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ORIGINAL ARTICLE

Studies on the development of black gram incorporated biscuits and their storage studies

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ABSTRACT
The present investigations entitled "Studies on the development of Black Gram incorporated Biscuits" were carried out at Division of Food science and Technology, SKAUST-K, Shalimar, during 2022. Biscuits were prepared using 100, 95, 90,85,80,75 percent wheat flour and Black gram flour incorporation at 5, 10,15,20,25 percent. The products were evaluated for various physical, nutritional and sensory attributes to ascertain the effect of Black gram incorporation on product quality and consumer acceptability. Biscuits with 15 percent black gram incorporation were adjudged superior compared to other flour combinations, and were packed in polypropylene boxes and HDPE pouches to evaluate/ study their physical, chemical, sensory attributes and storage stability under ambient conditions for a period of three months. In the product of biscuits packed in Polypropylene boxes and HDPE pouches during 90 days of storage shows gradual increase in mean moisture content in BOPP 2.522 than HDPE that is 2.473, water activity in BOPP 0.295 than HDPE. On an overall basis at 15 percent concentration of black gram flour proved to be superior in exhibiting nutritional and sensory attributes, which could possess technological and nutritional advantages of having additional health benefits.
Key words: Wheat Flour, Black Gram Flour, Biscuits, Polypropylene boxes, HDPE pouches

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INTRODUCTION

Black gram (BG), also referred to as *Vigna mungo*, is a plant belonging to the Leguminoseae family. The BG has a lot of dietary fibre, protein, vitamins, and minerals, but less fat (5.13%). Additionally, polar BG compounds produce lubricity and creaminess in bakery goods that are comparable to those in full-fat goods. However, the inclusion of non-polar molecules gives BG functional fat properties like lipid-soluble favor carrying capacity. Given that high viscosity and gel formation are the desirable features in a fat substitute, polysaccharides including gums, starches, pectin, and cellulose can function as thickeners or gelling agents and consequently as fat replacers in foods. BG's ingredients have certain advantageous properties, including aqueous solubility, swelling, water binding, foaming, gelation, and emulsifying capability, which could make it a viable fat substitute in food applications. Significant levels of protein (25%) ash (3.40%) crude fibre (4%) and fat (1%) are present in black gram. Calcium (145 mg/100 g), iron (7.8 mg/100 g), starch (43%), and vitamins B1 (0.58 mg/100 g, B2 (0.26 mg/100 g), A (300 IU), C (5.0 mg/100 g), and niacin (2.0 mg/100 g) are all present in very little amounts. One of the main dietary problems in developing nations is protein energy malnutrition (PEM). Considering that cereals make up the majority of the diets in these nations and that they mostly rely on plant-based food sources, treating PEM by substituting pulses for wheat flour can be a successful technique. Black gram gives the opportunity to be used in bakery products like cookies, bread, pasta, soups, and snack foods due to its high protein level and well-balanced amino acid profile [1]. One of the top ten products that consumers in the Asia Pacific area most frequently consume is a biscuit. In an effort to enhance the nutritive value and dietary fibre of bakery-based products, much research has been done utilizing various types of legumes, cereals, and plant fibre. According to a literature review, the physiochemical features of the legumes included in the formulation as well as the method used to prepare the bean flour are what determine the nutritional, physical, and sensory qualities of biscuits. Recent studies have revealed that the nutritional pigeon pea (*Cajanus cajan* L.) grain is extensively consumed after being properly processed in biscuits and has potential utility as an affordable source of protein. Another study revealed that large improvements in the protein and fibre contents could be made in muffin formulation by substituting 30% of wheat with lupin flour, without degrading the muffins' physical or sensory qualities [2].

MATERIAL AND METHODS

The Division of Food Science and Technology (FST), Sher-i-Kashmir University of Agricultural Science and Technology of Kashmir (SKAUST-K), Shalimar, carried the current study, "Studies on the development of black gram incorporated biscuits." The raw materials employed are listed in this section, along with details on the processing techniques, analytical steps, sensory evaluation methodologies, and statistical approaches used during the research.

Raw materials

Collection of raw materials

Commercial wheat flour, black gram whole, icing sugar, butter, eggs was purchased from local market including baking powder.

Packaging material Polypropylene boxes and HDPE pouches as packaging material to storebiscuits.

