Research Article

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Sprouted wheat flour for improving physical, chemical, rheological, microbial load, and quality properties of fino bread

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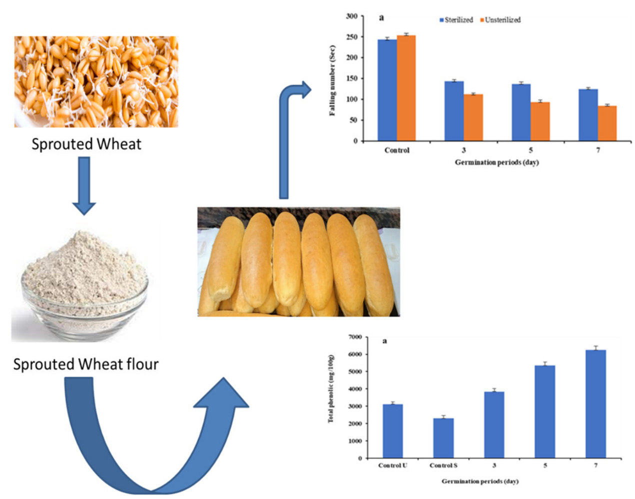
Abstract: The aim of this work was to improve the quality parameters, functional properties, and sensory attributes of the fino bread using sprouted whole wheat flour (SWWF) at different levels, i.e., 3, 6, and 9%. Results demonstrated that SWWF has two-fold phenolic compounds and antioxidant ability compared to unsprouted wheat. The SWWF was found to be high in protein, minerals, and fat while low in carbohydrates compared to the control sample.



Graphical abstract

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Additionally, the microbial loads of SWWF were within processing-acceptable limits. Dough stability and rheological attributes of wheat with SWWF were evaluated to predict the texture of the final bread. There was a positive correlation between stability time and mixed dough and texture parameters of wheat bread with SWWF. The bread made using SWWF was high in protein content. The panelists accepted the bread up to 9% SWWF addition from a sensory perspective. The findings demonstrated that SWWF might be suggested for utilization as an enhancer, particularly up to 9% addition in the bread-making industry.

Keywords: sprouting, antioxidants, wheat grains, bread, functional, quality parameters

1 Introduction

The process of germination may be useful in achieving the ideal balance between technological performance and nutritional benefits, as well as improving the rheological properties [1]. Recently, the germination of wheat grains (WGs) has been utilized to obtain new materials used in food processing [2]. Peñaranda et al. [3] stated that the majority of the new products with germinated components have been snacks (22%), flours (19%), and bakery products (15%). Based on a recent review by a number of authors, germination is linked with an increase in the nutritive content of grains [4].

Controlled-sprouted wheat under ideal circumstances has been proposed to measure the degree of changes in sprouted grains on a processing scale [5]. In addition to improving organoleptic properties, sprouted wheat's native enzymes may reduce or replace the utilization of commercial enzymes, like flour enhancers, which are frequently used in the process of making baked goods [6]. Additionally, sprouting is a great way to generate green foods and enhance the nutritional value of seeds [7]. One investigation by Naumenko et al. [2] showed that wheat-sprouted wholegrain flour improved the microstructure parameters of bread dough.

After germination, the structure of gluten may have changed because of the formation of phenolics that can bind sulfides and allow for the creation of disulfide bridges [8]. This is necessary for the gluten structure to be formed; gluten can also be strengthened, and protein oxidation can occur [9].

α-Amylase is viewed as the principal restricting factor for utilization in the creation of flour from germinated grains; it is capable of hydrolyzing starch molecules, which results in the production of sticky crumbs, a decrease in the dough's viscosity, and a loss of the products' shape stability. It is possible to mix various batches of flour with varying falling number (FN) values during the bread-making process to produce high-quality bakery goods [10].

A drawback of germinated grain is starch digestibility, which typically increases remarkably after sprouting due to the treatment's increase in α-amylase and protease activities [11], which becomes inappropriate for bakery products [12]. This could occur directly in the field if the grains were left in wet conditions for a long duration or if the germination process was done in uncontrolled temperatures or moisture [13].

Bread is a crucial item and is a popular food consumed in Egypt and worldwide. It has a lot of energy but little nutritional value [14]. Wheat is an essential major crop and is typically used to make flour worldwide [15]. Researchers have done their best to enhance the quality and acceptability of bakery goods using sprouted grains such as barley [16], beans [17], and soybeans [18]. Few researchers used whole-wheat sprouted flour for bread making. However, no investigation worked on sprouted-sterilized wheat flour in bakery goods.

This research aimed to (i) assess the impacts of the sprouted-sterilized process on the physical properties (the FN, particle size [PS], and gluten index [GI]), chemical properties, microbiological, and antioxidant ability (AA) of wheat flour; and (ii) impact of sprouted whole wheat flour (SWWF) on the rheological properties, sensory response, and quality attributes of fino bread.

2 Materials and methods

2.1 Materials

WGs (*Triticum aestivum* L.) variety Giza 171 were collected in 2019, from the Agricultural Research Centre, Kafr El-Sheikh, Egypt. Refined wheat flour (RWF; 72% ext.) was provided by the Flour Mills Company, Cairo, Egypt. 2,2-diphenyl-1-picrylhydrazyl (DPPH), Folin–Ciocalteu reagent, sodium carbonate, sodium hypochlorite, and petroleum ether (40–60°C) were provided by Sigma-Aldrich Company (St. Louis, USA). Fine salt and dry active yeast were bought from a market in Kafr El-Sheikh, Egypt. All the chemicals were of high-grade quality.

