wheat flour + 50% corn flour

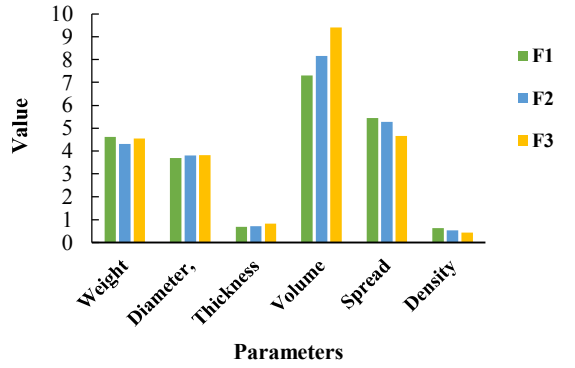

Figure 2. Effect of potato and corn flour on physical properties of biscuits.

3.3 Nutritional properties of fortified biscuits: The biscuits samples were analyzed for moisture, ash, protein, fat, and total carbohydrate. The results obtained are presented in Table 5.

Table 5. Nutritional composition of fortified biscuits

Sample	Moisture (%)	Ash (%)	Protein (%)	Lipid (%)	Total Carbohydrate (%)	Energy (Kcal/100g)
F1	5.02	0.72	8.02	16.93	69.31	456.54
F2	4.45	1.11	7.54	17.21	69.69	462.32
F3	4.72	0.78	7.80	17.68	69.02	480.74

F1= 100% wheat flour; F2= 50% wheat flour + 50% potato flour; F3= 50% wheat flour + 50% corn flour.

3.3.1 Moisture: According to Table 4, the moisture content of three different types of biscuits ranged from 4.45 to 5.02%. Factors such as the starting moisture content of different types of flour used in baking, storage conditions, and packaging materials may all contribute to the observed difference in biscuits' moisture levels. The F1 sample had a significantly higher moisture content than the rest. Different types of flour, such as wheat flour, potato flour, and corn flour, all have different amounts of solid matter, which may explain this phenomenon. According to [19], research showed that the moisture content of composite biscuits was anything from 5.13 percent to 7.17 percent dry basis. The biscuits used in this study all had moisture levels that were within the acceptable range, as established by earlier researchers.

3.3.2 Protein: Due to the larger percentage of gluten in wheat flour, the protein content reduced as the quantity of potato or corn flour increased. Protein content varied greatly between the samples, with F2 having the lowest and F1 having the most. Wheat flour biscuits had a 6.6% (db) protein content, while potato-enriched biscuits had a 6.1% (db) protein content, as reported in [20]. According to the research by [19], composite biscuits' protein content was between 6.88% and 11.45% (db). The results suggest that potato or corn flour can make low-protein biscuits.

3.3.3 Lipid: The lipid composition of the specimens fell within 16.93-17.68%, as presented in Table 4. The potato flour supplementation resulted in a negligible variation in fat content, whereas the corn supplementation increased fat content. This finding is consistent with the study conducted by [20], which revealed that the biscuits supplemented with 20% potato flour contained 25.8% (db) fat, while the control group had 25.9% (db) fat.

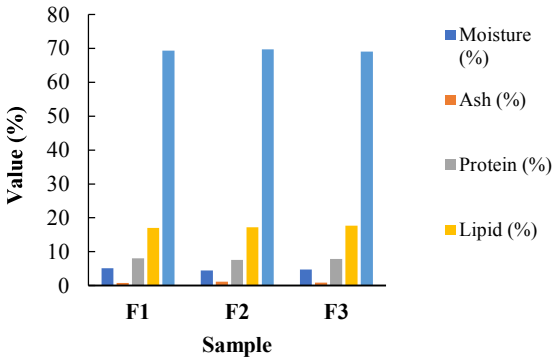

Figure 3. Nutritional properties of fortified biscuits.

3.3.4 Ash: The ash percentage ranged from 1.11% in the sample denoted as F2 to 0.72% in the sample denoted as F12. Because potato flour has a higher mineral content than wheat flour, including it in the biscuits caused them to have a higher ash level. According to [21], research showed that the ash content of composite biscuits was between 0.99 and 1.13% (wb). However, biscuits with 20% potato flour were reported to have an ash value of 1.7% by [20], while the control biscuit had an ash value of 1.4% (db).

3.3.5 Total Carbohydrate: Carbohydrate content varied from 69.02 to 69.69% throughout the samples (Table 4). Differences in protein, fat, ash, and moisture content may account for the wide range of total carbohydrate values seen in the biscuits we tested.

3.3.6 Energy: The total energy, expressed in calories, of the developed biscuits, varied between 456.54 and 480.74 for a 100 g consumption.

