Effect of sprouted barley flour on the quality of wheat bread, biscuits and cakes

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Abstract: Sprouted barley flour was used at the ratio of 0, 5, 10 and 20% in the wheat flour and effect of incorporation on the quality of bread, biscuits and cakes was evaluated. The chemical analysis of barley-wheat flour blends exposed that protein, fat, energy and β-glucan significantly increased with the addition of sprouted barley flour at different levels. Flour blends rheology regarding water absorption, dough development and dough stability improved with the addition of sprouted barley flour. Physicochemical composition of baked products revealed significantly the improvement in nutritional profile especially β-glucan while carbohydrates decreased with the addition of barley into the blend. Sensory evaluation revealed that as the sprouted barley flour increased to 15%, biscuits, cakes and bread showed product acceptability while 20% level revealed significant decline in sensory acceptability. In conclusion, optimum level of sprouted barley flour improved rheology of blend as well as nutritional and sensorial properties of the baked products.

Keywords: Sprouted barley; wheat flour; rheology; bread; biscuit; cake; quality assessment

1. Introduction

Consumers are more conscious nowadays about the selection of food products and prefer those food items that have more health benefits with good sensory attributes/aesthetic value. Baked food products especially bread, biscuits and cakes are frequently consumed which are made from refined wheat flour that has low protein along with deficiency of essential amino acids. Moreover, high gluten in refined flour causes gluten allergy in some gluten-sensitive people. Baking products especially biscuits, bread and cakes are popular all over the world due to their readily availability, expediency and long stability. Because world population is increasing at a rapid rate while fresh food products availability is less along with a serious time constraint to prepare fresh food products at homes as breakfast, lunch and dinner. Refined wheat flour is being used in the baking industry which has inferior quality protein than that of other cereal grains because essential amino acids such as lysine, methionine and threonine are deficient in it (S. Hussain et al., 2020).

Animal protein is costly and its affordability is not possible for a large segment of world poor population. Globally human protein consumption from animal and plant sources is 40 and 60%, respectively (FAOSTAT, 2018). Shifting from animal protein to plant protein reduces the production of greenhouse gas that is injurious for human health (Chaudhary & Krishna, 2019). Lysine as a building block of protein is necessary for growth, repair and maintenance of body tissues. It is also important for synthesis of hormones, neurotransmitters and is immune booster. Its daily...
requirement is 30 mg per kg body weight (Leinonen et al., 2019). Wheat, oats, barley, cottonseed and soya meal contains 0.45, 0.76, 0.535, 1.654 and 2.991 mg/100 g lysine, respectively.

During the production of refined flour, significant losses of other nutrients also occur. Therefore, wheat flour may be efficiently utilized with the other cereals to enhance the level of protein, minerals, vitamins and other nutrients like dietary fiber (Foyer et al., 2016; S. Hussain et al., 2020). These flour blends may serve as functional food but their acceptability may or may not be equal to the control products.

At present, consumers are more conscious about their health and want to consume such foods that are immune booster. Food products containing more protein and fiber are preferred by consumers to maintain their health status and prevent them from different diseases such as coronary heart disease (CHD), diabetes and obesity etc. (Bhatt & Gupta, 2015; M. Hussain et al., 2021).

Barley (Hordeum vulgare) is a multipurpose cereal which possesses nutty aroma and pasta like steadiness. Barley contains a soluble dietary fiber β-glucans and its concentration in wheat and barley flour is 1.75 and 5.12%, respectively, which has been reported to normalize blood cholesterol due to their positive effect on total and LDL cholesterol and is a good fiber source that lowers body glucose level. β-glucans are also helpful for the maintenance of blood sugar levels and acts as diabetes preventer. Barley is a good source of protein containing more lysine (essential amino acid) than wheat (Gupta et al., 2014). Therefore, barley flour can be mixed with wheat flour to develop various bakery products like bread, cakes, crackers and cookies which can be of better nutritional quality and has certain human health benefits. There is direct relationship between ailments, overweight and fiber consumption.

Some people cannot tolerate or digest wheat gluten; so replacement of wheat flour with barley flour is a good option to produce low gluten foods that cannot be so allergic for gluten intolerant people and therefore are more nutritious and can prevent various human dietary and nutritional problems (Balakireva & Zamyatnin, 2016). Sprouting enhances dietetic and nutraceutical properties of wheat as this process is easy, cost-effective and increases the nutrients availability particularly minerals; besides this, it suppresses various anti-nutritional food ingredients (Ikram et al., 2021; Yaqoob et al., 2018). Furthermore, sprouted grains have more available nutrients than mature grains and be easier to digest. Moreover, sprouted barley is high in fiber, especially β-glucans, which may reduce cholesterol and blood sugar levels. Sprouted barley utilization as improving agent in various bakery products has longer history. Blending of sprouted barley flour in refined wheat flour has beneficial effect on technological, nutritive and sensory attributes of baked products (Honcu et al., 2015).

