Influence of heat treatment for some wheat milling fractions on fino bread quality

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Abstract The influence of incorporating dry-heated wheat bran, at 5, 10, 15, and 20 g/100 g levels with dry-heated wheat germ at 3 g/100 g level, on fino dough rheology and bread quality was studied in comparison with fino bread containing unheated fractions, and white wheat bread. Dry heat treatment showed insignificant effects on the chemical composition and the dietary fibers of wheat bran and wheat germ, but was effective in reducing lipase activity by half in wheat bran, and by 100% in wheat germ. Dough containing dry heated fractions lowered the water absorption, extended the development time, strengthened the protein network, and increased the stability time, starch gelatinization, hot-gel stability, and starch retrogradation. Fino bread had larger loaf volume, darker crumb color, and lesser firm, gummy, and chewy texture. Sensory acceptability of fino bread loaves containing heated fractions indicated significant ($P \leq 0.05$) improvement in taste, flavor and overall acceptability scores. Fino bread provided 9.0 to 21.5% of the dietary fiber intake (DFI) for the adults, showed significant loss of phytic acid (30–34%), had higher significant total phenolic contents (109.2–198.2 mg GAE/100 g), and antioxidant activity (40.17–47.46%). Levels of 10 and 15 g heated bran with 3 g heated germ/100 g showed acceptable results among all studied characteristics. Dry heat treatment could be applied on wheat bran and wheat germ to mitigate their negative influences on dough rheological behavior, and to deliver functional

fino bread to consumers, with more dietary fiber, high-quality nutrients and antioxidant activity.

Keywords Fino bread · Dry heated wheat bran and wheat germ · Dough rheology · Sensory quality attributes · Physical characteristics · Nutritional value

Introduction

Wheat grain is an excellent source of nutritive ingredients which are chiefly present in the bran layers and germ of the wheat kernel (Demir and Elgün 2014). During the roller-milling process, wheat grain is milled to produce white wheat flour from endosperm with minimal inclusions of bran and germ, significantly reducing the nutritional value of the produced flour (Gil et al. 2011). Nevertheless, today, consumers and food manufacturers have become more aware of the benefits and effects of fiber-enriched food. These benefits and effects can be classified into nutritional benefits (from the nutrients present), mechanical benefits (on the gastrointestinal tract, due to the fiber content) and antioxidant effects (from the bioactive compounds found such as total phenols and phytic acid (Stevenson et al. 2012). In consequences, this has led to a boost in developing whole grain foods or inclusion of some parts of the grain fractions (Cai et al. 2014; Jacobs et al. 2016).

Bread is a significant part of the daily diet in several regions of the world, wherein it accounts for about 20% of the calories consumed by people (Saccotelli et al. 2017). In Egypt, the second most popular wheat bread is fino after balady. It is a type of long bread loaves, made from the lower extraction rate flour (72%), fat, water, and yeast. It looks like French bread, but it is soft and light (Mahmoud and Abou-Arab 1989). Fino bread is well known in making

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sandwiches, especially indoors, at many restaurants and university canteens, as well as street vendors. For this reason, it could be as an excellent vehicle to deliver wheat bran and wheat germ. However, wheat bran and wheat germ have a poor shelf life due to the presence of unsaturated fatty acids, as well as oxidative and hydrolytic enzymes; that influence the wheat flour stability and bread properties during storage (Demir and Elgün 2014). In addition, wheat bran physically increases dough water absorption, decreases dough strength, disrupts the starch-gluten matrix and decreases the gas holding capacity, resulting in a reduced bread loaf volume. Besides, wheat bran accelerates starch retrogradation and bread staling. On the other hand, wheat germ has a significant effect on the gluten matrix, due to the presence of glutathione, a powerful reducer that weakens the gluten network by breaking the disulphide bonds. Furthermore, wheat germ leads to a reduction of bread quality, mainly due to the increase in bread hardness and the decrease in bread volume (Gómez et al. 2012; Majzoobi et al. 2012; Paucean et al. 2016).

Many efforts have been developed to overcome these problems and to improve the dough properties and bread baking quality, including reduction of bran particle size (Wang et al. 2017a, b), incorporation of improvers into the bread formulation (Paucean et al. 2016), and thermal and hydrothermal stabilization (Demir and Elgün 2014).

Thermal stabilization, particularly the dry heat treatment is the most extensive and cost-effective method used in the bran or germ fraction of wheat kernel. It reduces microorganism contents, inactivates lipase and increases the shelf life of wheat bran and wheat germ. In addition, the dry heat treatment can improve the accessibility and availability of the phenolic compounds in wheat bran and enhance the end-product performance without significant nutrient losses (Rose et al. 2008; Bucsell et al. 2017; Wang et al. 2017a, b). However, there were many contradicting and largely unexplained observations about the performance of heat stabilized wheat bran and wheat germ during bread making. Some authors found that heat treatments prolonged the dough development time, and increased the loaf volume (de Kock et al. 1999; Nandeesh et al. 2011; Gómez et al. 2012). While Srivastava et al. (2007) observed adverse effects on the dough rheological properties and loaf volume; however, Wang et al. (1993) observed only minor changes in the loaf volume upon extrusion of bran.

