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Passer Journal of Basic and Applied Sciences

Passer 7 (Issue 2) (2025) 1113-1117

*Original Article*

# Sprouted Barley Flour Substitution with Wheat Flour to Improve the Chemical, Nutritional, and Quality of Bread

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Received 26 June 2025; revised 10 August 2025;
accepted 28 August 2025; available online 11 October 2025

DOI: 10.24271/PSR.2025.531214.2218

## ABSTRACT

Wheat bread is a frequently consumed baked product in Middle Eastern countries, including Iraq. Because of its increased requirements, its quality and nutritional improvements are necessary. Objectives: To examine the effect of sprouted barley flour (SBF) as an improver on the wheat flour bread's quality and rheological features. Materials and methods: SBF (0, 5, 10, and 15%) was added to the wheat flour (WF), and its effect on the quality of bread evaluated due to various assessments, including chemical composition, rheological, sensorial, textural, total phenol/flavonoid content, and antioxidant capacity. Results**:** The physicochemical analysis showed that protein/ash contents were increased, while fat and moisture were decreased by adding a higher level of SBF (15%). The flour blend rheology, including water absorption, dough development time, and dough stability, was enhanced after adding SBF. Sensory evaluation revealed that bread showed product acceptability in term of TPC, TFC, and antioxidant capacity levels in bread were observed with increased SBF substitution for WF. Also, adding SBF into WF significantly ($p \leq 0.05$) increased the bread's hardness. Conclusions: The optimum level of SBF improved the wheat bread's rheology, nutritional, and sensorial properties.



*Keywords: Sprouted barley, wheat bread, proximate analysis, dough rheology, baking quality, sensory evaluation*.

## 1 Introduction

Consumers nowadays commonly refer to foods with more health benefits, acceptable sensory attributes, and aesthetic standards [1]. Bread is among the most interesting baked products due to its rheological properties, ready-to-eat convenience, and cost competitiveness [2]. Barley (*Hordeumvulgare* L.) contains 5.12% soluble dietary fiber (β-glucans) that can normalize blood cholesterol due to its effect on total/low-density lipoprotein (LDL) and lower blood glucose which also affect weight lose because it contain less energy come from barley flour because of high level content of b-glucans which is consider as a good source of protein, as it contains more essential amino acids (lysine) than wheat. Therefore, barley flour (BF) can be mixed with wheat flour (WF) to develop various bakery products with better nutritional quality and improve human health [1]. Raw barley materials like malts, extracts, and flours could strengthen WF. Adding these materials in suitable amounts positively affected bread's technological/sensory characteristics [2,3].

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Peer-reviewed under the responsibility of the University of Garmian.

Sprouted barley is cereals predominantly used in clinical studies. Compared to their plain flours, sprouting can reduce serum cholesterol, blood pressure, blood glucose, and plasma lipid peroxide while increasing zinc and ferrous absorption [4,5]. Blending sprouted barley flour (SBF) in refined WF has valuable effects on baked foodstuffs' dietary, technological, and sensory characteristics [6,7].

Minor individuals cannot digest wheat gluten, so barley flour is a choice to yield low-gluten diets that are not allergic to gluten-intolerant persons and finally convert by beneficial bacteria in gut and produce short chain fatty acid which lower the pH of intestine and considers as a food for cell wall which prevent gut from toxic substances which can avoid multiple dietary and nutritional issues. Sprouting is an easy and cost-effective process that can improve wheat's dietetic/nutraceutical features and increase nutrient quality, especially minerals and also act as a prebiotic substances for probiotic production by beneficial bacteria in the gut [8,9]. Additionally, sprouted materials contain more nutrients than mature grains and are stress-free. SBF contains more fiber, particularly β-glucans that can lower cholesterol and blood sugar [10].