The current research was conducted to explore the impact of sprouted barley flour into wheat flour and evaluated the role of sprouted barley as improver on blend rheology and quality of biscuits, cakes and bread.

2. Methodology

2.1. Production of sprouted barley flour
Grains of barley variety Jau-17 were taken from Wheat Research Institute, Ayub Agriculture research institute (AARI), Faisalabad-Pakistan. The cleaned grains were steeped in water 1:3 ratios in a plastic container for 24 hours at room temperature. After steeping, water was eliminated and seeds were washed twice with distilled water so as to avoid microbial invasion during sprouting. Wet grains were kept for 4 days in muslin cloth for sprouting purpose at 15-20°C. Grain samples were kept at optimum spraying conditions and watering frequency was 3-4 times a day. These sprouted grains were dried over night by air at room temperature. Dried grains were graded by a lab mill (LM-120, Model No. 080138, Perten, Sweden) with the mesh size of 120 and packed in air tight plastic jar (Yaqoob et al., 2018).
2.2. Production of refined wheat flour
Grains of wheat variety Akbar-19 were taken from Wheat Research Institute, AARI, Faisalabad-Pakistan, and were cleaned thoroughly to remove dirt, dust and other foreign particles. These grains were then tempered at 15% moisture level for 16 h and milled with a CD 1 Auto mill (Chopin Technologies, France) to get break flour, reduction flour, germ and bran. Break flour and reduction flour were mixed to generate straight grade flour or refined white flour that was packed in air-tight plastic bags and stored at ambient temperature for further analysis.

Dried sprouted barley flour was added in the wheat flour of Akbar-19 in the ratio of 0, 5, 10, 15 and 20% to replace wheat flour and prepared five treatments of flour blends.

2.3. Physico-Chemical composition and Dough Rheology of Flour Blends
Cleaned wheat and barley were analyzed for various physico-chemical quality parameters such as moisture content, thousand kernel weight, test weight, protein content, starch, gluten, ash, lipid, β-glucan and energy. Flour blends were analyzed for their proximate composition according to AACC (2000) methods (AACC Method 923.03; AACC Method 960.52; AACC Method 963.15) reported by Shafi et al. (2016). Moreover, gluten was determined through NIR technique by ISO-17025 accredited Lab Instrument that is Kernelizer/Overanalyze, Bruins, Germany. Falling Number value (Sec) was assessed by ISO-17025 accredited Lab Instrument (Falling Number Apparatus (FN-1310), Perten, Sweden). Carbohydrates were determined by difference procedure and Calorific value of blend was analyzed by Bomb calorimeter (Model: 1341, Parr Instrument Company, Werke IKA). β-glucans were determined through a procedure reported by Hussein et al. (2006). However, dough rheology of flour blends with regard to water absorption capacity (%), dough development time (min) and dough stability time (min.) was tested through method No. 54–20 by Farinograph (Model No. 810114), Brabender, Germany (American Association of Cereal Chemists, 2010).

2.4. Preparation of bread
Straight dough procedure with some modifications was followed for mixing 1000 g flour blends, 5 g yeast powder, 15 g sodium chloride and 750–800 ml water. All these ingredients were mixed in lab grade mixer (Hobart mixer; Model No. C-100, USA) for 6 min till homogenous mixture of dough was formed. Resting time for initial fermentation of dough was kept 1 hour at 30°C and 85% relative humidity. Then, dough was divided into 125 g dough balls which were kept for 45 min at same temperature and humidity (30°C at 85% relative humidity). After that, dough balls were flattened to 20 cm diameter and proofing of the flat loaf was done at 30°C at 85% relative humidity for time interval of another 15 minutes. Proofing of loaf was baked at 180°C for 60 minutes in Baking Oven (Model No. DC-11, Sveba Dahlen AB, Sweden). Baked bread was cooled for 60 min at ambient temperature and packed in plastic bags which were kept at 18°C for further analysis and sensory evaluation (Hussein et al., 2013).