From the above-mentioned report, it appears that optimizing the quality of bread enriched with heat stabilized bran and germ is a challenging task. Consequently, the present research work aimed to study the influence of dry-heat treatment for wheat bran and wheat germ on the quality characteristics of Egyptian fino bread.

Materials and methods

Materials

Wheat grain variety Shandaweel 1 was obtained from Wheat Department, Field Crops Research Institute, Agricultural Research Center, Al Jizah-Egypt. Fresh wheat germ flakes were obtained from Wadi El-Melouk Company for Milling, Third Industrial Region, 6th October City, Al Jizah-Egypt. Granulated cane sugar, instant dry yeast, table salt, and corn oil were obtained from the local market, Al Jizah, Egypt. Instant dry yeast ingredients as mentioned on the label were *Saccharomyces cerevisiae* and emulsifier (E491): Sorbitan monostearate. Super Beta multipurpose bread improver was obtained from Bake Land Company, Industrial Zone C-1, 10th Ramadan City, Egypt. Ingredients as mentioned on the label were wheat flour, maize starch, ascorbic acid, and plant origin enzymes (α -amylase and xylanase). Sodium phytate, Gallic acid, α -amylase, protease, amyloglucosidase, 2,2-diphenyl-1-picrylhydrazyl (DPPH) and an anion-exchange resin Dowex[®] 1X2 were obtained from Sigma-Aldrich Chemical Co., St. Louis, USA. All other chemicals were analytical reagent grade.

Methods

Wheat grain milling and particle size

Wheat grain was tempered overnight to 14% moisture content and milled into a flour extraction rate of 72 g/100 g with a Quadrumat Junior Mill (Bra bender, Duisburg, 191 Model QU-J, Germany). Coarse bran was ground for more time to get a finer particle size then combined with fine bran and passed through 310 μ m sieve openings. Wheat germ flakes were ground and passed through 310 μ m sieve openings to get a finer particle size. The obtained bran and germ were stored separately at -20 ± 2 °C for dry heat treatment, composition analyses, and bread baking experiments.

Dry heat treatment of wheat bran and wheat germ

The dry heat process was performed on wheat bran and wheat germ, according to Rose et al. (2008). Wheat bran and wheat germ were separately spread into stainless steel porous tray, in an air-circulated oven at 175 °C for 20 min. After that, samples cooled down at room temperature (28 ± 2 °C) and stored in a sealed glass jar at -20 ± 2 °C, until further use.

Flour blends preparation and Mixolab analysis

The heated wheat bran (HWB) and unheated wheat bran (UWB) were blended with the control white wheat flour (WWF) in proportions of 5, 10, 15, and 20 g/100 g (dry basis). Then heated (HWG) and unheated (UWG) wheat germ were added in the proportion of 3 g/100 g (as its naturally occurring proportion in the wheat kernel) to prepare eight different flour blends namely FUH₅, FH₅, FUH₁₀, FH₁₀, FUH₁₅, FH₁₅, FUH₂₀ and FH₂₀ (Table 2). Dough mixing properties, quality of starch and protein of control WWF and the flour blends were determined using a Mixolab 2 (Chopin Technologies, France), Standard Chopin⁺ analyzes protocol according to AACC International (2003) Approved Method 54-60 compliant with ISO ICC173/1. A 50 g mixing bowl and mixing speed of 80 RPM were used. Water absorption (WA) of WWF was (54%), on the basis of (14%) moisture (recombined with the initial moisture content of the samples). The Mixolab curves showed WA or the percentage of water required for the dough to produce a torque of 1.1 ± 0.05 Nm. Development time (DT), is the time (min) to reach the maximum torque at 30 °C. Stability (ST) is the time (min) until the loss of consistency is lower than 11% of the maximum consistency reached during the mixing. C1 determines maximum dough torque for water absorption (Nm). C2 measures protein weakening as a function of mechanical work and temperature (Nm). C3 measures starch gelatinization (Nm). C4 measures hot gel stability (Nm). C5 measures starch retrogradation (Nm).

Fino bread (FB) baking

Fino bread (FB) was baked according to AACC International (2003) Approved Method 10-10. The baking formula included 1000 g of WWF blend (14% moisture basis), 20 g of instant dry yeast, 60 g of granulated cane sugar, 10 g of table salt, 15 g of bread improver, and 70 g of corn oil. All ingredients were mixed with the time and amount of water estimated from the Mixolab 2 test in a 1000 g Hobart A-200 dough mixer, USA. The FB dough was manually rounded into small portions each of 60 g, proofed at 30 °C for 30 min, and fermented at Lucks chamber at 60 °C for 20 min and relative humidity 85%. Then baked at 260 °C for 15 min in a Half Rack Oven with rotating shelves. Samples were cooled down at room temperature for about 2 h before instrumental and sensory analyses.