2.2 Preparation of germinated-sterilized WGs

WGs (50 kg) were cleaned manually from foreign materials and then pre-washed with distilled water at 25 ± 1°C. WGs were surface-disinfected by soaking in a 0.07% NaClO solution at 25 ± 1°C for 30 min, at a grain/solution ratio of 1:5 (w:v), and then washed. Before germination, the WG was further hydrated by soaking in water at 25 ± 1°C for 24 h at a grain/water ratio of 1:20 (w:v) [19]. The WG samples were put in sprouting trays, where wet cotton was outspread, covered, and then left in the incubator (G-120-ASL Snijders, Netherland) at 20 ± 1°C, RH 90 ± 1%, dark chamber at different times, i.e., 0, 3, 5, and 7 days. The germinated wheat was harvested once the bud size reached ≥1.5 mm in ≥90%. The germinated wheat was dehydrated (Air-Drier Model-720, Binder, Germany) at 40 ± 1°C for 10 h, and the moisture level was 10 ± 1% [20].

2.3 SWWF

The SWWF was ground into uniform PSs for 3 min at a constant speed of 15,000 rpm in a Perten 3300 lab mill (Perten, Sweden). The flour was then sieved using a 0.5 mm screen [21]. The flour was stored in hermetic polyethylene bags at 5 ± 1°C.

2.4 Fino bread processing

Fino bread was made in accordance with AACC [22] with minor modifications. Briefly, all ingredients, such as flour RWF and/or SWWF at different levels (3, 6, and 9%), 2% instant dry yeast, 5% sugar, 1% table salt, and 7% corn oil, were gently mixed using a mixer (Orland, Italy). Water was added in accordance with Farinograph absorption at 30 ± 1°C and then mixed for 10 min to obtain a uniform dough. The dough was divided into small portions (55 ± 5 g), proofed at 30 ± 1°C for 30 min, fermented in a chamber at 45 ± 1°C for 45 min and RH 82 ± 2%, and then baked at 255 ± 5°C for 15 min in a Half Rack Oven with rotating shelves (REC 1280, Germany). The Fino loaves were cooled at 25 ± 1°C, packed, and kept at ambient temperature.

2.5 Physicochemical properties

The weight (g) and volume (cm^3) of the bread samples were determined according to AACC [22], while the specific volume ($cm^3\ g^{-1}$) and density ($g\ cm^{-3}$) were calculated. The moisture, protein, fat, carbohydrate, fiber, and ash of samples were determined (AOAC [23]). The mineral content was analyzed using an atomic and flame photometer [24]. All tests were conducted in triplicate.

The FN was measured according to AACC (FN 1700; Perten Instruments, Sweden) [22]. A glutomatic instrument (Perten Instrument AB, Sweden) was used to calculate the GI [22]. The size of the flour was gauged with a Mastersizer 3000 analyzer (Malvern Instruments, Malvern, UK) [22].

2.6 Total phenolic (TP) and antioxidant capacity

The TP of SWWF was determined with Folin–Ciocalteu reagent at 750 nm [25]. TP was expressed as mg gallic acid equivalent per 100 g SWWF. The DPPH activity of SWWF was measured at 517 nm based on Liu et al. [26].

2.7 Rheological properties

Various rheological characteristics of the dough were performed using a Farinograph (Brabender OHG, Germany) and Extensograph (Brabender, Germany HZ 50) [22,27].

2.8 Microbiological assay

The SWWF was homogenized (Stomacher, England), and the filtrate was collected after placing it in a stomacher bag (Rockland, USA) along with 25 mL of buffered peptone water (Difco; 0.1%). Sequent dilutions were carried out, and 100 µL of the disperse was plated (duplicate) onto Plate Count Agar (Difco, USA) for the total bacterial count, Rose Bengal Agar for yeast and molds, and Sorbitol MacConkey Agar (Difco, USA) for *E. coli* to assay the number of cells that were still present. Colonies of bacteria were counted after 48 h at 37 ± 1°C, while those of yeast and molds were recorded after 5 days at 25 ± 1°C. Populations were measured in $\log_{10}$ CFU g^{-1} [28].

2.9 Sensory evaluation

A 20-person, a skilled panel from the Food Science program at Kafrelsheikh University (aged 30–45 years old) assessed the fortified bread with SWWF at different levels: 3, 6, and 9%. The samples were placed on paper plates with three-digit codes. After the samples had been baked for 1 h, the sensory assessment was done. The panelists assessed the bread samples based on the nine-point-hedonic scale approach for color, taste, odor, texture, appearance, and overall acceptability [29].

2.10 Data analysis

In this study, assays were run in triplicate and sensory assessment was carried out with 20 panelists. With two factors and three levels of SWWF, a factorial design ANOVA was used using SPSS, version 18, with a 5% significance level (IBM; Armonk, NY, USA) and Tukey's multiple comparison tests [30].

3 Results and discussion

3.1 Physical properties

Germination of WGs is an important approach for producing new material with functional properties and has been recently utilized in various food products. The sprouting yield of WGs at different sprouting periods is presented in Table 1. The results demonstrated that the germination yield of WGs increased with time. On days 3, 5, and 7, the germination rates were 97.9, 98.2, and 98.6%, respectively. The impact of germination and sterilization on the FN, PS, and GI of the sprouted wheat flour is presented in Figure 1. As shown in Figure 1a, the FNs of sterilized and unsterilized control flour (without germination) were 243 and 254 s, while after day 7 of germination, they were 125 and 85 s, respectively. However, the FN in refined flour (RF) was 360 s (data not shown). The significant decrease ($p \geq 0.5$) in FN in germinated flour may be linked to an increase of α-amylase enzyme activity in the WG during the germination process. This means that sprouted whole-wheat flour can only partially replace RF in order to produce high-quality bread (SWWF). The outcomes correspond with the data provided by Kiszonas et al. [31], who reported that the FN in sprouted wheat flour ranged from 70 to 300 s for α-amylase activity. Another study by Naumenko et al. [2] showed that the FN of sprouted flour was 75 s, and that of RF was 245 s. According to the literature [10], α-amylase is viewed as the principal restricting factor for utilization in the creation of flour from the germinated grain. It is capable of hydrolyzing starch molecules, which results in the production of sticky crumbs, a decrease in the dough's viscosity, and a loss of the products' shape stability. It is possible to mix various batches of flour with varying FN values during the bread-making process to produce high-quality bakery goods.