SB is an enhancer in numerous bakeries and has an extensive history [3]. The seeds hydrated completely, activated their metabolism, and mobilized materials [6]. When the moisture is very low, the seeds synthesize and/or release hormones and degrading enzymes (amylase, proteases, and lipases). Consequently, free amino acids and γ-amino butyric acid are increasing, while total phenolic content (TPC) and antioxidants decrease the antinutritional factors and increase mineral bioavailability [11]. This nutrient alteration due to the sprouting is mainly related to health benefits .Currently, there is little or conflicting data on the direct effect of such changes on health biomarkers [7].Thus, we aimed to develop a wheat bread substitute with various concentrations of SBF and to examine the effectiveness of incorporating this ingredient in bread's rheological, organoleptic, and nutritional characteristics.

## 2 Methods and Materials

### 2. 1 Production of SBF

The locally cultivated raw barley grain of the Rafidain variety was harvested from the Agriculture Research Centre, University of Sulaimani, Sulaimaniyah, Iraq. The grains were cleaned and steeped in water at a ratio of 1:3 overnight at 25 C°. After steeping and water removal, the seeds were rinsed twice with distilled water to inhibit infectious growth. Then, wet grains were retained for 4 days in a muslin cloth for sprouting at 15-20°C, while they were sprayed 3-4 times/day until the seeds become wet again. Finally, sprouted grains were air-dried overnight at room temperature, then ground(Lab Mill-120, mesh size 120, Perten, Sweden) and put in an airtight plastic jar for further analysis [9].

### 2. 2 Production of Wheat flour WF

The Qandahar variety wheat grains were also obtained from the Agriculture Research Centre, University of Sulaimani, Sulaimaniyah, Iraq. They were appropriately cleaned to remove dirt particles. Then, the grains were milled, sieved, packed in airtight plastic jars, and stored at ambient temperature for additional analysis.

### 2. 3. WF substitution with SBF

Dried SBF was added in 0, 5, 10, and15% ratios to replace WF [3]. Then, the prepared flour blends at different concentrations of SBF were used for further analysis.

### 2. 4 Physicochemical analysis of WF and SBF

Moisture, ash, protein (total nitrogen×5.7), and fat compositions were tested using AACC, 2010 methods 46- 11A, 30-10.01, 08-01, and 44- 15A, respectively. Then, the values were presented as % of dry matter [12].

### 2. 5 Total phenol content (TPC), total flavonoids composition (TFC), and antioxidant activity

TPC was assessed and presented as Gallic acid equivalent [15]. Gallic acid solutions (50 - 100 µg/mL) and samples (200 and 400 µg/mL) were prepared. Then, 0.5 mL of each solution or blank (methanol, 95% v/v) was mixed with 2.0 mL of the F-C reagent and vortexes for a few seconds. After 3 min, 4.0 mL of sodium carbonate was added, mixed well, transported to a quartz cuvette, and read at 400-900 nm from 5-60 min at 5-minute intervals. The spectra and absorbance were used to find the $\lambda_{max}$ and the optimum reaction time [16]. Additionally, TFC was tested by adding 1.0 mL of aluminum chloride (2.0% in ethanol) and 10 µL of acetic acid to 10 mg of a sample. The volume was completed to 25 mL with distilled water and left for 45minutes at room temperature. The regression equation of quercetin (QUR) was $y=0.0073x+0.0137$ ($R2=0.9964$). Lastly, the absorbance was measured spectrophotometrically at 415 nm, and the result was stated as mg of QUR equivalent (RE; 5-25 µ g/mL) per gram dry extract [17]. The antioxidant activity was found through the radical 2,2-diphenyl-1-picrylhydrazyl (DPPH) test [18]. Briefly, different concentrations of DPPH solution were read at 400-600 nm against the blank (methanol). The absorbance was used to find the $\lambda_{max}$ and to create the linear relationship between absorbance and the standard concentration [16].

