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Effect of Gluten-free Composite Flour on Physico-chemical and Sensory Properties of Cracker Biscuits

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Abstract

Coeliac disease is an antibody-mediated enteropathy that presents permanent intolerance to ingested gluten, for which only treatment is lifelong devotion to a gluten-free diet. The aim of this study was to produce and investigate cracker biscuits prepared from gluten-free composite flour. Gluten was separated from wheat flour to make gluten-free wheat flour (GFWF). Raw rice, Bengal gram, fresh potatoes and Italian millet were dried and ground into powder. The cracker biscuits were prepared by incorporating different levels of gluten-free composite flour. The cracker biscuits were investigated for their physico-chemical and sensory properties. The spread ratio of control biscuits containing only 100% wheat flour was higher but weight was lower than other cracker biscuits containing gluten-free composite flour. Chemical analysis showed that gluten-free cracker biscuits had higher moisture, ash, and fat content, while lower protein content than control biscuits. The sensory results showed that overall acceptability, taste, flavor and texture scores differed significantly ($p<0.05$). The cracker biscuits containing 45% gluten-free wheat flour, 25% rice flour, 15% Bengal gram flour, 10% potato flour and 5% Italian millet flour was the favorite sample of the sensory evaluation with the highest overall acceptability among all types of gluten-free cracker biscuits.

Keywords: Coeliac disease; Gluten intolerance; Gluten-free diet; Cracker biscuits.

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1. Introduction

Celiac disease (CD) is a permanent gluten-sensitive enteropathy which is a life-long disorder characterized by a severe damage of the small-intestinal mucosa when taking a diet containing

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gluten and unequivocal [1]. Gluten is the general term for the proteins that have been found to be toxic in those with CD - specifically the storage proteins (prolamins) in wheat (gliadin), rye (secalin) and barley (hordein). Many individuals with CD may be only mildly symptomatic or asymptomatic at diagnosis. Or, they may present with various nutrition or malabsorption-related problems such as unintentional weight loss, bloating and gas, ongoing fatigue, lactose intolerance, diarrhea or constipation, iron deficiency anemia, folate deficiency and low serum levels of vitamin B_{12}, magnesium and phosphorous [2]. The majority of those diagnosed with this disease is silent and latent cases and have the potential but may or may not develop the disease [3]. As the worldwide average of celiac sufferers has been predicted to increase by a factor of 10 over the next number of years, there is a growing market for high-quality gluten-free cereal products [4]. Challenge for food scientists to overcome such problem is of importance, because it can only be treated by strict adherence to a gluten-free diet. Developing gluten-free foods, regulated to have gluten level not exceeding 200 ppm, is difficult because gluten is very common in food sources. Attempts to remove the gluten ingredient in foods, also, may result in the loss of nutritional balance of the products [5, 6]. Gluten-free flours require a gluten replacement to provide structure and gas retaining properties in the dough [7]. Replacement of gluten is one of the major challenges for gluten-free product development. Corn, rice, tapioca and potato flour, which are allowed in a gluten-free diet, are not able to supply the same technological characteristics as gluten [8].

Among gluten-free diet, biscuit with a universal appeal is an important cereal product. Biscuits are convenient food products, becoming very popular among both rural and urban populations across the world. Some of the reasons for such wide popularity are low cost relative to other processed foods, varied taste and longer shelf life. Biscuits have also been considered a better vehicle of fortification with protein because of their popularity, high nutrient density and long shelf-life [9].

As gluten-free products are usually protein-free products with low mineral and vitamin content and based often on pure starches, resulting in a dry, sandy mouth-feel with low organoleptic characteristics; new gluten-free product formulations with better organoleptic and nutritional properties should be proposed. So, recently there are some studies on gluten-free biscuits. The effects of buckwheat flour, brown rice flour, soya flour [10], king palm flour [11], corn flour, amaranth flour and linseed flour [12] in the formulation of gluten-free biscuits were previously studied and some affirmative results were obtained. In the present study, it was aimed to improve gluten-free cracker biscuit formulation by using rice flour, gluten-free wheat flour, Bengal gram flour, potato flour and Italian millet flours in standard formulation and the final products were investigated for some important parameters including physico-chemical and sensory properties.