Physical characteristics of FB loaves

Loaf volume

FB loaf volume (cm³) was measured immediately after baking using clover seed displacement according to AACC International (2003) Approved Method 10-05. The FB was sealed in a plastic bag without slicing and stored at − 20 °C for further analyses.

Crumb color

The crumb color of FB loaves was measured in triplicate using a colorimeter (CR-400, Konica Minolta Sensing Inc., Japan). The color values were recorded as L^* = lightness (0 = black, 100 = white), a^* (− a^* = greenness, + a^* = redness) and b^* (− b^* = blueness, + b^* = yellowness).

Crumb texture

The crumb texture of FB loaves was determined at 18 h after baking using Texture Profile Analyzer according to AACC International (2003) Method 74.09. The Texture Profile Analyzer model was Inc., Middleboro, MA 02346-1031, USA, equipped with a 1000 kg load cell. FB loaves were placed into a flat metal plate and compressed twice to 40% of its original thickness at a speed of 2.0 mm/s, using a TA-AACC36 probe. From the force time curves, firmness (N), cohesiveness, gumminess (N), and chewiness (N) were calculated.

Chemical analyses for wheat-milling fractions and FB

Chemical composition

Chemical composition was performed on WWF, UWB, HWB, UWG, HWG, and FB samples. The contents of moisture, crude protein, crude fat, ash, total dietary fiber (TDF), and insoluble dietary fiber (IDF), were determined according to the AACC International (2003) Approved Methods 44-16, 46-30, 30-10, 08-01, 32-07, respectively. Soluble dietary fiber (SDF) was calculated by difference. Crude protein content was calculated as $N \times 5.7$ for WWF and FB, $N \times 6.31$ for UWB and HWB, and $N \times 5.45$ for UWG and HWG.

Determination of lipase activity

Lipase activity (μmol/g) was measured in UWB, HWB, UWG, and HWG according to Srivastava et al. (2007). A sample of 0.5 g was dispersed in 15 mL of distilled water with triacetin in 0.2 M phosphate citrate buffer of pH 7.8.

The free fatty acids produced were determined by titrating against 0.1 mol/L sodium hydroxide. The activity was expressed as μ mol of fatty acids formed during 24 h incubation at 37 °C.

Determination of phytic acid

The phytic acid was measured in FB according to Latta and Eskin (1980) using an anion-exchange column. The phytate eluent was diluted, then Wade reagent was added, and the absorbance of the supernatant was read at 500 nm against sodium phytate standard.

Determination of total phenolic content (TPC) and antioxidant activity (AOA)

The TPC of FB was determined according to Singleton and Rossi (1965) using Folin-Ciocalteu reagent. Samples were measured at 765 nm, and the concentration was expressed as milligrams of Gallic acid equivalents (GAE)/100 g. The AOA of FB was evaluated by measuring free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging capacity according to Blois (1958). The absorbance was measured against pure methanol at 515 nm, and the AOA was calculated as percent discoloration from the following equation:

$$\text{Inhibition (\%)} = [1 - (A_1/A_0)] \times 100$$

where A_0 is the absorbance of the pure methanol control at the beginning of the reaction ($t = 0$) and A_1 is the absorbance of sample extract at the end of the reaction ($t = 30$ min). All chemical tests were averaged from three replicates.

Sensory evaluation of FB loaves

A panel of 35 subjects from the staff of Food Technology Research Institute (Agricultural Research Center, Al Jizah-Egypt) evaluated the sensory properties of FB loaves according to Martin et al. (2013). The panelists gave scores for crust color, crumb appearance, texture, taste, flavor, shape symmetry, and overall acceptability (OAA) on a hedonic scale from one (dislike extremely) to nine (like extremely).

Statistical analysis

The data of rheological, chemical, physical and sensory evaluations were analyzed using computer software CoStat 6.303, CoHort, USA, 1998–2004 for Windows; an analysis of variance (ANOVA) followed by Duncan's multiple range tests at $P \leq 0.05$ to compare between means.

Results and discussion

The influence of dry heat treatment on the chemical composition of the wheat-milling fractions

Table 1 shows the chemical composition (g/100 g) and lipase activity (μ mol/g) of the wheat-milling fractions. The WWF had a significantly ($P \leq 0.05$) higher amount of moisture and a significantly ($P \leq 0.05$) lower amount of dietary fibers. However, UWB and UWG had significantly ($P \leq 0.05$) higher amounts of crude protein, crude fat, ash, and TDF contents than WWF. After the dry heat treatment for the wheat bran and wheat germ, there were no significant ($P \leq 0.05$) changes in terms of crude protein, crude fat, and ash contents compared with the heated samples. However, there was a significant ($P \leq 0.05$) reduction in their moisture contents. Reductions in moisture contents may drastically reduce the water uptake and induced changes in hydration kinetics of these fractions (Jacobs et al. 2016).