2.5. Preparation of biscuits
1000 gram of flour blend was mixed in a lab grade mixer with 5.9 g baking powder, 312.5 g shortening, 281.3 g sucrose, 23.4 g skim milk and 95 ml water for 10 min. Then, dough was manually kneaded till homogenous mixture was developed. Dough sheets of 3.5 mm thickness were made and biscuits of various shapes were made using specific dies. These raw biscuits were baked in aluminum trays at 220°C for 15 min. Then, the biscuits were cooled for half an hour at ambient temperature and kept in sealed plastic jars for 24 hours. The biscuits were then packed in plastic bags at ambient temperature for further analysis (Yaqoob et al., 2017).

2.6. Preparation of cakes
Cakes were prepared following Creamery method elaborated by an author (Masoodi et al., 2002). One thousand gram (1000 g) of wheat and barley flour blend was taken while 840 g each of powdered sugar, fat and eggs were taken along with 70 g baking powder. Finely ground sugar and fat were uniformly blended and whole eggs were mixed in the material. After this, flour was added followed by baking powder in the so-called batter. All the material was uniformly mixed by the
Hobart mixer (ModelNo.C-100), Ohio-USA. Batter was baked at 180°C for 15–20 min and cakes were removed from oven and cooled for half an hour and kept in airtight plastic jars before further analysis and evaluation.

2.7. Analytical and sensory evaluation of bread, biscuits and cakes

Bread, biscuits and cakes were analyzed for their proximate composition following AACC (2000) methods as reported earlier. Calorific values of baked products were determined by Oxygen Bomb Calorimeter (Model: 1341, Parr Instrument Company, Werke IKA, China). Calorific value of the product treatments was assessed following procedure reported by Krishna and Rajhan (1981) and sensorial assessment (crust color, crumb color, texture, taste, aroma/odor, pore structure and loaf volume) of different treatments was performed by trained panel of judges following 9-point hedonic scale (Meilgaard et al., 2007).

2.8. Statistical analysis

The current results were analyzed as means ± standard deviation of three independent replications of each parameter. Data were also subjected to statistical analysis by applying one-way ANOVA using the statistical package at SPSS-23.0 (SPSS Inc., Chicago, IL).

3. Results

3.1. Physicochemical composition of the wheat and barley grains

Wheat variety Akbar-19 and a barley variety Jau-17 were used in the present study. Akbar-19 contained 10.8 ± 0.03% moisture content, 39.5 ± 0.08 g thousand grain weight, 71.2 ± 0.25 Kg/hl test weight, 10.8 ± 0.02% protein content, 1.5 ± 0.01%ash, 2.4 ± 0.01% lipids, 50.3 ± 0.08% starch, 24.5 ± 0.05% gluten, 318 ± 10.5 Kcal energy per 100 g and 0.9 ± 0.01% β-glucan while Jau-17 enclosed 14.2 ± 0.05% moisture content, 52.5 ± 0.09 g thousand kernel weight, 60.5 ± 0.12 Kg/hl test weight, 11.6 ± 0.05% protein content, 2.1 ± 0.01%ash, 1.4 ± 0.01% lipids, 51.5 ± 0.04% starch, 7.8 ± 0.04% gluten, 338 ± 9.5 Kcal energy per 100 g and 4.8 ± 0.03% β-glucan concentration (Table 1).

3.2. Physico-chemical composition of flour blends

Moisture, protein, fat, ash, energy and β-glucan content increased while gluten, falling number value and carbohydrates decreased significantly in all wheat-barley flour blend treatments as compared to the control treatment which contained only the refined wheat flour (Table 2).

| Physicochemical characteristics | Wheat Akbar-19 | Barley variety Jau-17 |
|---------------------------------|----------------|-----------------------|
| Thousand kernel weight (g)      | 39.5 ± 0.08<sup>b</sup> | 52.5 ± 0.09<sup>a</sup> |
| Test weight (Kg/hl)             | 71.2 ± 0.25<sup>a</sup> | 60.5 ± 0.12<sup>b</sup> |
| Moisture content (%)            | 10.8 ± 0.03<sup>b</sup> | 14.2 ± 0.05<sup>a</sup> |
| Crude protein content (%)       | 10.8 ± 0.02<sup>b</sup> | 11.6 ± 0.05<sup>a</sup> |
| Ash (%)                         | 1.5 ± 0.01<sup>b</sup>  | 2.1 ± 0.01<sup>a</sup>  |
| Lipids (%)                      | 2.4 ± 0.01<sup>a</sup>  | 1.4 ± 0.01            |
| Starch (%)                      | 50.3 ± 0.08<sup>b</sup> | 51.5 ± 0.04<sup>a</sup>|
| Gluten (%)                      | 24.5 ± 0.05<sup>b</sup> | 7.8 ± 0.04<sup>a</sup> |
| Energy (Kcal/100 g)             | 318 ± 10.5<sup>b</sup>  | 338 ± 9.5<sup>a</sup>  |
| β-glucan (%)                    | 0.9 ± 0.01<sup>b</sup>  | 4.8 ± 0.03<sup>a</sup> |