Proximate Analysis of raw materials

Moisture content

Pre -weighed samples (2 g) of each flour were dried in hot air oven (Make: Tanco India Ltd) at130±1ºC for one hour and moisture content in percent was calculated from loss in weight as under (A0CC, 2010):

$$\text{Moisture content (\%)} = \frac{\text{Weight of original sample (g)} - \text{weight of dried sample (g)}}{\text{Weight of original sample (g)}} \times 100$$

Ash content

In a silica crucible that had already been pre-weighed, one gram of moisture-free sample was recovered. By gradually heating over a flame, preliminary ash was produced, allowing fat to be smoked off without being burned. The sample was burned for eight hours at 600 °C in a muffle furnace after it stopped smoking. The crucibles were removed, weighed, and then allowed to cool in a desiccator. The ash content, expressed as a percentage, was calculated using the weight in difference of the crucible wand.

$$Ash\ Per\ cent = \frac{Weiht\ of\ ash\ (g)}{Weight\ of\ Sample\ (g)} \times 100$$

Crude protein

In order to convert nitrogen content to crude protein using the micro-Kjeldahl method, a ratio of 6.25 was utilized.In a Kjeldahl digestion flask, combined sulphuric acid (20 ml) and digestion mixture (10.0 g) are used to break down a 1.0 gram weighted sample. Before being transferred to a 250 mL volumetric flask, the ingredients were chilled. With distilled water, the volume was raised to the required level and then mixed. A predetermined amount was put into a distillation flask, and then 40.0 percent sodium hydroxide was added to it. A condenser was used to obtain ammonium borate, which was then placed in a flask with 10 ml of a 4 percent boric acid solution. A 0.1 N sulfuric acid titration was performed on the distillate. Along with the sample, a blank sample was also collected.

$$\text{Nitrogen \%} = \frac{\text{Titre value X 0.00014 X volume made}}{\text{Aliquot taken (g) X Weight of sample (g)}} \times 100$$

Crude fat:

To evaluate crude fat, the soxhlet extraction technique was performed. The sample's fat content was simply extracted into petroleum ether, an organic solvent, between 60 and 80 degrees Celsius, and then refluxed for six hours. The proportion of fat content was calculated using the formula.

$$\text{Crude fat percent} = \frac{\text{Ether extract amount (g)}}{\text{Weight of Sample (g)}} \times 100$$

$$= \frac{W2-W1}{W} \times 100$$

Sample Weight = W (g)

Empty Beaker Weight = W1 (g)

Empty Beaker weight+ content fat (ether extract) W2 (g)

Preparation of biscuits

Table 1: Six treatment combinations were used for preparation of blends for biscuits

Table 1: Formulation of biscuit samples						
Ingredients	Percentage					
	T1	T2	T3	T4	T5	T6
Wheat	100	95	90	85	80	75
BGF	0	5	10	15	20	25
Sugar	40	40	40	40	40	40
Fat (vegetable refined oil)	35	35	35	35	35	35
Egg	13.4	13.4	13.4	13.4	13.4	13.4
Salt	1	1	1	1	1	1
Baking powder	2	2	2	2	2	2
Water was added as per requirement to reach proper consistency of batter						

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Recipe for biscuit preparation

Using a dough mixer, the oil, sugar, and egg were initially creamed for five minutes before adding the egg and mixing for three more minutes to produce the dough. For three minutes, wheat flour, salt, and baking powder were thoroughly combined with water to create the biscuit dough. Dough was wrapped in in polythene bags and allowed to rest in refrigerator for 30 minutes to ensure uniformdistribution. The dough was then sheeted manually to 2.5 mm thickness and cut by pressing moldinto 35mm width. Baking was done in a baking oven at 180˚C for 20 minutes. After cooling for 5minutes at room temperature, biscuits were separately wrapped in a metalized polyester pouches and kept at ambient room temperature (19±2˚C) for further investigations.

1. Sifting wheat flour and black gram flour with baking powder
2. Adding icing sugar and salt
3. Mix in dough mixer
4. Adding butter and eggs
5. Mixing for 10 minutes till dough leaves smoothly
6. Make dough balls
7. Manual flattening dough balls for cutting and sheeting
8. Proofing for 5 minutes
9. Baking at 180 ºC for 5 minutes
10. Cooling in refrigerator
11. Packing and wrapping in HDPE boxesStoring at ambient room temperature (20±2□C)

Flow chart for preparation of black gram incorporated biscuits

Crude fiber

Applying the AOAC (2012) standard method, crude fibre was calculated. 200ml of 125 percent sulphuric acid was added to a two-gram sample that had been removed from moisture and fat. Beaker was placed on a digestion apparatus with a previously controlled hot plate, and it boiled for 30 minutes.