As shown in Figure 1b, the PS of the 7-day sprouted flour samples ranged from 139 to 143 µm, and that of the control sample ranged from 153 to 160 µm. The RF sample showed a PS of 98 µm (data not shown). It was noted that the sprouting process had a remarkable effect on the distribution of PSs; particles were uniformly distributed across the size range in the SWWF sample. Naumenko et al. [2] found that the PS of sprouted wheat flour was 154 µm. Elkhalifa and Bernhardt [32] stated that the grain undergoes both structural and biochemical changes as a result of the processes that take place during germination. Naumenko et al. [33] stated that conventional milling should not be recommended to grind sprouted grains because of their high elasticity, which reduces the flour yield and increases the ash content. Figure 1c shows that SWWF has the highest GI, which may be due to its superior gluten quality in comparison to the control sample. These agree with a study by Hadnađev et al. [34]. After germination, the structure of the gluten may have changed because of the formation of phenolics that can bind sulfides and allow for the creation of disulfide bridges [8]. This is necessary for the gluten structure to be formed; gluten can also be strengthened and protein oxidation can occur [9].

3.2 Chemical composition

The RWF's composition was 14.1% moisture, 0.67% ash, 12.4% protein, and 1.16% fat (data not shown). The SWWF germinated flour (sterilized and unsterilized) exhibited the following chemical properties: 12.09–12.77% moisture, 2.38–2.47% ash, 12.94–13.13% protein, and 1.77–1.79% fat (Figure 2). However, the sterilized and unsterilized control samples (without germination) exhibited 10.03% moisture, 1.77% ash, 11.65% protein, and 1.21% fats. The

Table 1: Germination yield percentage of WGs during the germination process up to 7 days (mean ± SD, $n = 3$)

Germination periods (days)	Weight of germinated seeds (g)	Weight of non-germinated seeds (g)	Germinated seeds yield (%)
Control	0	750 ± 5.82^{a}	0^{b}
3	734.5 ± 7.56^{c}	15.5 ± 1.36^{b}	97.9 ± 2.4^{a}
5	736.5 ± 8.24^{b}	13.5 ± 1.18^{c}	98.2 ± 2.74^{a}
7	739.5 ± 9.44^{a}	10.5 ± 1.5	98.6 ± 1.88^{a}

^{abc}There are no significant changes between any two means "in the same column" having the same superscript letters ($p \geq 0.05$).