### 2. 6 Bread making

The straight dough method (AACC, 1983) was used to prepare bread loaves, and the ingredients were calculated using a g/100 g flour basis. Each loaf of bread was made from100 g WF, 2.0g instant active dry yeast, 1.0 g salt, 4.0 g sugar, 4.0 g dry milk, 2.0 g shortening, and water. Formulas (0, 5, 10, and 15%) containing SBF as a partial substitute for WF were placed in a bowl at 28±2.0 °C and mixed for 6 min. Then, the dough was rounded manually by folding it 20 times, and the bulk dough was left to rest for 10 minutes. The prepared dough was then placed in a lightly greased baking pan, proofed for 80 min in a cabinet at 30±0.5°C/85% relative humidity, and baked for 20 min at 225°C in an electric oven. Then, the baked bread was cooled at room temperature [13,14].

### 2. 7 Dough rheology of WF and SBF

The AACC, 2000 technique number 54 - 21, using a Farinograph (Brabender, Duisburg, Germany), was used to analyze the dough qualities of the flour samples, including water absorption (WA), stability time (ST), development time (DT), and mixing tolerance index (MTI). Each analysis was performed in triplicate [13].

### 2. 8 Sensory evaluation

The bread sensory characteristics were evaluated using semi-trained panelists (n=5). Then, the acceptability, taste, appearance, aroma, crust colour, and texture were assessed on a ten-point scale, scoring from one (immensely not agree with it) to ten (extremely acceptable) [19].

### 2. 9 Texture profile analysis (TPA)

Texture Profile Analysis (TPA) is specifically designed to quantify parameters like hardness, cohesiveness, and springiness, along with other textural properties such as chewiness, gumminess, and resilience. TPA aims to mimic the sensory experience of chewing by subjecting a sample to a double compression test of formulated loaf bread based on a force-time curve [20].

## 2. 10 Statistical analysis

The collected data were investigated using the Statistical Package for the Social Sciences (IBM, Chicago, USA). Descriptive and inferential statistics were calculated for different variables. Statistical significance between groups was considered at $p \leq 0.05$ using the Duncan test.

## 3 Results and Discussions

The increasing demand for healthy food products has promoted the use of germinated seeds as an alternative to refined WF to produce functional flours [10]. Thus, we aimed to produce flour blends with higher nutritional and bio functional potential than WF.

### 3. 1 Proximate composition

The chemical composition of flour blends is shown in Table1. Replacing WF with SBF results indicates that there were significant differences in term of moisture, fat, protein and ash which obtained from 31.56-26.50% , 2.70-3.39, 10.98 -11.67 and 0.15- 1.08 respectively. In general, high moisture may reduce the shelf life of the bread because it fosters microbial growth that results in bread spoilage [21], while increased ash content might be due to the phytic acid inhibitive activity of β-glucans in the SBF that hinders mineral bioavailability. On the other hand, the increase in protein after barley germination might be related to changes in fractional composition, hormone activity, or enzymatic hydrolysis that result in the decomposition of some other ingredients. Germinated barley contains lower fat than raw barley, which might be from the formation of new compounds from fat degradation during the germination [22]; thus, reducing fat after adding SBF increase the shelf life of the bread due to protecting it from oxidative rancidity [3].

**Table 1:** Proximate composition of wheat flour substituted with sprouted barley flour (SBF) at different levels.

| SBF Replacement Level | Moisture% | Ash% | Protein % | Fat% |
|---|---|---|---|---|
| **Control** | 31.56$^{a}$ | 2.70$^{c}$ | 11.22 $^{c}$ | 1.08 $^{a}$ |
| **5%** | 28.70$^{c}$ | 3.70$^{a}$ | 10.98 $^{d}$ | 0.85 $^{b}$ |
| **10%** | 27.60$^{b}$ | 2.80$^{c}$ | 11.27 $^{a}$ | 0.36 $^{c}$ |
| **15%** | 26.50$^{d}$ | 3.39$^{b}$ | 11.67 $^{a}$ | 0.15 $^{d}$ |

Different letters mean significant differences at the level of $p \leq 0.05$ using Duncan test.