Carbohydrate (%):

The difference method was used to calculate the amount of carbohydrates. It was obtained by deducting 100 from the sum of the percentages of moisture, fat, protein, fibre, and ash.

Carbohydrate (%) =100- (moisture % + fat %+ protein % + ash%+ fiber %).

Energy value (k Cal / 100g):

Energy (Kcal/100g) was calculated by conversion method. The proximate components of wheat flour were multiplied with their calorific factor and the energy content of test flours was calculatedby the following formulae;

Carbohydrate (%) ×4.2 + protein (%) ×4 + Fat (%) × 9 = total energy.

Fig. 1: Dough Mixer

Fig.2: Baking oven used for biscuit preparation

Quality characteristics of the prepared biscuits

Based on sensory evaluation, the biscuit products developed from best two treatments T4 and T5 were packaged in polypropylene boxes and HDPE pouches for analyzing their storage stability with regard to various physicochemical quality parameters over a period of 90 days under ambientstorage conditions (temperature 19±2°C, relative humidity 52±2%).

Sensory evaluation of biscuits:

Fresh biscuits were evaluated for sensory attributes that is appearance, cell, uniformity, flavor, color, moistness, mouthfeel, crispiness and overall acceptance) through a panel of 15 members using 9 point hedonic scale. On the basis of sensory evaluation best blend was used for storage studies and was stored at ambient conditions for 90 days. Evaluation of biscuits were done at an interval of 15 days.

Statistical Analysis

The Data recorded for different parameters during the course of present investigation wassubjected to statistical analysis using completely randomized block design (CRBD) with three replications or otherwise as indicated (Gomez and Gomez, 1984).

Fig. 3: Black gram incorporated biscuits

Fig.4: Black gram incorporated biscuits stored in HDPE boxes

RESULTS AND DISCUSSION

The result of experiment obtained in the present investigation entitled "studies on development ofblack gram incorporated biscuits" in the preceding chapter has been discussed with suitable reasoning.

Table 2: Physiochemical characteristics of Wheat flour and Black gram

S No.	Parameters	Wheat flour	Black gram flour
1	Moisture (%)	13.90a ± 0.12	11.70b±0.18
2	Crude Protein (%)	9.01b ± 0.10	24.29±a1.20
3	Crude Fat (%)	1.74a±0.01	1.44b±0.02
4	Crude Ash (%)	0.40b±0.01	4.28a±0.61
5	Crude Fiber (%)	1.89b±0.02	5.56a±0.01
6	Carbohydrates (%)	91.08±0.06	98.71±0.38
7	Starch (%)	66.79a±2.01	45.5b±0.05
8.	Bulk density (g/cm3)	0.65b±0.01	0.71a±0.02
9.	Calcium (mg/100g)	32.10b±1.91	95.02a±2.02
10.	Iron (mg/100g)	3.20a±0.02	3.00b±0.01
11.	Magnesium(mg/100g)	132.20a±10.01	128b±6.01
12.	Potassium (mg/100g)	345.01b±7.01	800a±7.01
13.	Total Phenol Content (mg GAE/g)	16.73b ± 0.11	390a±16.05
14.	Anti-oxidant Activity (%DPPH)	5.83b±0.03	62.31a±0.21

CD (p≤0.05

*Values presented as mean ± standard deviation

Physiochemical composition of wheat flour, black gram showed marked variation in their proximate composition for various nutritional and other parameters. Moisture content of 11.70, 13.90 were noticed in black gran, wheat flour. Wheat flour possessed highest carbohydrate content(91.08%) but exhibit lowest content of crude protein (9.01%), crude fiber (1.89 %), crude fat (1.74%), crude ash (0.40%), starch (66.79%), calcium (32.10 mg/100g), iron (3.20mg/100g), magnesium (132.20mg/100g) and potassium (345.01%) than black gram. Black gram exhibit highest carbohydrate content (98.71%),crude protein (24.29%), ash content (4.28%), crude fiber(5.56 %), calcium (95.02mg/100g), iron (3.00 mg/100g),magnesium(128mg/100g)and potassium (800mg/100g).The high amount of moisture content has been attributed to higher protein content having higher affinity for moisture and reduction of water content has the greatest effect of increasing protein [3]. The genetic make-up of the species and the physical and chemical properties of the growing medium influence the protein content of black gram [4].