2. Materials and Methods

The study was conducted in the laboratory of the Department of Food Technology and Rural Industries, Faculty of Agricultural Engineering and Technology, Bangladesh Agricultural University, Mymensingh. Commercial wheat flour of 'Teer' brand (12% moisture and 10.50% protein) was used for making gluten-free wheat flour. Raw (un-parboiled) rice (12.61% moisture and 6.20% protein), potato of diamond variety (77% moisture and 2% protein), Bengal gram (13. 62% moisture and 19.76% protein) and Italian millet (12.53% moisture and 14.01% protein) were collected from local market and cleaned before use. Salt, dalda, baking powder were procured from the local market. Other minor ingredients were used from laboratory stocks.

2.1. *Preparation of gluten free wheat flour (GFWF)*

1000 gram wheat flour was taken in a bowl and 500 ml water was added and mixed into firm dough until uniformly mixed. Dough was allowed to stand immersed in water for 15-20 minutes. Then dough was manipulated under a gentle stream of water. The work was continued until separation of gluten. After separation of gluten the liquid portion was taken in separate bowl and allowed to settle the solid for 5-6 hours. After this, the upper liquid layer was decanted from the solid and the solid fraction was taken in trays. Then it was kept in a cabinet dryer at 40ºC for 6-7 hours. After drying it was ground into powder in a grinder, sieved, packaged in polythene bags and stored at room temperature.

2.2. *Preparation of potato flour (PF)*

The potatoes were sorted, peeled by knives and chopped into small cubes and blanched with hot water at 100°C for 5minutes.Then the water was drained. Potato cubes were cooled and spread in trays and dried in cabinet dryer at 60±2°C for 8 hours. After cooling at room temperature, the dried potato cubes were ground into powder in a grinder, sieved, packaged in polythene bags and stored at room temperature for further use for the preparation of biscuits.

2.3. *Preparation of rice flour (RF), Italian millet flour (IMF) and Bengal gram flour (BGF)*

Raw rice (RR), Italian millet (IM) and raw Bengal gram (BG) were cleaned to remove dirt and other undesirable materials. The clean RR, M and BG were then dried in a cabinet dryer separately at 60±2°C for 4 hours and then ground into powder in a grinder, sieved, packaged in polythene bags and stored at room temperature.

2.4. *Formulations of cracker biscuits*

The formulations used for preparation of cracker biscuits are outlined in Table 1.

2.5. *Cracker biscuits making process*

The GFWF, RF, PF, BGF, IMF and other ingredients were weighed accurately. The pre-weighted ingredients were mixed. Fat was added into the dry ingredients. Water was added accurately to form dough. The dough was then kneaded and rolled to a uniform thickness of 3 mm. The biscuits were cut out with round biscuits cutter of 3.5 cm diameter. Then the biscuits were baked at 220^{0}C for 10-15 minutes, cooled to ambient temperature and packed in high density polyethylene (HDPE) film.

2.6. *Physical properties of cracker biscuits*

Diameter of biscuits was measured by laying six biscuits edge to edge with the help of a scale rotating them 90^{o} and again measuring the diameter (cm) of six biscuits and then taking average value. Thickness as measured by stacking six biscuits on top of each other and taking average thickness (cm). Weight (g) of biscuits was measured as average of values of six individual biscuits with the help of digital weighing balance. Spread ratio was calculated by dividing the average value of diameter by average value of thickness of biscuits [13]. Percent spread was calculated by dividing the spread ratio of cracker biscuits containing gluten-free composite flour with spread ratio of control biscuits and multiplying by 100.

Table 1. The formulations of cracker biscuits.

Ingredients	Sample code of biscuits			
	S_1	S_2	S_3	S_4
Wheat flour (g)	100	-	-	-
Gluten-free wheat flour(g)	-	45	35	25
Rice flour (g)	-	25	30	35
Bengal gram flour (g)	-	15	10	20
Potato flour (g)	-	10	15	5
Italian millet flour (g)	-	05	10	15
Fat (hydrogenated) (g)	25	25	25	25
Water (ml)	30	30	30	30
Salt (NaCl) (g)	1.5	1.5	1.5	1.5
Baking powder (g)	1.5	1.5	1.5	1.5
Ammonium bicarbonate (g)	0.4	0.4	0.4	0.4

2.7. *Chemical analysis of raw materials and cracker biscuits*

Various raw materials and cracker biscuits were chemically analyzed for moisture, ash, protein and fat contents by appropriate AOAC methods [14]. The total carbohydrate content was determined by difference [15]. All the determinations were done in triplicate and the results were expressed as average value. Energy value was calculated using modified Atwater general factors by multiplying the portions of protein, fat, carbohydrate (as monosaccharide equivalents, determined by subtracting dietary fiber from total carbohydrate content) and dietary fiber by their physiological fuel value of 4.0, 9.0, 4.0 and 2.0 Kcal/g respectively and taking the sum of the products [16].