Different letters (a-b) within the row indicated the interaction of wheat and barley are significantly different (p ≤ 0.05). Results are expressed as the mean value ± standard deviation (n = 3)
3.3. Rheology of flour blends
Flour blends rheology exposed that water absorption capacity (%) of the wheat-barley flour blends increased as the barley proportion increased in the blend. Similarly, dough development time (min.) increased with increased sprouted barley content in the consecutive treatments. Dough stability time (min) also showed direct proportion pattern with increased barley flour in the blends that is stability time increased with increased sprouted barley in the dough blend in comparison with the control treatment (Figure 1–3).

3.4. Physico-chemical composition of the baked products
Physico-chemical composition of the all three types of baked products depicted that moisture, protein, fat, ash and β-glucan concentration of bread, biscuits and cakes significantly increased while carbohydrates reduced significantly as the proportion of sprouted barley increased in the blends as compared to control treatment that was devoid of sprouted barley and had only the white wheat flour (Table 3).

3.5. Sensory evaluation of the baked products
Sensory evaluation of all three types of products revealed that as the amount of sprouted barley flour increased in the blend, sensory quality of the resultant product showed reducing trend. However, sprouted barley flour at the level of 15% in the wheat-barley flour blend of each product showed product acceptability by the sensory quality judges panel but as the sprouted barley flour proportion increased at a level of 20%, sensory acceptability of all three types bakery products was reduced (Table 4).

4. Discussion
Sprouted barley flour was used in the present study because it has high protein, high β-glucan, and low in gluten, dough rheology improver, lowers elevated cholesterol and can be used in white flour for the production of functional or healthier bakery products that has become part and parcel of every consumer at global level.

According to Food and Drug Organization, soluble fibers decreases risk of Coronary Heart Disease due to their positive effect on total and LDL bad cholesterol. β-glucan is also good to maintain blood sugar concentration and prevents from diabetes. Sprouted barley was used because sprouting process increases digestibility of proteins and suppresses various anti-nutritive components. Phytic acid as anti-nutritional factor combines with essential minerals and hinders their absorption in gastrointestinal tract (GIT). Fermentation, baking and sprouting are the processes that decrease its fraction (Bhatt & Gupta, 2015).

4.1. Flour blend
In the present study, water absorption capacity of the flour blends significantly increased compared to control treatment of white wheat flour according to a study finding reported by Rieder et al., (2012) who worked on dough blends of wheat flour with soluble fiber (barley flour) as additive and concluded that dough improver increased water absorption capacity, dough development and stability that is in favor of our study findings. The author added that high β-glucan content of barley increased considerably water absorption capacity of wheat-barley flour blend. Moreover, due to increased water absorption of blend, gluten network is developed properly which requires high water requirement and consequently dough development and stability time of blend is increased. Similar results were also recorded by an author during determination of rheological properties from incorporation of barley flour into the wheat flour (Abou-Raya et al., 2014).

Dough development time also followed the similar pattern of increase that ranged from 3.0 to 6.5 min. Similarly, the dough stability time of the dough blend also increased as compared to the control sample. The parameters of water absorption, mixing time and stability time increased with the incorporation of sprouting barley flour into wheat flour. These results verified the verdict of Hussein et al. (2013) who observed that addition of barley flour in wheat flour significantly
Table 2. Physicochemical composition of flour blends