Quality characteristics of prepared biscuits

Based on sensory evaluation, the biscuit products developed from best treatment were packaged in polypropylene box (BOPP) and HDPE pouches for analyzing their storage stability with regardto various physicochemical quality parameters over a period of 90 days under ambient storage conditions (temperature 19±2C, relative humidity 52±2%).The data recorded for various physicochemical quality parameters of test biscuit products during storage are presented in Table4.3

Table 3: Effect of black gram flour incorporation on the sensory quality of biscuits

Sample	Appearance	Taste	Texture	Color	Overall acceptability
T1(100:0)	8.20±0.12	8.27±0.31	8.27±0.14	7.11±0.03	8.04±0.04
T2(95:5)	7.14±0.15	7.06±0.50	8.06±0.15	8.03±0.05	8.00±0.04
T3(90:10)	8.21±0.11	8.30±0.42	8.20±0.17	8.9±0.11	8.06±0.05
T4(85:15)	7.14±0.12	6.16±0.11	6.06±0.16	7.09±0.06	6.14±0.03
T4(80:20)	7.13±0.16	5.10±0.10	4.26±0.25	5.32±0.17	5.32±0.02
T5(75:25)	5.12±0.10	4.23±0.14	3.11±0.11	4.31±0.15	5.11±0.01

CD (p≤0.05)

* Values presented as mean ± standard deviation

The data shown in Table 3 showed that adding black gram to prepared biscuits significantly improved their, appearance, textural profile, colour, and up to a concentration of 25%, but that as concentration increases, these characteristics drastically decline in terms of texture, colour, flavour, appearance, and taste. Regarding appearance, it was found that adding black gram results in biscuits with a grainy look, which panelists members favored up to 25% of the time. However, biscuits with an excessively grainy appearance received worse ratings. Increased black gram concentration caused the colour attributes of biscuits to become darker, which increased consumer attractiveness by 15%. In terms of the colour values of the biscuits that were included, a similar tendency to that of flavour scores was seen. The texture of biscuits is a key factor in determining their general acceptability; in the case of biscuits containing black gram, a slight improvement in crispiness was seen in samples with up to 15% of black gram, which led to better scores, whereas panelists reported dry mouth with biscuits containing 25% of black gram, which led to the lowest scores. By combining all the ratings for appearance, colour, texture, and taste, composite flour-based biscuits' total acceptability was calculated. The results showed that sample T3, which included 10% black gram, had the highest score (8.06), followed by sample T1, which contained 80% of black gram, and control, which contained 80% of black gram. Sample T5, which contained 25% of black gram, received the lowest overall acceptability. The adding of black gram flour in the production of composite flour up to 10% was found to be superior to all other treatments and the control sample based on the overall acceptance of the biscuits. In light of the sensory quality characteristics, 10% BGF incorporation in the creation of composite flour for biscuits may be thought of as the ideal level. This finding is in line with the findings of the [5].