2.8. *Sensory properties of cracker biscuits*

Sensory characteristics of all types of cracker biscuits were evaluated for different sensory attributes by a panel of trained and semi trained 30 panelists each. All the panelists were briefed before evaluation. Sensory attributes like appearance, color, texture, flavor, taste and overall acceptability for all samples were assessed using nine point hedonic scales. Hedonic scale was in the following sequence: 9 = Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like nor dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2= Dislike very much and 1= Dislike extremely [17]. The samples were coded with letters and served to the panelists at random to guard against any bias.

2.9. *Statistical analysis*

The data obtained from the experiments were statistically analyzed for analysis of variance (ANOVA) and consequently Duncan's Multiple Range Test (DMRT) was used to determine significant difference among the various samples in triplicate. Data were analyzed using the software, IBM SPSS Statistics, version 20 at the 0.05 level [18].

3. Results and Discussions

3.1. *Composition of wheat flour (WF), fresh potato (FP), raw rice (RR), Bengal gram (BG) and Italian millet (IM)*

The initial WF, FP, RR, BG and IM were analyzed for their moisture, ash, protein, fat, and total carbohydrate contents. The results are shown in Table 2. The analysis showed that the composition of WF as moisture 12.0%, ash 0.30%, protein 10.50%, fat 0.80% and total carbohydrate 76.4%. The FP contained moisture 77.00%, ash 0.69%, protein 2.00%, fat 0.16% and total carbohydrate 20.15%. The moisture content (12.61%), ash (0.96%), protein (6.93%), fat (1.41%) and total carbohydrate (78.09%) of RR were analyzed. The BG contained moisture 13.62%, ash 3.50%, protein 19.76%, fat 5.32%, and total carbohydrate 57.80%. The IM contained moisture 12.53%, ash 1.28%, protein 14.01%, fat 4.01%, and total carbohydrate 68.17%. The analysis showed BG had the higher rates for ash (3.50%) protein (19.76%) and fat (5.32%) among the flour samples used in this study.

Table 2. Proximate Composition of wheat flour (WF), fresh potato (FP), raw rice (RR), Bengal gram (BG) And Italian millet (IM) (% of dry matter)[1,2]

Components	WF	FP	RR	BG	IM
Moisture	12.0±0.006^{e}	77.00±0.006^{a}	12.61±0.006^{c}	13.62±0.006^{b}	12.53±0.006^{d}
Ash	0.30±0.006^{e}	0.69±0.006^{d}	0.96±0.006^{c}	3.50±0.006^{a}	1.28±0.006^{b}
Protein	10.50±0.006^{c}	2.00±0.006^{e}	6.93±0.006^{d}	19.76±0.006^{a}	14.01±0.006^{b}
Fat	0.80±0.006^{d}	0.16±0.006^{e}	1.41±0.006^{c}	5.32±0.006^{a}	4.01±0.006^{b}
Total Carbohydrate (by difference)	76.40±0.021^{b}	20.15±0.023^{e}	78.09±0.012^{a}	57.80±0.012^{d}	68.17±0.000^{c}

[1]Values are mean ± standard error of triplet determinations.
[2]Different superscript within the same row differ significantly ($p < 0.05$) using Duncan multiple range test.

3.2. *Composition of gluten-free wheat flour (GFWF), potato flour (PF), raw rice flour (RF), Bengal gram flour (BGF) and Italian millet flour (IMF)*

The GFWF, PF, RF, BGF and IMF were analyzed for their moisture, ash, protein, fat, and total carbohydrate contents. The results are shown in Table 3. The analysis showed that the GFWF contained moisture 10.53%, ash 0.62%, protein 0.09%, fat 1.75%, total carbohydrate 87.01% and dietary fiber 0.52%. The composition of PF as moisture 11.0%, ash 2.90%, protein 5.47%, fat 0.80%, total carbohydrate 79.83% and dietary fiber 5.29%. The moisture (10.85%), ash (1.27%), protein (7.82%), fat (1.84%), total carbohydrate (78.22%) and dietary fiber (1.52%) for RF were analyzed. The BGF contained moisture 11.08%, ash 3.71%, protein 20.28%, fat 5.82%, total carbohydrate 59.11% and dietary fiber 2.95%. The composition of IMF as follows: moisture 11.02%, ash 1.68%, protein 15.27%, fat 4.68%, total carbohydrate 67.35% and dietary fiber 5.65%.