| Treatments | Moisture (%) | Protein (%) | Gluten (%) | Fat (%) | CH₂O (%) | Ash (%) | Energy (K Cal) | FN(SEC) | β-glucans, (%) |
|------------|--------------|-------------|------------|---------|----------|---------|----------------|---------|----------------|
| T₀         | 11.2 ± 0.5<sup>a</sup> | 10.4 ± 0.5<sup>a</sup> | 24.0 ± 0.5<sup>a</sup> | 1.4 ± 0.01<sup>a</sup> | 73.9 ± 0.4<sup>a</sup> | 0.4 ± 0.01<sup>c</sup> | 325.0 ± 18.8<sup>a</sup> | 541.0 ± 4.1<sup>a</sup> | 0.92 ± 0.02<sup>c</sup> |
| T₁         | 11.8 ± 0.6<sup>ab</sup> | 10.9 ± 0.5<sup>ab</sup> | 24.0 ± 0.5<sup>ab</sup> | 1.5 ± 0.01<sup>b</sup> | 72.4 ± 0.5<sup>ab</sup> | 1.5 ± 0.02<sup>b</sup> | 340.9 ± 13.7<sup>ab</sup> | 325.0 ± 1.5<sup>a</sup> | 1.04 ± 0.03<sup>b</sup> |
| T₂         | 12.5 ± 0.5<sup>abc</sup> | 11.8 ± 0.4<sup>abc</sup> | 23.0 ± 0.5<sup>c</sup> | 1.6 ± 0.01<sup>c</sup> | 72.0 ± 0.5<sup>abc</sup> | 1.7 ± 0.02<sup>c</sup> | 356.0 ± 16.6<sup>abc</sup> | 310.0 ± 2.6<sup>c</sup> | 1.40 ± 0.03<sup>c</sup> |
| T₃         | 13.4 ± 0.5<sup>c</sup> | 12.55 ± 0.5<sup>c</sup> | 22.0 ± 0.5<sup>c</sup> | 1.7 ± 0.01<sup>c</sup> | 71.7 ± 0.8<sup>c</sup> | 1.89 ± 0.05<sup>c</sup> | 373.0 ± 10.6<sup>c</sup> | 280.0 ± 1.5<sup>c</sup> | 1.52 ± 0.02<sup>c</sup> |
| T₄         | 14.1 ± 0.5<sup>c</sup> | 13.2 ± 0.5<sup>c</sup> | 20.0 ± 0.55<sup>c</sup> | 1.7 ± 0.01<sup>c</sup> | 70.0 ± 0.7<sup>c</sup> | 2.45 ± 0.05<sup>c</sup> | 389.8 ± 16.5<sup>c</sup> | 250.0 ± 2.6<sup>c</sup> | 1.72 ± 0.02<sup>c</sup> |

Different letters (a-c) within the column indicated the interaction of different treatments are significantly different (p ≤ 0.05). Results are expressed as the mean value ± standard deviation (n = 3)

CH₂O: Carbohydrates, FN: Falling Number value, K Cal: Kilo Calorie.
improved the rheological characteristics of the blend (particularly water absorption capacity, dough development time and dough stability time) used for bakery products especially bread. Asghar et al. (2005) reported that incorporation of barley flour into wheat flour contributed a positive improvement in the dough rheology and sensorial attributes of the blend used for baking purpose that is also comparable to our work.

Blending of barley flour with wheat flour significantly increased moisture content of blend because barley contains more moisture than wheat due to more fiber as reported by Lin et al. (2011). Other scientists also reported similar results (Hooda & Jood, 2003). This more moisture may be due to moisture given to the barley at sprouting phase. Protein contents of the wheat-barley flour blend also significantly increased with the addition of sprouted barley flour into white wheat flour according to the results of Bazaz et al. (2016) who found more protein content in germinated gram than non-germinated gram. The increase in protein of flour blend might be by fractional changes as a result of degradation of certain grain components during germination. Enzymes released by sprouted process might cause starch hydrolysis resulting in increased protein contents.

Due to the blending process, carbohydrates, gluten contents and falling number value significantly decreased as reported by an author (Yaqoob et al., 2017) who found that germinated barley
is gluten-free and amylases enzymes liberated during germination process hydrolyze starch leaving behind less carbohydrates and low FN value of the flour blend.

Fat, ash, energy and β-glucan content of the blend showed increasing trend as compared to the control treatment. Kim et al. (2012) reported that germinated barley has less increased fat than raw barley that might be from synthesis of new compounds from fat degradation during germination process. Ash contents of the flour blend increased due to the β-glucan in the barley that suppresses anti-nutritional factor such as phytic acid that hinders minerals bioavailability. Energy contents of sprouted germinated barley-wheat flour blend increased due to increased protein and fat contents of the blend while β-glucan concentration increased due to addition of germinated barley flour in the blend which is its good source (Harijono, 2012).