The IDF and TDF were decreased; however, SDF was increased. These changes in dietary fiber contents by dry heat treatment were not significantly ($P \leq 0.05$) different from those of the unheated samples. Probably, dry heating or roasting is a mild process than other mechanical treatments. For example, excessive autoclaving and extrusion cooking resulted in significant changes in dietary fiber contents, probably due to rupture of glycoside bonds leading to hydrolysis and loss of arabinoxylans (Siljeström et al. 1986).

Heat treatment was effective in reducing lipase activity by 50 and 100% in HWB and HWG, respectively, as has obtained by de Kock et al. (1999); Srivastava et al. (2007); Nandeesh et al. (2011); Jacobs et al. (2016). The reason for incomplete deactivation of lipase activity of wheat bran using the dry heat treatment may be due to the fact that wheat bran proteins are partially stable against denaturation in a dry environment (Rose et al. 2008).

The influence of dry heat treatment of wheat bran and wheat germ on fino dough rheological behavior

Table 2 summarizes the rheological behavior of fino dough for the control WWF and the different flour blends obtained from Mixolab curves. The first phase of Mixolab curves determines the protein properties during dough mixing. Data showed that WA % was increased with the addition of wheat germ and with the increased proportions of wheat bran. These results are in agreement with the findings of Srivastava et al. (2007), Nandeesh et al. (2011), Banu et al. (2012), Majzoobi et al. (2012), Paucean et al. (2016) and Liu et al. (2017). The increase in WA was due

Table 1 Chemical composition (g/100 g) and lipase activity ($\mu\text{mol/g}$) of wheat- milling fractions

Samples	Moisture (g/100 g)	Crude protein (g/100 g)	Crude fat (g/100 g)	Ash (g/100 g)	SDF (g/100 g)	IDF (g/100 g)	TDF (g/100 g)	Lipase activity ($\mu\text{mol/g}$)
WWF	10.61 $\pm$ 0.16 ^a	11.85 $\pm$ 0.05 ^c	1.21 $\pm$ 0.01 ^c	0.5 $\pm$ 0.02 ^c	0.46 $\pm$ 0.4 ^c	2.8 $\pm$ 0.5 ^d	3.26 $\pm$ 0.4 ^c	–
UWB	7.4 $\pm$ 0.14 ^c	16.17 $\pm$ 0.06 ^b	3.8 $\pm$ 0.06 ^b	4.99 $\pm$ 0.03 ^{ab}	2.9 $\pm$ 0.5 ^b	41.37 $\pm$ 0.7 ^a	44.27 $\pm$ 0.3 ^a	790 $\pm$ 1.2 ^a
HWB	4.4 $\pm$ 0.1 ^d	15.96 $\pm$ 0.06 ^b	4.15 $\pm$ 0.08 ^b	5.86 $\pm$ 0.04 ^a	3.30 $\pm$.53 ^{ab}	38.88 $\pm$ 0.4 ^{ab}	42.18 $\pm$ 0.2 ^a	395 $\pm$ 1.6 ^c (50% loss)
UWG	7.95 $\pm$ 0.2 ^b	23.33 $\pm$ 0.3 ^a	7.51 $\pm$ 1.1 ^a	3.9 $\pm$ 0.02 ^{bc}	2.81 $\pm$ 0.7 ^b	15.72 $\pm$ 0.5 ^c	18.53 $\pm$ 0.2 ^b	770 $\pm$ 1.1 ^b
HWG	2.65 $\pm$ 0.06 ^c	24.53 $\pm$ 0.4 ^a	8.31 $\pm$ 1.57 ^a	4.5 $\pm$ 0.01 ^b	3.61 $\pm$ 0.43 ^a	13.92 $\pm$ 0.1 ^c	17.53 $\pm$ 0.12 ^b	nd (100% loss)

WWF, white wheat flour of 72 g/100 g extraction rate; UWB, unheated wheat bran; HWB, heated wheat bran; UWG, unheated wheat germ; HWG, heated wheat germ; SDF, soluble dietary fiber; IDF, insoluble dietary fiber; TDF, total dietary fiber; nd, not detectable

Data are presented as means $\pm$ SDM ($n = 3$) and means within a column with different letters are significantly different at $P \leq 0.05$

Table 2 Mixolab parameters of Chopin⁺ protocol of white wheat flour and flour with different proportions (5–20 g/100 g) of heated and unheated wheat bran and 3 g/100 g heated and unheated wheat germ at the target consistency value (C1: 1.10 $\pm$ 0.05 Nm)