### 3. 2 Bread quality (Rheological properties)

Data in table 2 indicates that there were significant differences between treatments for rheological properties in term of values for WA (from 82.2 to 85.1%) ($p \leq 0.05$), DT (from 4.2 to 4.7 min) ($p \geq 0.05$), and ST (from 1.1 to 1.2 min) ($p \geq 0.05$) of the wheat-barley flour blend at 15% than other replacements levels (5 and 10%) and WF alone (control). Generally, more WA means firmer dough because it absorbs high percentages of liquids and retains more carbon dioxide. Similar outcomes were observed in other studies [3,23]. The outcomes of WA might be due to high levels of total protein, β-glucans, together with the' high water binding capacity of dietary fibers and gums/mucilage available in SBF that might compete with the flour protein for water. In this study, slower dough DT at higher SBF amounts might be related to the high gluten content of SBF and its WA, as dough requires more mixing time and absorbs more water. In contrast, MTI significantly ($p \leq 0.05$) decreased from 228 to 173 min. High MTI describes weak flour, which means the formulated dough breaks down rapidly after making a loaf of bread. Hence, we found that SBF addition exerted a less softening capacity and high strength effect in the formulated dough related to the physical interruption of the gluten content that makes the dough weaken and break down more quickly, as the gluten is responsible for the viscoelastic network and dough strength (Table 2).

**Table 2:** Bread quality of wheat flour substituted with sprouted barley flour (SBF) at different levels.

| SBF Replacement Level | Water Absorption (basis on 14%) | Development Time(min) | Stability (min) | Mixing Tolerance Index (BU) |
|---|---|---|---|---|
| **Control** | 82.2$^{b}$ | 4.2$^{c}$ | 1.1$^{b}$ | 228$^{a}$ |
| **5%** | 82.2$^{b}$ | 5.2$^{c}$ | 1.1$^{b}$ | 192$^{b}$ |
| **10%** | 80.7$^{c}$ | 4.9$^{b}$ | 1.8$^{a}$ | 160$^{d}$ |
| **15%** | 85.1$^{a}$ | 4.7$^{c}$ | 1.2$^{b}$ | 173$^{c}$ |

Different letters mean significant differences at the level of $p \leq 0.05$ using Duncan test.

### 3. 3 Total phenol content TPC, TFC total flavonoid composition, and antioxidant activity of wheat flour substituted

Results in table 3 showed that there were significant differences in term of levels of each TPC, TFC, and antioxidant capacity in bread with increased SBF substitution for WF. These might be related to SBF containing various phytochemicals with antioxidant properties, including phenolic acids, flavonoids, and lignans. Similar results for antioxidant capacity were seen by El-Taib et al. [23], who revealed that BF had significantly higher antioxidant activity (97.34 mg Trolox/g) than WF (55.33 mg Trolox/g).

**Table 3:** Total phenol (TPC), total flavonoid composition (TFC), and antioxidant activity of wheat flour substituted with sprouted barley flour (SBF) at different levels.

| SBF Replacement Level | TPC (mg FAE/g) | TFC (mg CE/g) | DPPH Antioxidant Capacity (%) |
|---|---|---|---|
| **Control** | 0.788 $^{d}$ | 0.222 $^{d}$ | 36.49 $^{d}$ |
| **5%** | 1.592 $^{c}$ | 0.316 $^{c}$ | 51.00 $^{c}$ |
| **10%** | 2.066 $^{b}$ | 0.354 $^{b}$ | 62.037 $^{b}$ |
| **15%** | 2.659 $^{a}$ | 0.468 $^{a}$ | 71.520 $^{b}$ |

Different letters mean significant differences at the level of $p \leq 0.05$ using Duncan test.

## 3. 4 Sensory evaluation

Sensory evaluation of bread containing different amounts of SBF is shown in Table (4). Flavor and taste are prioritized when a food is assessed for sensory evaluation. Sometimes, a food is more attractive; however, consumers do not accept its flavor and taste. Colour is an essential criterion for the consumer's initial acceptability of the baked product; hence, in this study, the bread containing 15% SBF had the highest crust colour ($p \leq 0.05$) compared to other treatments. Similar results were correct for the bread's appearance, texture, and overall acceptability ($p \leq 0.05$). However, bread with all concentrations of SBF addition non-significantly ($p \geq 0.05$) gave the volunteers satisfactory taste and aroma. Consequently, consumers would readily accept up to 15% SBF in bread. In this regard, El-Taib et al. [23] revealed that sensory characteristics of prepared bread (containes10% SBF) were not significantly different from the control for crust colour, grain and texture. Whereas Abdullah et al.[3] stated that control bread had the uppermost sensory scores, while at a 20% replacement level, dough bread presented poor loaf volume and crumb colour/texture. BF generally has the highest levels of β-glucans compared to WF, which can contribute to better rheological and sensory characteristics.