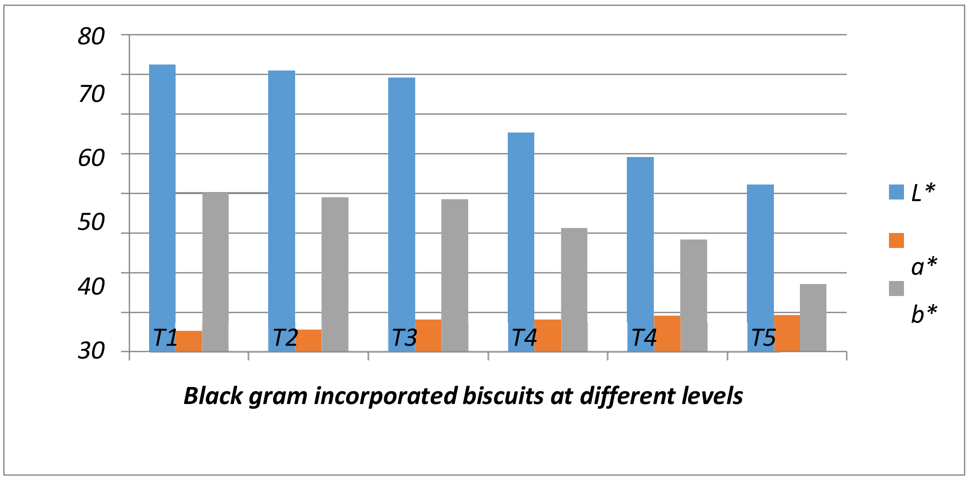

Fig 4.1: Color profile analysis of developed biscuits

The results in Fig. 4.1 demonstrate that as the amount of BGF in the biscuit's four blend progressed, the surface colour of the sample biscuits gradually darkened and became less light (L*), more yellow (b*), and more red (a*). Similarly, [14] found that cookies made from mixtures of wheat and buckwheat flours had lower L* and b* values and higher a* values. Such changes in colour could be attributed to browning reactions that would have taken place during baking. Brown colours should be produced during biscuit baking as a result of mallard browning and sugar caramelization [6]. Numerous parameters, such as the product's moisture level [7], pH, water activity, baking temperature, sugar type, and the makeup of the amino compounds present [8], have an impact on these browning events.

Table 4: Proximate composition of blackgram incorporated biscuits (85% wheat flour and 15% Black gram flour- best treatment)

S No.	Parameters	T4(85:15)
1.	Moisture (%)	4.28±0.10
2.	Crude Protein (%)	20.21±1.11
3.	Crude Fat (%)	19.30±1.10
4.	Crude Ash (%)	2.78±0.01
5.	Crude Fiber (%)	1.97±0.11
6.	Carbohydrates (%)	93.88±2.11

CD ($p \leq 0.05$)

* Values presented as mean ± standard deviation

Moisture content

The moisture content was found to be 4.28% for the best treatment was observed in biscuits, was found in the range and the results are in agreement with [9] and indicates the shelfstability of biscuits. These values of were found to be in the range as reported by [10] for oat starch.

Crude Ash

According to [11] ash concentration in biscuits ranged from 1.09 to 2.78 percent, which is consistent with the findings of this study. According to [12] and in conformity with the current investigation, the ash level of several processed biscuit samples ranged from 1.5 to 2.50 percent. On storage it showed decrease which may be because of packaged material and interactions.

Crude fiber

The crude fiber was found to be 1.97% for the best treatment was observed in biscuits, was foundin the range and the results are in agreement with [9] and indicates the shelf stability of biscuits.

Carbohydrates

Total carbohydrate content in this study is in line with the findings of the [9].The carbohydrate content decreases in biscuits this might be due to level of protein and environmental conditions.

Table 5: Influence of storage period and packaging materials on moisture content, water activity content of black gram incorporated biscuits

ParameterStorage	Moisture (%)		Water activity	
Period	**BOPP**	**HDPE**	**BOPP**	**HDPE**
0days	2.290	2.290	0.310	0.310
30 days	2.370	2.330	0.340	0.330
60 days	2.390	2.370	0.370	0.350
90 days	2.780	2.750	0.420	0.390
Mean	2.522	2.473	0.295	0.282
	P=0.009		P=0.009	
C.D(P<0.05)	S=0.013		S=0.012	
	P×S= 0.019		P×S=0.022	

Storage Studies of black gram flour incorporated biscuits.

Biaxially oriented polypropylene (BOPP) and high density polyethylene (HDPE) were used as packaging materials for the produced biscuits that contained black gram flour, which were stored at room temperature for 90 days. Significant effect ($p<0.05$) of both the packaging materials BOPP and HDPE as well as the storage period was recorded for the all the parameters *viz*. moisture content, water activity (aw), during the storage as well as the end of storage period.

Water activity and moisture content

Water activity and moisture content are considered as crucial factors for determining the storage life of baked foods. In both the packaging materials the effect of moisture content was non- significant for 30 days of storage. But, from 30th day a significant ($p<0.05$) increase was recordedtill 90th day of storage period. Among both the packaging, materials higher values of moisture content were recorded for BOPP as compared to HDPE. Non-significant increase in water activitywas recorded for a period of 30 days in both the packaging materials *viz*. BOPP and HDPE. However from 30th day onwards till 90th day a significant increase was recorded, although highervalues were recorded for cookies packed in BOPP as compared to HDPE. The biscuits absorb moisture due to their hygroscopic nature, which relies on the storage circumstances and type of packaging material utilized. Due to the high density polyethylene's effective barrier protection properties black gram flour incorporated biscuits showed relatively less moisture gain and water activity in HDPE as compared to BOPP packets. Similar results were observed by [13] for multigrain pasta packed and stored in HDPE and BOPP packets.

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Conflict of interest

No conflict of interest exists among authors.

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