4.2. Baked products
Moisture, protein, fat, ash, β-glucan and energy significantly increased while carbohydrates decreased significantly in all three baked products (bread, biscuits and cakes) with the increase in germinated barley flour proportion in the blend. Bedigian et al. (2011) described that moisture increased in the food products made from blend due to the presence of fiber in the barley as compared to control sample. This slight increase in the moisture may limit the shelf life of the baked products because higher moisture accelerates microbial growth rate that lead to product spoilage (Ezeama & Dobson, 2019). Substitution of wheat flour with sprouted barley flour increased ash content and protein contents of products as compared to control. In addition, current research investigated that bread and cookies prepared from barley flour had increased protein content as compared to control products. Furthermore, ash contents increased in the products due to phytic acid inhibitive activity of β-glucan in the sprouted barley flour. Protein increased after barley germination might be due to change in fractional composition or hormonal function (Dsouza, 2013) or enzymatic hydrolysis leading to decomposition of certain other ingredients (Mashayekh et al., 2008). In the present study, fat contents of flour blend products increased as compared to control treatment. In this regard, some authors reported that sprouted brown rice had increased fat content than the non-germinated one that supports the results of our finding. This slight increase in fat may reduce to some extent the shelf life of the products as result of oxidative rancidity.

Replacement of wheat flour with sprouted barley flour significantly increased energy content because barley proportion was increased in the subsequent treatments in comparison with the
### Table 3. Proximate composition of baked products

| Variable     | Bread  | Biscuit | Cake  |
|--------------|--------|---------|-------|
|              | T<sub>0</sub> | T<sub>1</sub> | T<sub>2</sub> | T<sub>3</sub> | T<sub>4</sub> | T<sub>0</sub> | T<sub>1</sub> | T<sub>2</sub> | T<sub>3</sub> | T<sub>4</sub> |
| Moisture (%) | 33.5 ± 0.03<sup>a</sup> | 33.5 ± 0.03<sup>b</sup> | 33.5 ± 0.03<sup>c</sup> | 33.5 ± 0.03<sup>d</sup> | 33.5 ± 0.03<sup>e</sup> | 33.5 ± 0.03<sup>f</sup> | 33.5 ± 0.03<sup>g</sup> | 33.5 ± 0.03<sup>h</sup> | 33.5 ± 0.03<sup>i</sup> | 33.5 ± 0.03<sup>j</sup> |
| Protein (%)  | 10.1 ± 0.02<sup>a</sup> | 10.1 ± 0.02<sup>b</sup> | 10.1 ± 0.02<sup>c</sup> | 10.1 ± 0.02<sup>d</sup> | 10.1 ± 0.02<sup>e</sup> | 10.1 ± 0.02<sup>f</sup> | 10.1 ± 0.02<sup>g</sup> | 10.1 ± 0.02<sup>h</sup> | 10.1 ± 0.02<sup>i</sup> | 10.1 ± 0.02<sup>j</sup> |
| Fat (%)      | 3.2 ± 0.06<sup>a</sup> | 3.2 ± 0.06<sup>b</sup> | 3.2 ± 0.06<sup>c</sup> | 3.2 ± 0.06<sup>d</sup> | 3.2 ± 0.06<sup>e</sup> | 3.2 ± 0.06<sup>f</sup> | 3.2 ± 0.06<sup>g</sup> | 3.2 ± 0.06<sup>h</sup> | 3.2 ± 0.06<sup>i</sup> | 3.2 ± 0.06<sup>j</sup> |
| O<sub>4</sub>(%) | 72.5 ± 0.04<sup>a</sup> | 72.5 ± 0.04<sup>b</sup> | 72.5 ± 0.04<sup>c</sup> | 72.5 ± 0.04<sup>d</sup> | 72.5 ± 0.04<sup>e</sup> | 72.5 ± 0.04<sup>f</sup> | 72.5 ± 0.04<sup>g</sup> | 72.5 ± 0.04<sup>h</sup> | 72.5 ± 0.04<sup>i</sup> | 72.5 ± 0.04<sup>j</sup> |
| Ash (%)      | 0.6 ± 0.02<sup>a</sup> | 0.6 ± 0.02<sup>b</sup> | 0.6 ± 0.02<sup>c</sup> | 0.6 ± 0.02<sup>d</sup> | 0.6 ± 0.02<sup>e</sup> | 0.6 ± 0.02<sup>f</sup> | 0.6 ± 0.02<sup>g</sup> | 0.6 ± 0.02<sup>h</sup> | 0.6 ± 0.02<sup>i</sup> | 0.6 ± 0.02<sup>j</sup> |
| Energy (K Cal) | 325 ± 15.9<sup>a</sup> | 325 ± 15.9<sup>b</sup> | 325 ± 15.9<sup>c</sup> | 325 ± 15.9<sup>d</sup> | 325 ± 15.9<sup>e</sup> | 325 ± 15.9<sup>f</sup> | 325 ± 15.9<sup>g</sup> | 325 ± 15.9<sup>h</sup> | 325 ± 15.9<sup>i</sup> | 325 ± 15.9<sup>j</sup> |
| β-glucan (%) | 0.3 ± 0.02<sup>a</sup> | 0.3 ± 0.02<sup>b</sup> | 0.3 ± 0.02<sup>c</sup> | 0.3 ± 0.02<sup>d</sup> | 0.3 ± 0.02<sup>e</sup> | 0.3 ± 0.02<sup>f</sup> | 0.3 ± 0.02<sup>g</sup> | 0.3 ± 0.02<sup>h</sup> | 0.3 ± 0.02<sup>i</sup> | 0.3 ± 0.02<sup>j</sup> |