Flour	WA (%)	DT (min)	ST (min)	C2 (Nm)	C3 (Nm)	C4 (Nm)	C5 (Nm)
WWF	54.0 $\pm$ 1.05 ^d	1.35 $\pm$ 0.02 ^c	6.30 $\pm$ 0.35 ^c	0.43 $\pm$ 0.02 ^d	1.89 $\pm$ 0.00 ^{ab}	1.57 $\pm$ 0.00 ^c	2.44 $\pm$ 0.01 ^b
FUH ₅	55.3 $\pm$ 0.4 ^d	1.35 $\pm$ 0.05 ^c	6.25 $\pm$ 0.24 ^c	0.41 $\pm$ 0.02 ^c	1.89 $\pm$ 0.01 ^a	1.48 $\pm$ 0.03 ^d	2.22 $\pm$ 0.02 ^c
FH ₅	54.8 $\pm$ 0.64 ^d	4.0 $\pm$ 0.36 ^d	6.48 $\pm$ 0.23 ^d	0.44 $\pm$ 0.03 ^d	1.81 $\pm$ 0.04 ^c	1.47 $\pm$ 0.04 ^d	2.25 $\pm$ 0.02 ^c
FUH ₁₀	57.1 $\pm$ 0.2 ^{bc}	3.97 $\pm$ 0.33 ^d	5.35 $\pm$ 0.21 ^f	0.44 $\pm$ 0.01 ^d	1.72 $\pm$ 0.02 ^e	1.38 $\pm$ 0.01 ^e	2.00 $\pm$ 0.02 ^d
FH ₁₀	56.2 $\pm$ 1.34 ^c	5.07 $\pm$ 0.44 ^c	7.51 $\pm$ 0.25 ^b	0.53 $\pm$ 0.03 ^b	1.90 $\pm$ 0.01 ^a	1.75 $\pm$ 0.04 ^a	2.69 $\pm$ 0.04 ^a
FUH ₁₅	58.5 $\pm$ 0.4 ^{ab}	4.73 $\pm$ 0.12 ^c	4.87 $\pm$ 0.35 ^g	0.47 $\pm$ 0.02 ^c	1.79 $\pm$ 0.02 ^d	1.28 $\pm$ 0.01 ^f	1.88 $\pm$ 0.01 ^d
FH ₁₅	58.1 $\pm$ 0.90 ^b	8.03 $\pm$ 0.64 ^a	7.82 $\pm$ 0.30 ^a	0.55 $\pm$ 0.02 ^a	1.86 $\pm$ 0.11 ^b	1.74 $\pm$ 0.06 ^{ab}	2.70 $\pm$ 0.06 ^a
FUH ₂₀	61.3 $\pm$ 0.4 ^a	4.93 $\pm$ 0.44 ^c	4.77 $\pm$ 0.22 ^g	0.47 $\pm$ 0.03 ^c	1.79 $\pm$ 0.02 ^d	1.16 $\pm$ 0.06 ^g	1.55 $\pm$ 0.06 ^e
FH ₂₀	60.0 $\pm$ 1.0 ^a	6.32 $\pm$ 0.39 ^b	7.38 $\pm$ 0.25 ^c	0.52 $\pm$ 0.01 ^b	1.86 $\pm$ 0.02 ^b	1.71 $\pm$ 0.02 ^b	2.69 $\pm$ 0.02 ^a

WA, water absorption (14% moisture basis); DT, development time; ST, stability time; C1, maximum dough torque to determine water absorption; C2, protein weakening as a function of mechanical work and temperature; C3, starch gelatinization; C4, hot gel stability; C5, starch retrogradation in the cooling phase; WWF, white wheat flour; FUH, flour blend with unheated wheat bran and unheated wheat germ; FH, flour blend with heated wheat bran and heated wheat germ, heated and unheated bran levels 5, 10, 15 and 20 g/100 g, heated and unheated wheat germ level 3 g/100 g

Data are presented as means $\pm$ SDM ($n = 3$) and means within a column with different letters are significantly different at $P \leq 0.05$

to the water absorption capacity of the hydrocolloids, globulin protein and fiber-rich fractions specifically, pentosans of wheat germ and wheat bran. During dough mixing, these components could compete with other dough components for water through hydrogen bonding; alter the dough WA (Cai et al. 2014; Ertaş 2016). Our results showed that the WA of flour blends (FH_{5–20}) with HWB and HWG was lower than that of flour blends (FUH_{5–20}) with the UWB and UWG at the same conditions, but no significant difference ($P \leq 0.05$) was observed for most samples, as has already been observed by Wang et al. (2017a, b). That may be due to forming a lipid coating during the dry heat treatment, reduced the hydration rate of bran and rendered its surface hydrophobic (Jacobs et al. 2016).

With regard to DT, wheat germ and wheat bran prolonged the DT to reach the maximum consistency of dough

up to 1.1 Nm, as has already been observed by Banu et al. (2012). This effect is due to the dilution, and the physical hinderece for gluten network by adding germ and bran fractions, which prevents protein hydration and extends the DT (Gajula 2017). Dough enriched with HWB and HWG showed higher significant ($P \leq 0.05$) DT than dough with UWB and UWG; specifically of the level 15 g/100 g (FH₁₅) was comparable and reached the higher consistency. This result may be due to the higher content of soluble fiber in HWB and HWG; this type of fiber shows a greater capacity to compete for water with proteins (Gajula 2017; Wang et al. 2017a, b).