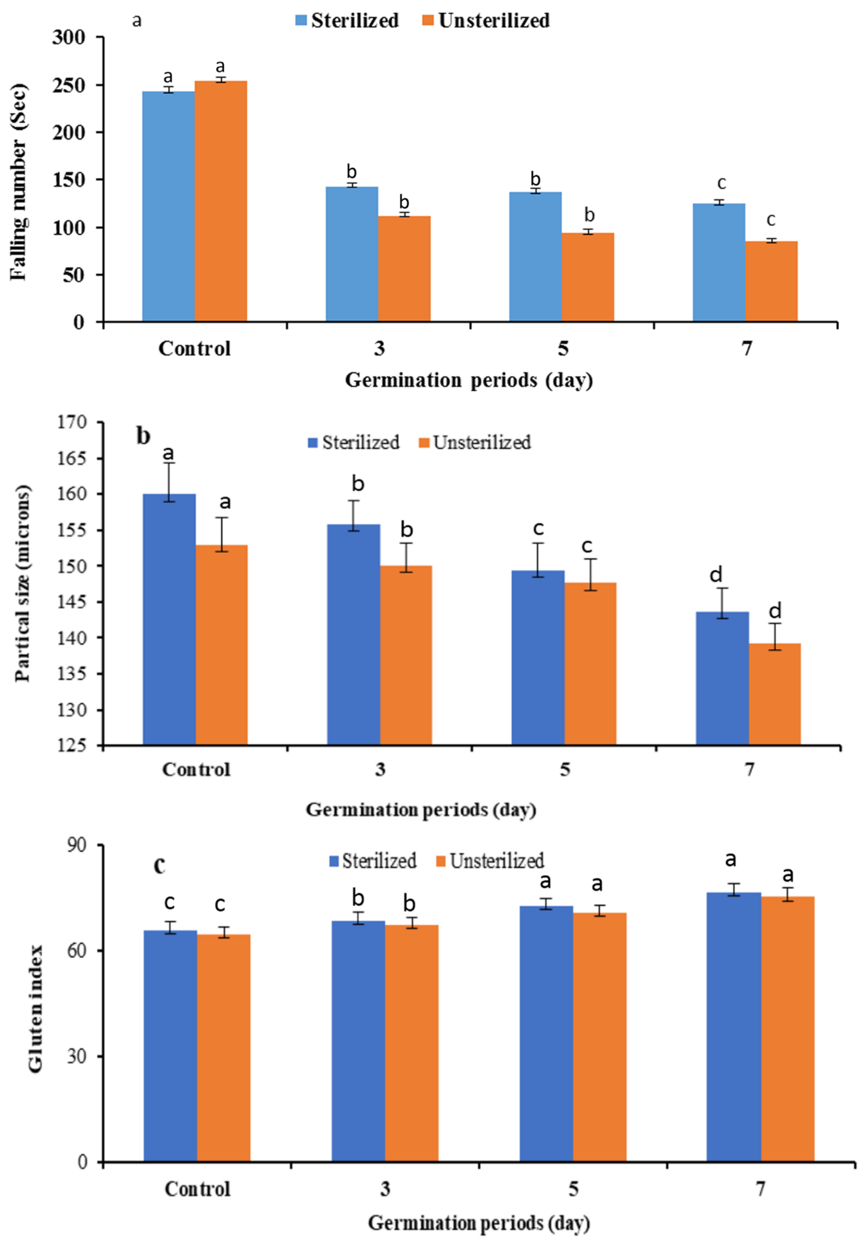

Figure 1: Impact of controlled-sprouted wheat flour on FN (a), PS (b), and GI (c). Error bars represent standard deviation (n = 3).

obtained data showed that the protein value of the sprouted flour was high. The figures matched the information that had been previously published by Kassegn et al. [35]. Previous research reported an increase in protein of 5–10% in germinated barley [36], oats and wheat [37], rice [38], and millet [39]. However, the increase in protein can be linked to the loss of carbohydrates during respiration [40]. Nevertheless, a slight increase in the contents of fat and ash was observed. The sprouting process may have contributed to the slight increase in free lipids that led to an increase in flour lipids [41]. The carbohydrate and fiber content was high in sprouted wheat flour compared to the control sample. Previous investigations showed that soluble and insoluble dietary fiber's compositions and amounts change when sprouted [36,42] Hung et al. [43] found that the loss of reserve compounds, primarily starch, decreased the total dietary fiber content of wheat after 4 days of sprouting. Marti et al. [12] showed that the amount of soluble dietary fiber increased by three to four times after sprouting.

3.3 Mineral content

Changes in the mineral contents before and after germination are shown in Figure 3. It was noticed that there was a

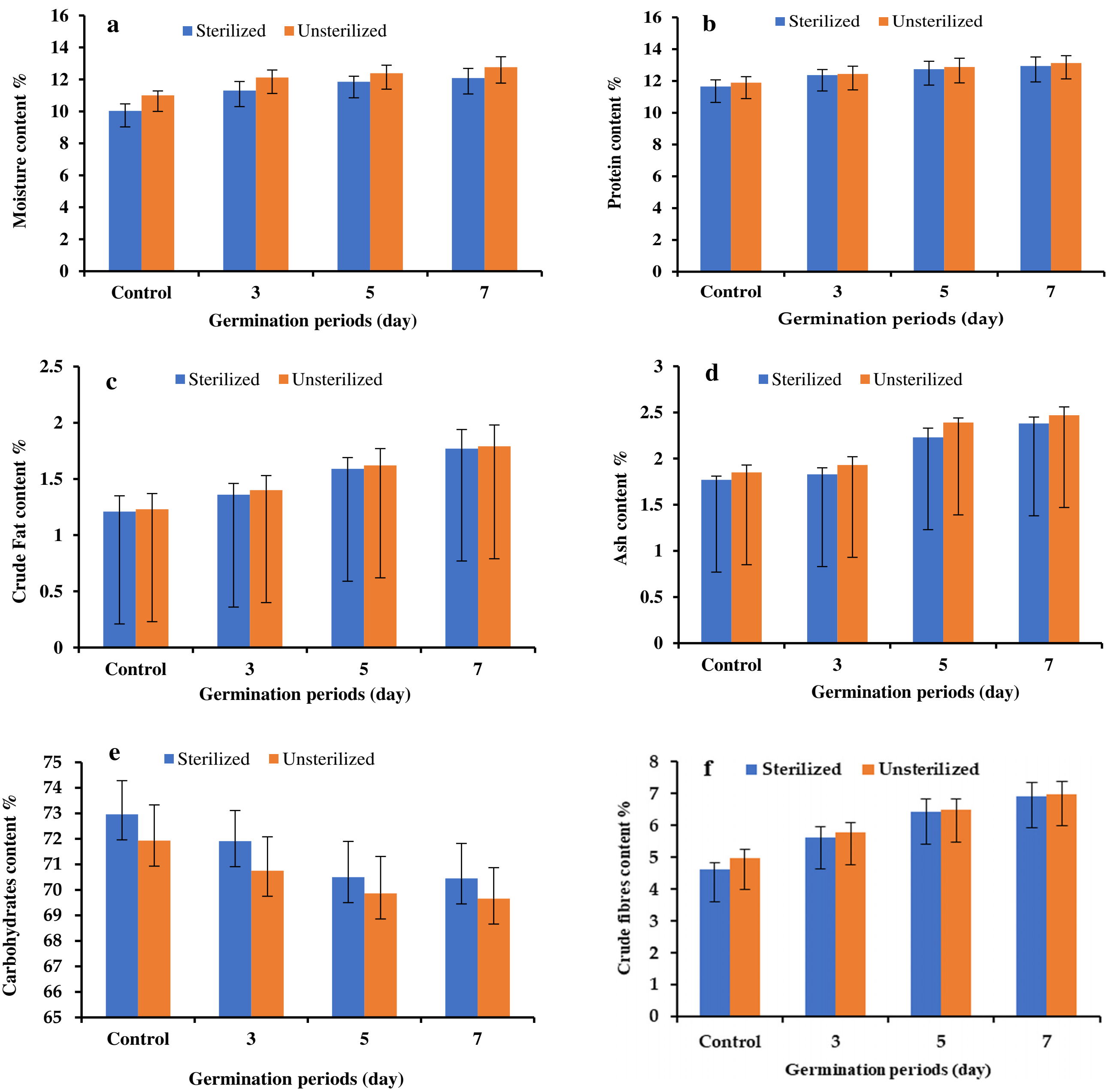

Figure 2: Chemical composition of controlled-sprouted wheat flour: (a) moisture, (b) protein, (c) fat, (d) ash, (e) carbohydrates, and (f) fibers. Error bars represent standard deviation (n = 3).