Table 3. Composition of gluten-free wheat flour (WFWF), potato flour (PF), raw rice flour (RF), Bengal gram flour (BGF) and Italian millet flour (IMF) (% of dry matter)[1,2]

Components	GFWF	PF	RF	BGF	IMF
Moisture	10.53 ± 0.012^{d}	11.00 ± 0.006^{b}	10.85 ± 0.012^{c}	11.08 ± 0.006^{a}	11.02 ± 0.012^{b}
Ash	0.62 ± 0.006^{e}	2.90 ± 0.006^{b}	1.27 ± 0.006^{d}	3.71 ± 0.012^{a}	1.68 ± 0.006^{c}
Protein	0.09 ± 0.000^{e}	5.47 ± 0.003^{d}	7.82 ± 0.012^{c}	20.28 ± 0.015^{a}	15.27 ± 0.003^{b}
Fat	1.75 ± 0.003^{d}	0.80 ± 0.003^{e}	1.84 ± 0.006^{c}	5.82 ± 0.006^{a}	4.68 ± 0.003^{b}
Total carbohydrate (by difference)	87.01 ± 0.015^{a}	79.82 ± 0.007^{b}	78.22 ± 0.035^{c}	59.11 ± 0.009^{e}	67.34 ± 0.018^{d}
Dietary fiber	0.52 ± 0.006^{e}	5.29 ± 0.003^{b}	1.52 ± 0.003^{d}	2.95 ± 0.006^{c}	5.65 ± 0.012^{a}
Energy value (kcal/100 g)	363.13 ± 0.096^{b}	337.83 ± 0.067^{e}	357.67 ± 0.035^{d}	364.04 ± 0.052^{a}	361.32 ± 0.078^{c}

[1]Values are mean ± standard error of triplet determinations.
[2]Different superscript within the same row differ significantly ($p < 0.05$) using Duncan multiple range test.

Table 3 shows that BGF the highest content for ash (3.71%), protein (20.28%) and fat (5.82%) content among the flour samples used in this study. The GFWF had the highest level of carbohydrate (87.01%) and IMF had the higher dietary fiber content (5.65%). Energy value for the GFWF, PF, RF, BGF and IMF were 363.13kcal/100g, 337.83kcal/100g, 357.67kcal/100g, 364.04 kcal/100g and 361.32kcal/100g, respectively.

3.4. *Physical properties of cracker biscuits*

Four types of cracker biscuits were prepared; the first control formula (S_1) contained only wheat flour while the others were prepared from various amounts of gluten-free wheat flour, rice flour, potato flour, Italian millet flour and Bengal gram flour. The physical properties of cracker biscuits were evaluated and the results are presented in Table 4.

The weights of all types of cracker biscuits (S_2, S_3 and S_4) containing gluten-free composite flour were higher than that of control biscuits (S_1) containing 100% wheat flour. The range of cracker biscuits weight was 4.06g to 4.52g with maximum value in S_2 cracker biscuits (4.52g). The control biscuits (S_1) had the highest diameter (4.55cm) followed by S_2 (4.36cm), S_3 (4.17cm) and S_4 (4.01cm) and the highest thickness (0.64cm) while lower thickness (0.58cm) was found in S_4 biscuits.

The spread ratio is considered as one of the most important quality parameters of biscuits because it co-relates with texture, grain finesse, bite and overall mouth feel of the biscuits. The changes in diameter and thickness were reflected in spread ratio and percent spread of biscuit. It can be seen that the addition of various amounts of composite flour significantly influences the spread ratio and present spread of cracker biscuits. The spread ratio (7.11) and percent spread (100%) of control biscuits (S_1) were higher than all types of cracker biscuits (S_2, S_3 and S_4) containing gluten-free composite flour. Reduced spread ratios of cracker biscuits containing gluten-free composite flour were attributed to the fact that composite flours apparently formed aggregates with increased numbers of hydrophilic sites available that competed for the limited free water in biscuit dough [19].