As seen in Table 2, data showed that the flour blends with UWB and UWG had a significant ($P \leq 0.05$) downward trend in ST, except of flour blend (FUH₅) with 5 g/100 g UWB and 3 g/100 g UWG, a value close to that of the control WWF. However, flour blends (FH_{5–20}) with

HWB and HWG showed a significant ($P \leq 0.05$) upward trend in ST. These results are consistent with the results from Nandeesh et al. (2011); Wang et al. (2017a, b). The change in ST is due to the action of disulfide bonds and the quality of protein matrix. Wheat germ and wheat bran contain reductive substances, such as glutathione, which can reduce the disulfide bridges, responsible for longer stability during dough mixing, resulting in a weakening gluten network with anti-parallel β -sheet structure. However, after heat stabilization, the total reducing substances of wheat bran and germ were significantly decreased (Srivastava et al. 2007; Majzoobi et al. 2012; Bock and Damodaran 2013; Paucean et al. 2016; Wang et al. 2017a, b). That might sequentially contribute to our findings.

C2 indicates protein weakening as a function of mechanical and thermal constraints. The C2 values (Nm) showed a significant ($P \leq 0.05$) increase in all dough blends in reference to the control WWF dough. This result is consistent with the result from Gajula (2017). This effect was mainly due to the higher resistance of gluten for heat, and the strength of its protein network during baking (Ortolan and Steel 2017). The C2 values (Nm) of flour blends (FH_{5–20}) with HWB and HWG were significantly ($P \leq 0.05$) higher than that of flour blends (FUH_{5–20}) with UWB and UWG. Dough produced from flour blend (FH₁₅) enriched with 15 g/100 g HWB and 3 g/100 g HWG recorded the highest significant ($P \leq 0.05$) C2 values. This effect could be attributed to the difference in glutenin to gliadin content in these fractions, where protein strength was negatively related to gliadin extent while positively to glutenin which is responsible for the elasticity and strengthen behavior of gluten (Singh et al. 2011). Incorporating wheat germ and wheat bran into WWF replaced some of these proteins with albumin and globulin proteins from the outer layer, and increases the C2 values (Banu et al. 2012; Ortolan and Steel 2017).

The second phase of the Mixolab curves shows the starch pasting properties of dough under mixing and heating constraints. C3 indicates the starch gelatinization ability. Data in Table 2 showed that the unheated dough samples had lower significant ($P \leq 0.05$) C3 values (Nm) compared with the control WWF dough and their counterparts; except for (FUH₅) dough with 5 g/100 g UWB and 3 g/100 g UWG, a value same to that of the white wheat dough. These lower values are an indication of a reduction in starch available for gelatinization process, as soluble fibers of the germ and bran competing with starch for water absorption, limiting the gelatinization process. Besides, a general reduction in starch content, as replaced with germ and bran (Rosell et al. 2007; Nandeesh et al. 2011; Wang et al. 2017a, b). However, there was no significant difference ($P \leq 0.05$) in C3 values between the

WWF dough and the HWB and HWG dough samples (FH_{10–20}); except of flour blend (FH₅) with 5 g/100 g HWB and 3 g/100 g HWG, a value is lower to that of the WWF dough. These effects may ascribe by the presence of pre-gelatinized starch in the heated germ and bran, as thermal treatment partially inactivates the glutathione and produce different degrees of the starch gelatinization (Wang et al. 1993; Paucean et al. 2016).

C4 indicates the stability of the hot gel formed under different Mixolab constraints. The C4 (Nm) values showed a significant ($P \leq 0.05$) downward in dough samples with UWB and UWG in compared to WWF dough and their counterparts. Similar results were described by Banu et al. (2012) who stated that bran contains a large quantity of α -amylases the cause of the reduction of the C4 values. However, dough samples with HWB and HWG had the highest significant ($P \leq 0.05$) C4 values that indicate the higher stability of their hot-formed gel or the higher ability of their starches to resist amylosis. This effect might be motivated by the inactivation of α -amylase after roasting or dry heat treatment (Jacobs et al. 2016).