remarkable increase in the mineral contents in sprouted wheat flour compared to the control sample. Furthermore, the Mg, Na, K, Fe, and Ca contents of sterilized and unsterilized WGs increased as the germination period progressed. In general, the mineral contents of SWWF increased by 2–4 times compared with those of the control. SWWF led to bread with higher mineral content, which is then available to humans using appropriate bread-making recipes. Afify et al. [44] found that zinc and iron bio-accessibility increased from 15 and 14% in sprouted wheat to 27 and 37%, respectively.

3.4 TP and antioxidant capacity

Figure 4 illustrates the impacts of sprouting and sterilization on the TP and AA of WGs. The TP and AA of WGs increased with the germination period. A significant difference in TP and AA levels was noted in the germinated WGs for up to 7 days. These results are consistent with those of Sytar et al. [45]. Prior research has demonstrated that sprouting enhances the antioxidant capacity of cereals by 1.2–2.9 times, with wheat showing the greatest increase

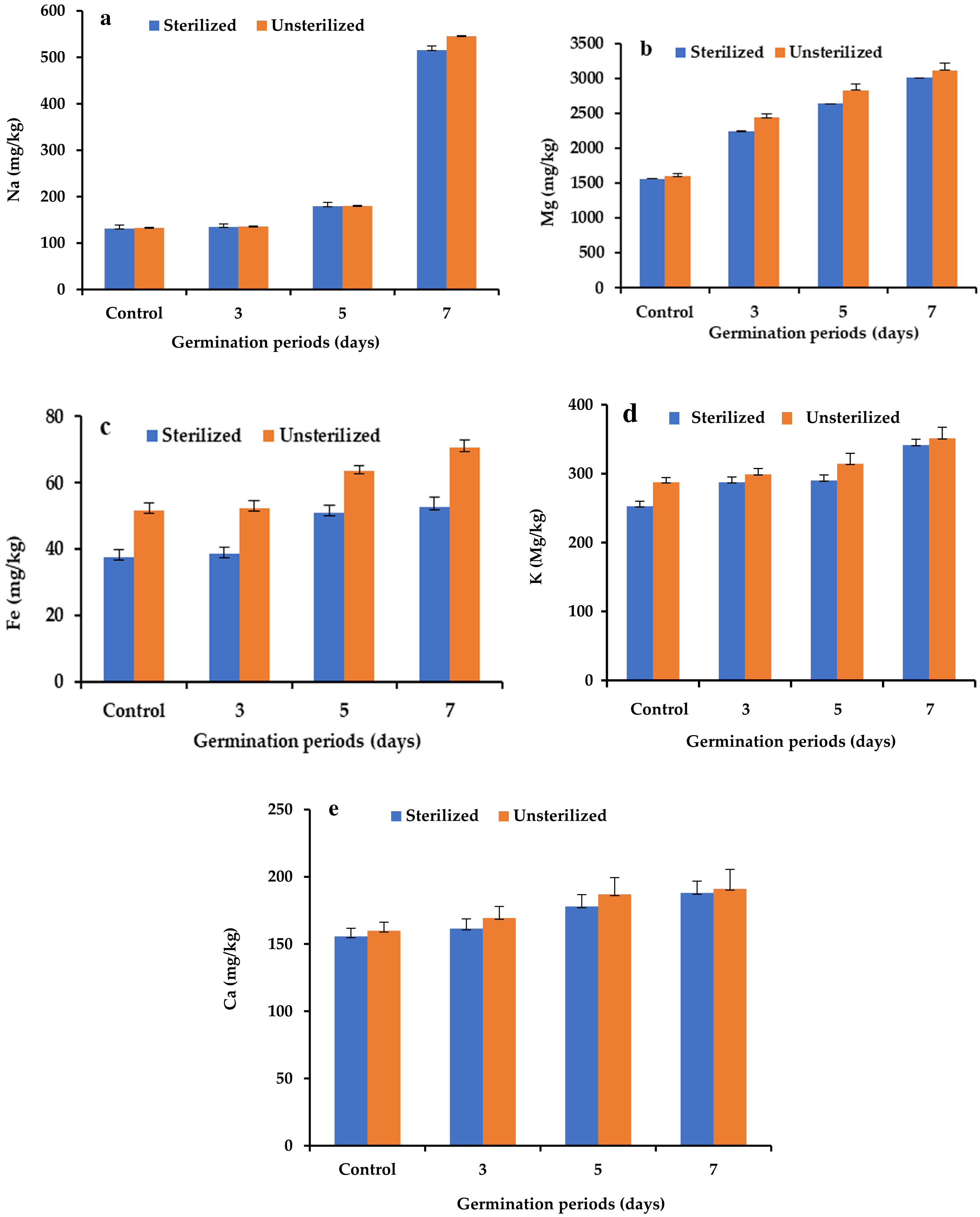

Figure 3: Changes in mineral content (mg kg^{-1}) of controlled-sprouted wheat flour during the germination process: (a) sodium, (b) magnesium, (c) iron, (d) potassium, and (e) calcium. Error bars represent standard deviation (n = 3).