Different letters (a-j) within the row indicated the interaction of different treatments are significantly different (p ≤ 0.05). Results are expressed as the mean value ± standard deviation (n = 3).

CH<sub>2</sub>O: Carbohydrates, FN: Falling Number value, B. glucan: Beta glucan, K Cal: Kilo calorie.
Table 4. Sensory evaluation of baked products

| Variable           | Bread     | Biscuit   | Cake      |
|--------------------|-----------|-----------|-----------|
|                    | T0       | T1       | T2       | T3       | T4       | T0       | T1       | T2       | T3       | T4       | T0     | T1   | T2       | T3       | T4       |
| Guilt color        | 8.6 ± 0.06  | 6.4 ± 0.06  | 6.3 ± 0.06  | 5.8 ± 0.06  | 8.4 ± 0.06  | 8.4 ± 0.06  | 7.7 ± 0.06  | 6.5 ± 0.06  | 5.3 ± 0.06  | 8.0 ± 0.06  | 8.0 ± 0.06  | 8.0 ± 0.06  | 7.0 ± 0.06  | 6.0 ± 0.06  |
| Mumb color         | 8.5 ± 0.03  | 6.6 ± 0.06  | 6.0 ± 0.03  | 5.9 ± 0.06  | 8.2 ± 0.06  | 8.1 ± 0.06  | 7.8 ± 0.06  | 6.6 ± 0.04  | 5.2 ± 0.06  | 8.3 ± 0.06  | 8.3 ± 0.06  | 7.9 ± 0.06  | 6.5 ± 0.06  | 5.1 ± 0.06  |
| Texture            | 8.4 ± 0.06  | 6.6 ± 0.06  | 6.1 ± 0.06  | 5.9 ± 0.06  | 8.3 ± 0.06  | 8.2 ± 0.06  | 7.9 ± 0.06  | 6.5 ± 0.06  | 5.1 ± 0.06  | 8.4 ± 0.06  | 8.0 ± 0.06  | 7.7 ± 0.06  | 6.5 ± 0.06  | 5.3 ± 0.06  |
| Taste              | 8.5 ± 0.03  | 7.0 ± 0.05  | 6.7 ± 0.03  | 5.7 ± 0.06  | 8.3 ± 0.06  | 8.1 ± 0.06  | 8.0 ± 0.06  | 6.9 ± 0.06  | 5.5 ± 0.06  | 8.2 ± 0.06  | 8.1 ± 0.06  | 7.9 ± 0.06  | 6.7 ± 0.06  | 5.6 ± 0.06  |
| Aroma/Odor         | 8.4 ± 0.06  | 6.5 ± 0.06  | 6.4 ± 0.06  | 6.1 ± 0.06  | 8.5 ± 0.06  | 8.2 ± 0.06  | 7.6 ± 0.06  | 6.4 ± 0.06  | 5.3 ± 0.06  | 8.3 ± 0.06  | 8.1 ± 0.06  | 7.5 ± 0.06  | 6.9 ± 0.06  | 5.5 ± 0.06  |
| OA                 | 8.4 ± 0.06  | 6.7 ± 0.03  | 6.2 ± 0.06  | 5.8 ± 0.03  | 8.4 ± 0.06  | 8.2 ± 0.06  | 7.6 ± 0.06  | 6.4 ± 0.06  | 5.3 ± 0.06  | 8.4 ± 0.06  | 8.2 ± 0.06  | 8.0 ± 0.06  | 7.0 ± 0.06  | 5.4 ± 0.06  |
| Pore structure     | 8.2 ± 0.06  | 6.4 ± 0.06  | 6.3 ± 0.06  | 6.0 ± 0.06  | 5.8 ± 0.06  | 8.4 ± 0.06  | 8.2 ± 0.06  | 6.4 ± 0.06  | 5.3 ± 0.06  | 8.4 ± 0.06  | 8.2 ± 0.06  | 8.0 ± 0.06  | 7.0 ± 0.06  | 5.4 ± 0.06  |
| Leaf volume        | 8.5 ± 0.03  | 7.0 ± 0.03  | 6.7 ± 0.03  | 5.7 ± 0.06  | 4.9 ± 0.06  | 8.4 ± 0.06  | 8.2 ± 0.06  | 6.4 ± 0.06  | 5.3 ± 0.06  | 8.4 ± 0.06  | 8.2 ± 0.06  | 8.0 ± 0.06  | 7.0 ± 0.06  | 5.4 ± 0.06  |