C5 reflects starch retrogradation. The dough samples (FUH_{5–20}) with UWB and UWG showed a significant ($P \leq 0.05$) decrease in C5 (Nm) values compared with WWF dough and their counterparts (FH_{5–20}). These data correspond with the result of Liu et al. (2017). This behavior can be explained by two factors. The first, wheat germ and wheat bran had higher lipid contents compared to WWF (Table 1), causing changes in the reassociation and recrystallization of the amylose molecules and forming V-type amylose–lipid complex that reduces starch retrogradation (Singh et al. 2010; Banu et al. 2012). The second, the relative content of starch declines with the addition of wheat germ and wheat bran levels (Wang et al. 2017a, b). However, the dough samples (FH_{5–20}) with HWB and HWG showed the highest significant ($P \leq 0.05$) C5 (Nm) values with fixed trend even with increased levels of HWB. This effect suggests that heat treatment changed the nature of the protein, starch and pentosans might stiffen to a highly rigid gel at the cooling phase (Bucella et al. 2017).

The influence of dry heat treatment of wheat bran and wheat germ on sensory acceptability of FB loaves

Table 3 represents the sensory acceptability scores of FB loaves. Data showed no significant differences ($P \leq 0.05$) between samples in terms of crust color scores. However, FB loaves showed significant differences ($P \leq 0.05$) in appearance, texture, and shape symmetry scores, as affected by the dark crumb color of FB loaves with wheat bran and wheat germ that may not be appealing to the

Table 3 Sensory acceptability scores of fino bread loaves

Bread	Crust color (9)	Crumb appearance (9)	Texture (9)	Taste (9)	Flavor (9)	Shape symmetry (9)	OAA (9)
WWB	8.8 ± 0.36 ^a	8.8 ± 0.41 ^a	8.7 ± 0.41 ^a	8.3 ± 0.82 ^{ab}	8.2 ± 0.75 ^{ab}	8.6 ± 0.49 ^a	8.6 ± 0.47 ^a
BUH ₅	8.6 ± 0.45 ^a	8.7 ± 0.44 ^a	8.5 ± 0.79 ^a	8.3 ± 0.82 ^{ab}	8.0 ± 0.74 ^{ab}	8.6 ± 0.45 ^a	8.6 ± 0.55 ^a
BH ₅	8.1 ± 0.49 ^a	8.5 ± 0.47 ^{ab}	8.6 ± 0.81 ^a	8.4 ± 0.49 ^{ab}	8.5 ± 0.56 ^a	8.6 ± 0.49 ^a	8.5 ± 0.45 ^a
BUH ₁₀	8.3 ± .55 ^a	8.0 ± 0.65 ^{bc}	8.2 ± 0.46 ^b	8.0 ± 0.55 ^b	7.5 ± 0.62 ^b	8.1 ± 0.47 ^{ab}	7.5 ± 0.64 ^{bc}
BH ₁₀	8.3 ± 0.59 ^a	8.3 ± 0.77 ^{abc}	8.3 ± 0.42 ^b	8.9 ± 0.41 ^a	8.7 ± 0.52 ^a	8.3 ± 0.58 ^{ab}	8.0 ± 0.77 ^{ab}
BUH ₁₅	8.0 ± 0.73 ^a	7.4 ± 0.63 ^d	7.9 ± 64 ^c	7.5 ± 0.41 ^{cb}	7.4 ± 0.62 ^b	7.9 ± 0.60 ^{ab}	7.5 ± 0.60 ^{bc}
BH ₁₅	8.0 ± 0.79 ^a	8.0 ± 0.62 ^{bc}	8.1 ± 0.58 ^c	8.8 ± 0.49 ^a	8.7 ± 0.52 ^a	8.0 ± 0.63 ^{ab}	8.0 ± 0.59 ^{ab}
BUH ₂₀	8.0 ± 0.88 ^a	7.2 ± 0.62 ^d	7.4 ± 65 ^d	7.3 ± 0.45 ^c	7.0 ± 0.60 ^b	7.0 ± 0.40 ^b	7.3 ± 0.67 ^c
BH ₂₀	8.0 ± 0.95 ^a	7.6 ± 0.65 ^c	8.1 ± 0.66 ^c	8.5 ± 0.49 ^a	8.5 ± 0.48 ^a	7.3 ± 0.41 ^b	7.8 ± 0.64 ^b

WWB, fino bread with white wheat flour; BUH, fino bread enriched with unheated wheat bran and unheated wheat germ; BH, fino bread enriched with heated wheat bran and heated wheat germ, heated and unheated bran levels 5, 10, 15 and 20 g/100 g, heated and unheated wheat germ level 3 g/100 g

OAA overall acceptability

Data are presented as means ± SDM (n = 35, a 9-point hedonic scale) and means within a column with different letters are significantly different at $P \leq 0.05$

consumers, besides their greater firmness and lower cohesiveness (Table 4). These differences could be due to the gluten dilution and the glutathione activity as reported by Majzoobi et al. (2012). Dry heat treatment significantly improved the taste and flavor of FB, especially levels (BH₁₀ and BH₁₅) of 10 and 15 g/100 g HWB with 3 g/100 g HWG. This improvement is due to Millard reaction formation during heat process, besides the sweetness and the pleasant flavor of the treated germ (Srivastava et al. 2007; Majzoobi et al. 2012).