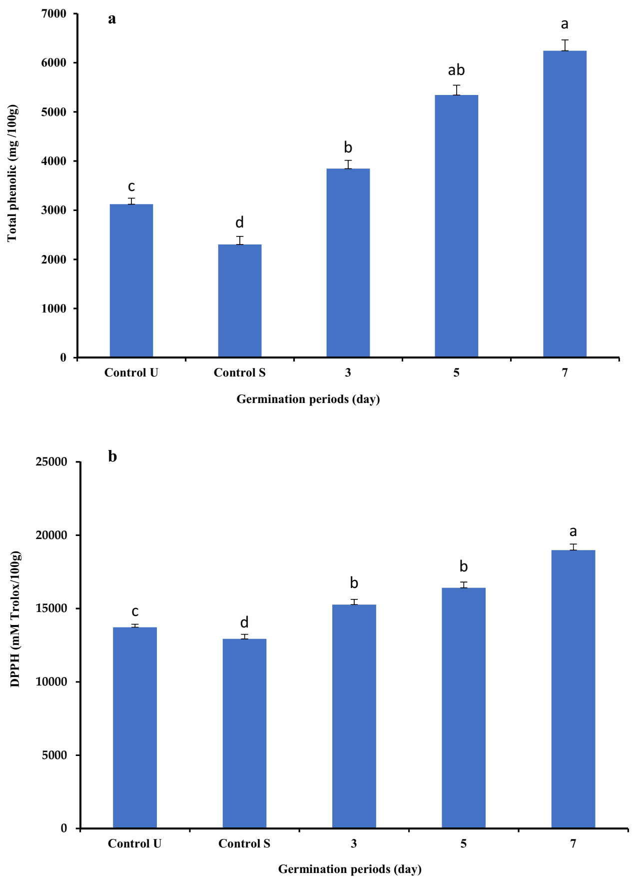

Figure 4: Impact of germination periods and sterilization process on TP contents (a) and antioxidant capacities (b) of wheat flour. Error bars represent standard deviation (n = 3).

[46,47] when germinated for 3 days at 15–28°C. The buildup of polyphenols and vitamin E is the primary cause of the increased efficacy of antioxidants in germinated grains [48]. Their capacity to scavenge free radicals, break free radical chain reactions, and chelate metals are linked to their antioxidant activity [49]. Ferulic, sinapic, vanillic, and p-hydroxybenzoic acids are the primary polyphenols found in cereal grains [50]. Typically, between 60 and 90% of the polyphenols in cereals are bound [49]. Wheat has been found to have a total polyphenol content that increased by 1.2–3.6 times [51], oats [52], and brown rice [8] when germinated for 4 days at 15–28°C. The sprouting grain's increased AA is crucial to its protection. However, the relationship between this increase and potential health benefits is debatable [53].

3.5 Rheological parameters

Table 2 shows the rheological parameters of the dough made from sprouted WG. The RF dough in the control sample had a high water absorption rate (61%) and agreeable stability for 8.2 min (data not shown), which is common in wheat flour with sufficient gluten. Water absorption decreased remarkably ($p \le 0:05$) when SWWF was used in place of RF. Pasqualone et al. [54] emphasized that the utilization of dietary fiber-rich raw materials raises water absorption because of their high hygroscopicity. However, SWWF is considered a complex system with high enzyme activity that affects the farinograph's quality. Because sprouted wheat has a lot of proteases working, the depolymerization of proteins may be the primary cause of the decrease in water absorption [8]. Previous investigations noticed that the action of proteolytic chemicals increased during germination. Gluten is hydrolyzed by these proteolytic enzymes, which also partially convert complex proteins with a high molecular weight into simpler ones. The dough's capacity to absorb water is diminished due to these changes, which significantly impact its rheological properties [55].

Table 2: Rheological properties of dough containing controlled-sprouted wheat flour at different levels

Parameters		Samples			
		Control	3%	6%	9%
Farinograph	Water absorption (%)	63 ± 1.82^{a}	59 ± 1.21^{b}	57 ± 1.30^{b}	55 ± 1.15^{c}
	Arrival time (min)	0.5 ± 0.01	1 ± 0.02^{c}	1.5 ± 0.03^{b}	2 ± 0.07^{a}
	Doug development time (min)	1 ± 0.01^{c}	1.5 ± 0.06^{b}	2 ± 0.05^{b}	3 ± 0.09^{a}
	Dough stability time (min)	5 ± 0.11^{a}	4.5 ± 0.17^{b}	5 ± 0.14^{a}	4 ± 0.15^{c}
	Weakening value (BU)	65 ± 2.11	70 ± 2.88^{c}	75 ± 2.19^{b}	80 ± 3.31^{a}
Extensograph	Extensibility (mm)	125 ± 5.15^{a}	117 ± 4.33^{b}	110 ± 3.58^{c}	100 ± 4.66
	Resistance (BU)	433 ± 12.55^{c}	441 ± 10.15^{c}	454 ± 11.55^{b}	465 ± 14.51^{a}
	proportional number	3.71 ± 0.21^{c}	3.95 ± 0.18^{b}	4.43 ± 0.33^{a}	4.76 ± 0.27^{a}
	Energy (cm^{2})	58 ± 1.44^{a}	52 ± 1.71^{b}	45 ± 1.66^{c}	39 ± 1.81^{d}

^{abc}There are no significant differences between any two means "in the same column" having the same superscript small letters ($p \ge 0.05$).

When SWWF is added, the dough's development time increases from 1.5 to 3 min, but the dough's stability decreases sharply to 3 min, indicating that the dough weakens because of the increased level of α-amylase activity. Additionally, the dough extensibility and extensograph quality indicators both significantly decreased when 9% of RF was replaced with SWWF. When equal amounts of soft wheat and durum wheat flour were added to the dough, a similar pattern was observed [56]. The gluten from RF and SWWF may interact differently, causing this phenomenon; the proteins of soft wheat and the gluten of durum wheat both produced results that were comparable [57]. The dough that was produced when 3% RF was replaced with SWWF had high stability and extensograph quality indicators. These results are consistent with those of Marti and his colleagues and may be linked to the moderate action of α-amylase and enzymes that cause insignificant damage to the gluten matrix [5].