OA (Overall acceptability)

Different letters (a-e) within the row indicated the interaction of different treatments are significantly different (p ≤ 0.05). Results are expressed as the mean value ± standard deviation (n = 3)
control sample. Higher fat and protein content of flour blend is also a source of energy that elevate the energy levels of wheat-barley flour bakery products than control treatment (Yaqoob et al., 2018) that favors the findings of current study.

However, carbohydrates content of the blend products decreased significantly as compared to control product. An author reported that during barley germination, amylase enzymes are released that cause starch hydrolysis due to which carbohydrate content of blend products decreased significantly Dsouza (2013) that is in line with present study.

4.3. Sensorial properties
Control bread had highest sensory scores while at 20% substitution level, blended flour dough bread showed poor loaf volume, crumb color and crumb texture according to the findings of Naem et al. (2002) who also found similar results. Pronounced changes recorded in the bread crumb from addition of barley flour led to decreased bread loaf volume due to which dense bread crumb and poor pores distribution was found. Addition of 10 % barley flour (highest in β-glucans) in wheat flour can attribute to improved rheological properties and sensory properties (Asghar et al., 2005). β-glucans in barley flour can contribute to reduced bread staling during storage (Gujral et al., 2003). The addition of 20% barley flour into wheat flour decreased bread loaf volume, crumb cohesive property while it decidedly reduced crumb softness and increased its chewiness. Similar results were recorded in our study in which when 15% barley flour was incorporated in wheat flour, product sensory acceptability by trained panel of judges was good that was significantly reduced at 20% barley flour addition in the blend.

Flavor and taste attributes are given more priority when a food product is evaluated for sensory attributes although a food product might be more attractive and energy dense but unless its flavor and taste is not appealing, it will not be accepted by the consumer in most cases (Frost et al., 2011). Regarding biscuits, 15% sprouted barley flour with refined wheat flour showed that this product treatment uncovered acceptable sensory quality and product acceptability by trained panel of judges. Color of the biscuits changed from creamy white to dull brown and the texture became hard at 20% barley flour in wheat flour. Skribc et al. (2011) found that with the addition of germinated barley flour in wheat flour resulted in decreased flavor score of biscuits. Another author Sudha et al. (2007) reported that addition of 20% barley in wheat flour did not greatly affect the sensory properties of the biscuits. But in the present study, incorporation of 20% sprouted barley flour had a significant effect on sensory quality of biscuits. Other authors found that taste score of the biscuits was reduced as the proportion of the sprouted barley flour in the blend was increased. Overall acceptability scores of different food products varied due to the use of varying quantity of inherent additives (Baba et al., 2016). Moreover, 15% germinated barley flour blend cakes showed product acceptability while cake’s sensory acceptability deteriorated at 20% germinated barley flour addition. Substitution of wheat flour with germinated barley flour significantly reduced color, flavor, taste and overall acceptability score of the resultant cake and these sensory attributes gradually reduced as the germinated barley flour proportion increased. Flavor score of cake deteriorated considerably due to germinated barley flour that might be due to production of different components by germination process (Yaqoob et al., 2018). Other authors (Skrbic and cvejanov 2011) also recorded analogous upshot for cookies produced from assimilation of germinated barley flour in wheat flour.

5. Conclusion
Sprouted barley and wheat flour blends composition indicated that the nutritional composition was significant improved regarding protein, ash, fat, energy and β-glucan concentration with the increase in replacement level of wheat flour with sprouted barley flour. Rheology of flour blends exposed to improve water absorption capacity, dough development time and dough stability time with the increase in sprouted barley content into blend. Nutritional analysis of all baked products depicted significant increase irrespective of carbohydrates. At 20% substitution level, bread production revealed poor loaf volume, poor crumb and pore structure and the same blending level in
cakes depicted dull brown color and hard texture while biscuits appearance changed from creamy white to dull brown and the texture became hard at 20% replacement level as compared to control treatment. However, sprouted barley flour addition at 15% level in flour blend showed product acceptability in all baked products.

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