**Table 4:** Sensory evaluation of wheat flour substituted with sprouted barley flour (SBF) at different levels.

| SBF Replacement Level | Crust color | Aroma | Taste | Appearance | Texture | Overall Acceptability |
|---|---|---|---|---|---|---|
| **Control** | 6.80$^{a}$ | 7.0$^{a}$ | 7.0$^{a}$ | 7.20 $^{a}$ | 6.80 $^{a}$ | 7.20 $^{b}$ |
| **5%** | 6.80 $^{a}$ | 7.20 $^{a}$ | 6.80 $^{a}$ | 7.40 $^{ab}$ | 7.00 $^{a}$ | 7.40 $^{ab}$ |
| **10%** | 7.40 $^{a}$ | 7.40 $^{a}$ | 7.20 $^{a}$ | 7.80 $^{ab}$ | 7.00 $^{a}$ | 7.80 $^{ab}$ |
| **15%** | 8.00$^{A}$ | 7.0$^{a}$ | 7.80 $^{a}$ | 8.20 $^{a}$ | 7.40 $^{a}$ | 8.200 $^{a}$ |

Different letters mean significant differences at the level of $p \leq 0.05$ using Duncan test

## 3. 5 Texture analysis

As observed in Table (5), adding SBF into WF significantly ($p \leq 0.05$) increased bread's hardness only, but not its cohesiveness and springiness. These results mean that bread crumb structures were not drastically impaired upon substitution of WF by up to 15% SBF. The loss of dough structure after diluting the gluten and starch matrix may reduce its gas-holding capacity and decrease specific volume, increasing the hardness, cohesiveness, and springiness. Another study mentioned that adding 20% SBF into WF decreased breadcrumb cohesive properties, while it reduced crumb softness and improved chewiness [3].

**Table 5:** Texture analysis of wheat flour substituted with sprouted barley flour (SBF) at different levels.

| SBF Replacement Level | Hardness | Cohesiveness | Springiness (mm) |
|---|---|---|---|
| **Control** | 684.50$^{d}$ | 0.780 $^{b}$ | 4.80$^{a}$ |
| **5%** | 985.50 $^{a}$ | 0.830 $^{a}$ | 4.80$^{a}$ |
| **10%** | 1166.0 $^{a}$ | 0.730 $^{c}$ | 4.80$^{a}$ |
| **15%** | 1065.50 $^{b}$ | 0.770 $^{b}$ | 4.80$^{a}$ |

Different letters mean significant differences at the level of $p \leq 0.05$ using Duncan test

## Conclusion

SBF substitution significantly improved the nutritional composition of protein, ash, fat, and moisture. The increased SBF level also improved the rheology of flour blends. At the 15% SBF substitution level, bread production revealed preferable sensorial and textural outcomes with the highest phenol/flavonoid contents and antioxidant capacity.

## Funding

No local or international grant was obtained.

## Acknowledgements

The author would like to thank the authorities of the Food Sciences and Quality Control Laboratory, College of Agricultural Engineering Sciences, University of Sulaimani, Sulaimaniyah, Iraq.

## Authors' contribution

HSK: Methodology, study registration, writing of the original manuscript, SFA: Conceptualization, methodology, data collection/analysis, SKM: Study administration, writing of the original manuscript, SAO: Methodology, data collection, writing of the original manuscript, DAS: Revising and editing of the original manuscript. All authors have agreed to submit the manuscript to this journal.

## Conflict of interest

The authors reported no potential competing interests.

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