3.6 Microbial quality

Figure 5 displays the SWWF microbial quality findings. In general, the microbial count of SWWF increased over the course of 7 days, particularly with unsterilized sprouting. The whole wheat flour sample's initial count of bacteria was 2.92 log CFU g^{-1}. The number increased by >3 log (6.2 log CFU g^{-1} of the sample) on day 3 of unsterilized sprouting despite the slight increase in sprouting under sterilized conditions. In a previous study, germination increased the microbial populations of wheat by 2.3 log [58]. Whole wheat flour had a yeast and mold count of 2.06 log CFU g^{-1}. After 3 days of germination under unsterilized conditions, this microbial population increased by more than 2 logs (4.44 log CFU g^{-1} of the sample) in comparison to sterilized conditions (2.31 log CFU g^{-1}). Comparable outcomes were noted by Peles et al. [59]; after wheat sprouting, the yeast and mold counts increased from 3.5 to 4.0 log CFU g^{-1}, while the bacterial counts increased from 4.9 to 6.2 log CFU g^{-1}. However, the wheat used for processing typically had a bacterial plate count between 3 and 8 log CFU g^{-1} and a yeast and mold count between 2 and 7 log CFU g^{-1} [60]. Moreover, the whole wheat flour had an *E. coli* count of 1.72 log CFU g^{-1}. After 3 days of sprouting under unsterilized conditions, this microbial increased by >1 log (2.28 log CFU g^{-1}) in comparison to sterilized conditions (not detected). These results corroborated with those published by Liu et al. [61]. The majority of pathogens that pose a threat to international public health safety are foodborne [62]. In 1996, radish sprouts were linked to 2,764 cases that were confirmed in Sakai City, Japan, from an outbreak of *E. coli* O157:H7 [63]. The EFSA outbreak reported in 2011 in Germany was estimated as follows: ~3,816 cases sick and 54 deaths from sprouted fenugreek contaminated with *E. coli* O104: H4 [64].

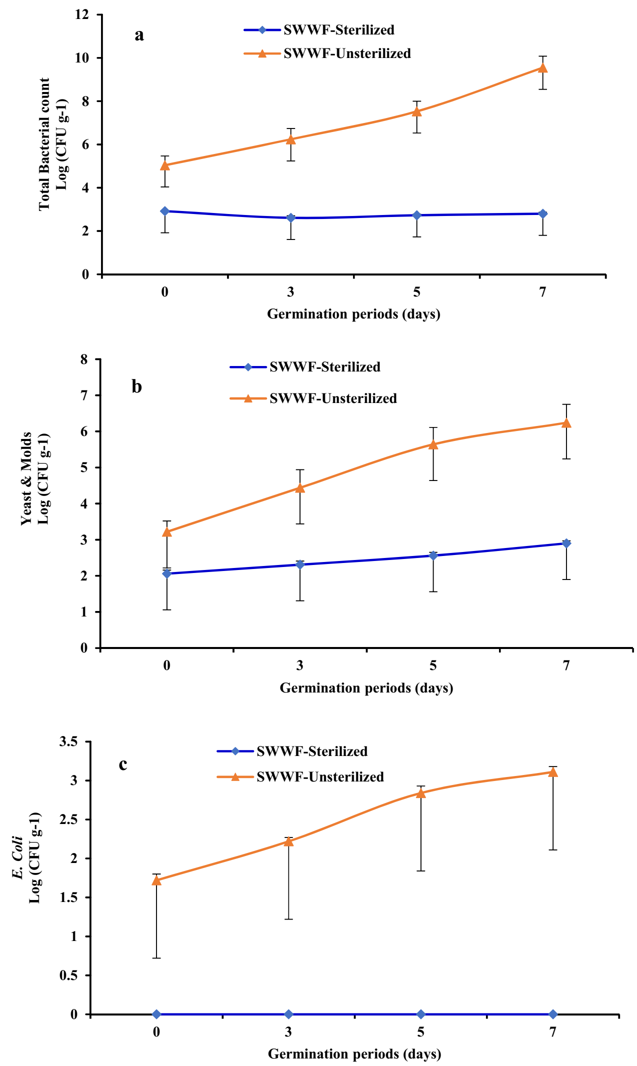

Figure 5: Changes in microbial quality of sterilized and unsterilized SWWF: total bacterial counts (a), yeast and molds (b), and *E. coli* (c) of wheat flour. Error bars represent standard deviation (n = 3).

3.7 Physicochemical properties of bread

The results in Table 3 revealed that the bread sample containing 9% SWWF had the highest loaf weight and volume compared to the control sample. Specific volume is a crucial criterion for determining bread quality. The data showed that bread, including 3% SWWF, had the highest value of specific volume, followed by bread, including 6% SWWF. These outcomes align with the previously

Table 3: Quality parameters of fino bread fortified with different levels of SWWF (mean ± SD, n = 3)

Treatments	Physical quality			
	Weight (g)	Volume (cm^3)	Specific volume ($cm^3\ g^{-1}$)	Density ($g\ cm^{-3}$)
Control	39.45 ± 0.05^c	119.21 ± 0.44	3.02 ± 0.04^b	0.33 ± 0.02^a
3%	40.25 ± 0.1^b	122.37 ± 0.38^c	3.04 ± 0.02^a	0.33 ± 0.03^a
6%	40.63 ± 0.12^b	123.88 ± 0.5^b	3.03 ± 0.02^a	0.33 ± 0.01^a
9%	41.32 ± 0.09^a	125.52 ± 0.31^a	3.01 ± 0.05^c	0.33 ± 0.02^a