The observed variation in the samples is linked to the inclusion of either potato flour, which demonstrated the highest total carbohydrate content (82.39%), or corn flour, which contained the highest amount of fat (2.54%). These findings are presented in Table 3.

3.4 Shelf-Life analysis for fortified biscuits: The shelf-life of fortified biscuits was examined over 28 days, as presented in Table 6. The biscuits were packaged in high-

density polyethylene (HDPE) and stored at room temperature. The shelf life was assessed through the periodic evaluation of texture, color, flavor, and overall acceptability at 7-day intervals over a 28-day duration.

Table 6. Shelflife studies of fortified biscuits

Storage period (days)	Sample code	Observation			
		Texture	Flavor	Color	Remark
0	F1	Crisp	Good	Good	Good
	F2	Crisp	Good	Good	Good
	F3	Crisp	Good	Good	Good
7	F1	Crisp	Good	Good	Good
	F2	Crisp	Good	Good	Good
	F3	Crisp	Good	Good	Good
14	F1	Less crisp	Slightly rancid	Slightly faded	Freshness declined
	F2	Less crisp	Slightly rancid	Slightly faded	Freshness declined
	F3	Less crisp	Slightly rancid	Slightly faded	Freshness declined
28	F1	Damp	Rancid	Good	Not acceptable
	F2	Damp	Rancid	Good	Not acceptable
	F3	Damp	Rancid	Good	Not acceptable

3.5 Sensory evaluation of composite flour biscuits:

The sensory evaluation of biscuit samples was evaluated for color, flavor, texture and overall acceptability by a panel of 25 tasters. Table 7 shows the typical results of a sensory evaluation. The color evaluation for the three samples showed that F2 was the most aesthetically pleasing. Once more, samples F1 and F3 were ranked best and good in terms of aesthetic quality in that order.

All three samples (F1, F2, and F3) had an appealing smell and the product's distinctive flavor without any unpleasant odors. Sample F2 was deemed to have the highest aesthetic quality, as shown in Table 7. A slight flavor difference was observed in the F3 sample (Figure 4).

Sample F2 scored higher than both F1 and F3 in terms of texture. Sample F2 had the highest rating for overall acceptability; it was also the most dissimilar to the other samples. Fisher's LSD, multiple comparison tests, showed that the F2 sample (biscuits made from 50% potato and 50% wheat flour) was the most popular (Figure 4).

Table 7. Mean score for color, flavor, texture and overall acceptability of fortified biscuits

Samples	Sensory attributes			
	Texture	Flavor	Color	Overall acceptability
F1	7.7^{b}	7.9^{b}	7.9^{b}	7.6^{b}
F2	8.5^{a}	8.6^{a}	8.3^{a}	7.7^{a}
F3	7.0^{c}	6.8^{c}	7.8^{c}	6.8^{c}

a= excellent, b= best, c= good; F1= 100% wheat flour biscuits; F2 = 50% potato + 50% wheat flour biscuits; F3 = 50% corn + 50% wheat flour biscuits.

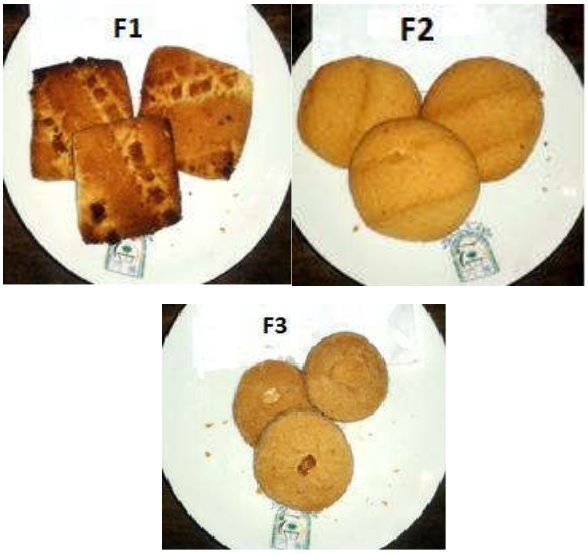

Figure 4: Physical and sensory characteristics of fortified biscuits.

4. CONCLUSION

Because of their rapid spoilage, 6.6% of all harvested potatoes in Bangladesh are lost after being wholesaled, 5.3% at the radar level, and 1.1% at the merchant level [22]. Potatoes and corn have the potential to serve as ingredients in the production of biscuits. Biscuits that are both nutritious and signature flavorful can be produced by incorporating potato or corn flour in addition to wheat flour. Wheat flour can be used to supplement potato or corn flour up to a maximum of 50% to produce biscuits that appeal to a wider range of consumers. The enhancement of the formulation can be achieved through the incorporation of food coloring agents, flavoring compounds, and vitamin supplements. Additional research can be conducted pertaining to vitamins and mineral contents, anti-oxidant activity, particle size distribution, hydration properties, etc.

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