Table 4.The effect of gluten-free composite flour on the physical properties of cracker biscuits[1,2]

Sample code	Wight (g)	Diameter (D) in cm	Thickness (T) in cm	Spread ratio (D/T)	% Spread
S_1	$4.06 \pm .015^d$	$4.55 \pm .021^a$	$0.64 \pm .012^a$	$7.11 \pm .012^a$	100^a
S_2	$4.52 \pm .025^a$	$4.36 \pm .015^b$	$0.62 \pm .007^b$	$7.03 \pm .003^b$	98.87^b
S_3	$4.44 \pm .012^b$	$4.17 \pm .015^c$	$0.60 \pm .006^b$	$6.95 \pm .006^c$	97.75^c
S_4	$4.31 \pm .021^c$	$4.01 \pm .015^d$	$0.58 \pm .006^c$	$6.91 \pm .003^d$	97.19^d

[1]Values are mean ± standard error of triplet determinations. [2]Different superscript within the same column differ significantly ($p < 0.05$) using Duncan multiple range test.

3.5. *Proximate composition of the cracker biscuits*

In the present study four types of cracker biscuits, one containing only wheat flour and others with various level of gluten-free composite flour, were prepared and analyzed for their composition. The results are presented in Table 5.

Table 5. Proximate composition of cracker biscuits (% of dry matter) [1,2]

Parameter	Sample code of biscuits			
	S_1	S_2	S_3	S_4
Moisture	$3.31 \pm .004^d$	$3.64 \pm .005^a$	$3.57 \pm .003^b$	$3.46 \pm .003^c$
Ash	$1.64 \pm .003^d$	$2.54 \pm .006^b$	$2.21 \pm .004^c$	$2.93 \pm .007^a$
Protein	$9.73 \pm .005^a$	$6.42 \pm .006^c$	$6.61 \pm .004^b$	$9.37 \pm .004^a$
Fat	$14.03 \pm .003^d$	$14.11 \pm .006^c$	$14.16 \pm .005^b$	$14.22 \pm .006^a$
Total carbohydrate (by difference)	$71.29 \pm .015^c$	$73.29 \pm .016^b$	$73.43 \pm .016^a$	$70.02 \pm .019^d$
Dietary fiber	$1.25 \pm .007^d$	$1.82 \pm .007^c$	$2.29 \pm .005^b$	$2.36 \pm .005^a$
Energy value (kcal/ 100 g)	$447.85 \pm .022^a$	$442.18 \pm .030^c$	$443.09 \pm .014^b$	$440.83 \pm .023^d$

[1]Values are mean ± standard error of triplet determinations. [2]Different superscript within the same row differ significantly ($p < 0.05$) using Duncan multiple range test.

The analysis showed that the moisture content of all biscuits was higher than that of control biscuit. The highest moisture content (3.64%) was obtained in S_2 followed by S_3 (3.57%), S_4 (3.46%) and control biscuits (3.31%). This variation might be due to various levels of water holding capacity of components of different flours. Similar effects were observed in sweet biscuits containing gluten free composite flour [20]. The S_4 gluten-free cracker biscuits had the highest ash (2.93%) and fat (14.22%) content. This variation might be due to high amount of Bengal gram (20%) that contained high amount of ash (3.71%) and fat (5.82%) used in S_4 cracker biscuits. The highest protein content was obtained in formulation S_1 cracker biscuits (9.73%) due to presence of wheat protein (gluten). Total carbohydrate content was higher in formulation S_3 cracker biscuits (73.45%) among the other types of cracker biscuits where in S_2 was 73.29%, in S_1 was 71.29% and in S_4 was 70.02%. The higher dietary fiber was obtained in formulation S_4 cracker biscuits (2.36%) due to high amount of Italian millet flour (15%) that contained higher amount of dietary fiber (5.65%). The energy values of the cracker biscuits ranged from 440.85 to 447.85kcal/100 g.