Treatments	Chemical quality				
	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)
Control	29.48 ± 1.10^a	12.18 ± 0.82^b	4.15 ± 0.12^a	1.23 ± 0.04^a	52.96 ± 2.45^a
3%	28.78 ± 1.22^a	13.77 ± 0.77^a	4.08 ± 0.29^a	1.44 ± 0.07^a	51.93 ± 1.8^b
6%	28.44 ± 1.12^a	14.12 ± 0.32^a	3.97 ± 0.22^a	1.70 ± 0.11^a	51.77 ± 1.58^b
9%	27.13 ± 1.02^b	14.88 ± 0.44^a	3.92 ± 0.17^a	1.84 ± 0.01^a	52.23 ± 2.34^a

^{abc}There are no significant differences between any two means “in the same column” having the same superscript small letters ($p \geq 0.05$).

published by Hassan et al. [65], who found that the specific volume of fino bread was 3.07 cm^3/g. The proximate composition of bread was prepared using SWWF at levels of 3, 6, and 9% (Table 3). Breads with different levels of SWWF had significantly different moisture contents ($p < 0.05$) than the control sample. Bread including 9% SWWF showed the lowest value for moisture compared to samples containing 3 and 6% SWWF, which were not remarkably different ($p \geq 0.05$). Bread made with whole-wheat flour (control) had 29.48% moisture content. This increase may be because the germinated wheat flour has a greater capacity to absorb water. Although there is no legal restriction on bread's moisture content, in most circumstances, it should not be greater than 38% [66]. The 9% SWWF bread had the highest protein level (14.88%), followed by 6 and 3% of SWWF bread. On the other hand, the control bread contained 12.18% less protein than any other bread. The amount of protein in wheat bread, as stated by Tiimub [67], was noted to be 11.88%., It was observed that there were no significant changes ($p \geq 0.05$) in the ash and fat levels with the addition of SWWF. Bread may have a higher fat content than flour due to the addition of butter during the cooking process. The carbohydrate content of SWWF bread was the lowest, though control bread showed an extremely high amount of carbohydrates. Germination prompts significant modifications in grain carbs that have been accounted in wheat; in this manner, a reduction in the carbohydrate level of the sprouted wheat bread was noticed. Dhillon et al. [68] additionally noted a drop in the carbohydrate content, which they attributed to increasing protein levels.

3.8 Sensory evaluation of the prepared bread

The bread's sensory characteristics are presented in Table 4. Bread samples containing SWWF generally received significantly higher scores ($p \leq 0.05$). When compared to the

Table 4: Sensory responses of fino bread fortified with different levels of SWWF (mean ± SD, n = 20)

Treatments	Sensory properties					
	Color	Taste	Odor	Texture	Appearance	Overall acceptability
Control	7.5 ± 0.37^c	7.8 ± 0.42^c	8.2 ± 0.21^b	7.5 ± 0.12^c	7.4 ± 0.24^c	7.8 ± 0.46
3%	8.4 ± 0.41^b	8.3 ± 0.22^b	8.8 ± 0.13^a	8.3 ± 0.21^b	8.2 ± 0.33^b	8.3 ± 0.47^c
6%	8.8 ± 0.17^{ab}	8.6 ± 0.38^{ab}	8.8 ± 0.44^a	8.4 ± 0.31^b	8.4 ± 0.23^b	8.6 ± 0.49^b
9%	8.9 ± 0.21^a	8.7 ± 0.24^a	8.9 ± 0.30^a	8.7 ± 0.33^a	8.7 ± 0.14^a	8.8 ± 0.23^a

^{abc}There are no significant differences between any two means “in the same column” having the same superscript small letters ($p \geq 0.05$).

control, the addition of SWWF resulted in improvements in color, flavor, and aroma. It was observed that the addition of SWWF at 6 and 9% to wheat flour had improved the sensory parameters in comparison to the control sample. The panelists preferred the bread samples with 6 and 9% SWWF from a sensory perspective. Due to the benefits of the sprouting interaction over the tangible profile of the WGs, it was found that the addition of SWWF prompted a superior evaluation by the specialists compared to the control.

Previous research demonstrated that WGs undergo enzyme activation during the sprouting cycle [69], and enzymes play a significant role in producing bread of high quality with improved surface and appearance [70]. Due to the release of fewer sugars and amino acids from WGs during germination, another study demonstrated that the sprouting process has an impact on flavor. During the baking system, these substances join to frame explicit Maillard response items, which affect the end result's flavor and variety [71]. Additionally, during sprouting, when endogenous amylolytic enzymes are activated, starch transforms into oligosaccharides and sugars, giving sprouted wheat flour its characteristic sweetness and, implicitly, bread [72]. As a result, it is possible to conclude that the sprouting process, which enhances the sensory profile of the grains that were subjected to this process and implicitly of the bread that contained sprouted flour, is primarily to blame. Similar findings from a previous study demonstrated that the addition of sprouted wheat flour enhanced the bread's sensory parameters [73].

4 Conclusions

This study's objective was to assess the fino bread's quality parameters at the 3, 6, and 9% levels using SWWF. Using varied amounts of SWWF, namely 3, 6, and 9%, to wheat flour allowed for an improvement in the quality metrics, functional qualities, and sensory attributes of the fino bread as compared to the control group. The TP compound in SWWF increased by more than two times after sprouting, and antioxidant activity also increased. The SWWF microbiological loads fell under allowable limits for processing. After using SWWF to prepare the bread, it was discovered to have a significant protein level. The results showed that SWWF might be recommended for use as an enhancer, especially in the bread industry up to 9%.

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