The proximate composition of cracker biscuits processed with different level of gluten-free composite flour was found in the acceptable range as moisture content was 3.46-3.64%, ash 2.21-2.93%, protein 6.42-9.37%, fat 14.11-14.22%, total carbohydrate content 70.02-73.43% and dietary fiber 1.82-2.36%. Jothi *et al.* (2013) analyzed the nutrient of some gluten free sweet biscuits. The authors reported the composition of gluten free sweet biscuits as moisture 3.92-4.16%, ash 2.12-2.86%, protein 6.37-8.68%, fat 22.31-23.84% and total carbohydrate 60.70-64.70%. A small difference was found due to different formulations, different holding capacity of ingredients, different composition of ingredients, different baked time etc.

3.6. *Sensory properties of cracker biscuits*

The cracker biscuits were subjected to sensory evaluation by a panel of 60 tasters. The mean score for color, flavor, texture, taste and overall acceptability of the biscuits are presented in Table 6. The one way analysis of variance indicated that all these sensory attributes of different cracker biscuits were significantly ($p<0.05$) different and thus the cracker biscuit samples showed varied degree of acceptability in terms of color, flavor, texture, taste and overall acceptability .

Table 6. Mean sensory scores of cracker biscuits.

Sample code of biscuits	*Mean scores on sensory attributes				
	Color	Flavor	Texture	Taste	Overall acceptability
S_1	8.029 ± 0.011^a	8.037 ± 0.042^a	8.176 ± 0.038^a	8.095 ± 0.041^a	8.043 ± 0.097^a
S_2	7.955 ± 0.107^a	7.897 ± 0.104^a	7.953 ± 0.127^a	7.989 ± 0.122^a	8.011 ± 0.142^a
S_3	7.687 ± 0.019^b	7.071 ± 0.027^b	7.041 ± 0.039^b	7.132 ± 0.153^b	7.059 ± 0.097^b
S_4	6.559 ± 0.034^c	6.364 ± 0.011^c	$6.029\pm.0129^c$	5.921 ± 0.195^c	6.211 ± 0.067^c
LSD ($p<0.05$)	0.4657	0.4657	0.4657	0.4657	0.4657

*Means ± Standard Error with different superscripts within a column are significantly different and the same superscripts do not significantly different (NSD) at $p<0.05$.

As shown in Table 6, the Duncan's Multiple Test (DMRT) revealed that the mean sensory score for color, flavor, texture, taste and overall acceptability of control biscuits containing only 100% wheat flour was higher among all others cracker biscuits containing gluten-free composite flour.

Among all type cracker biscuits, the color of S_2 cracker biscuit containing gluten-free composite flour was the most preferred one. But there was no significant difference in color preference between the S_1 and S_2 cracker biscuits. The flavor of S_2 cracker biscuit was significantly better than all the other cracker biscuit containing gluten-free composite flour. There was no significant difference in flavor preference between the S_2 cracker biscuits and control biscuits. Texture of S_2 cracker biscuit was most preferred and significantly better than all the other cracker biscuit containing gluten-free composite flour. The mean score for texture of S_2 cracker biscuits was 7.953. Among all the type of cracker biscuits, the taste of S_2 cracker biscuit was the most preferred one than all the other the cracker biscuit containing gluten-free composite flour. With respect to overall acceptability, S_1 control biscuits containing only 100% wheat flour and S_2 cracker biscuits were equally acceptable and significantly better than other types.

Among the experimental gluten free cracker biscuits, the S_2 cracker biscuit containing 25% rice flour, 45% gluten-free wheat flour, 15% Bengal gram flour, 10% potato flour and 5% Italian millet flour was the favorite sample concerning sensory evaluation with the highest overall acceptability followed by S_3 and S_4 cracker biscuits containing gluten-free composite flour.

4. Conclusions

Use of gluten-free composite flours had considerable effects on physical, chemical and sensory properties of cracker biscuits. From the above investigation it can be concluded that the cracker biscuit containing 45% gluten-free wheat flour, 25% rice flour, 15% Bengal gram flour, 10% potato powder and 5% Italian millet flour was the most accepted when compared with other formulated cracker biscuits containing gluten-free composite flour. The finding of this experiment may help to generate technology to diversify the use of gluten-free composite flour by the food processing industries, specially baking industries. The nutritional quality of gluten-free cracker biscuits can be improved by incorporating food colors, flavors and vitamins. More studies should be conducted to investigate the possibility of using gluten-free composite flour as an ingredient in other food products in order to increase applications of gluten-free food ingredient.

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