For the OAA, the control white wheat FB, gave the highest significant ($P \leq 0.05$) score, however, the FB loaves (BUH_{10–20}) contained UWB and UWG had the lowest significant ($P \leq 0.05$) scores. The FB loaves (BH_{5–15}) contained, HWB and HWG showed high acceptability up to 15 g/100 g HWB and 3 g/100 g HWG. Although the OAA scores of FB loaves (BH₂₀) made from 20 g/100 g HWB and 3 g/100 g HWG had the lowest scores, but they were not precisely low, they are still slightly acceptable (higher than five, the midpoint of the scale are).

Ertaş (2016) fortified flat bread with the hot-air stabilized wheat bran at 10% level it gives the best sensory properties such as color/appearance, taste/flavor, and overall acceptability. In addition, Majzoobi et al. (2012) found that toasted wheat germ at 5% had positive effects on flat bread taste and general acceptability. However, Hemdane et al. (2016) reviewed that adding bran to flour results in unwanted effects on color, texture, and taste. These adverse effects increase with higher levels of wheat flour substitution by bran.

The influence of dry heat treatment of wheat bran and wheat germ on physical characteristics of FB loaves

Table 4 and Fig. 1 display the physical characteristics of FB loaves. Data showed significant ($P \leq 0.05$) decrease in FB loaf volumes (cm³) with UWB and UWG, specifically, of levels 15 and 20 g/100 g (BH₁₅ and BH₂₀), showed a significant ($P \leq 0.05$) fall in their volumes. These results are consistent with the results from de Kock et al. (1999), Majzoobi et al. (2012) and Onipe et al. (2015). This effect was due to the higher IDF of wheat bran and wheat germ that may compete for water with gluten and disrupts the gluten network, which decreases the bread loaf volumes. Besides, the activities of the glutathione and the lipase present in bran and germ, lead to an accumulation of predominant components, reduction in the dough cohesive molecular forces, catalyzing disulphide linkage, and decreases loaf volumes (Cai et al. 2014; Ertaş 2016; Hemdane et al. 2016). However, the HWB and HWG showed no significant ($P \leq 0.05$) changes in FB loaf volumes up to a level (BH_{5–10}) of 10 g/100 g. This effect was because the dry heat treatment inactivates lipase (Table 1) and glutathione that might force gas cells to expand in a particular dimension at the lower proportion of bran (Majzoobi et al. 2012; Hemdane et al. 2016). While, at levels of 15 and 20 g/100 g (BH₁₅ and BH₂₀), showed a significant decrease in FB loaf volumes, as the dry heat treatment cannot compensate the effect of higher levels of HWB and HWG on the pierce of gas cells, and, hence, resulted in diminished gas retention in the dough and lower bread volume (Hemdane et al. 2016). The HWB and HWG

Table 4 Physical characteristics of fino bread loaves

Bread	Loaf volume (cm ³)	L*	a*	b*	Firmness (N)	Cohesiveness	Gumminess (N)	Chewiness (N)
WWB	366.67 ± 40 ^a	83.95 ± 3.1 ^a	−1.57 ± 0.62 ^h	16.88 ± 2.2 ^f	8.48 ± 0.2 ^e	1.14 ± 0.08 ^a	9.84 ± 0.69 ^d	4.02 ± 0.27 ^f
BUH ₅	283.67 ± 35 ^b	79.96 ± 3.3 ^{ab}	−1.01 ± 0.54 ^g	21.45 ± 0.95 ^{de}	11.94 ± 0.5 ^d	0.69 ± 0.01 ^{bc}	8.16 ± 0.71 ^e	4.03 ± 0.25 ^f
BH ₅	356.67 ± 20 ^a (increase 73 cm ³)	77.62 ± 2.2 ^b	−0.77 ± 0.04 ^f	22.24 ± 0.84 ^d	11.89 ± 0.6 ^d	0.78 ± 0.01 ^b	9.55 ± 0.1 ^d	4.00 ± 0.03 ^f
BUH ₁₀	276.55 ± 40 ^b	78.55 ± 2.4 ^b	0.26 ± 0.04 ^{de}	22.99 ± 0.09 ^d	17.01 ± 0.2 ^b	0.62 ± 0.02 ^c	10.27 ± 0.5 ^c	6.17 ± 0.05 ^d
BH ₁₀	334.67 ± 18 ^{ab} (increase 58.1 cm ³)	75.77 ± 0.08 ^c	0.29 ± 0.05 ^d	23.66 ± 0.03 ^c	13.18 ± 1 ^c	0.71 ± 0.01 ^b	9.78 ± 0.11 ^d	4.68 ± 0.04 ^e
BUH ₁₅	255.24 ± 26 ^c	75.0 ± 0.22 ^c	1.49 ± 0.04 ^c	25.33 ± 0.05 ^c	20.73 ± 0.1 ^{ab}	0.56 ± 0.02 ^d	11.77 ± 0.55 ^b	7.44 ± 0.15 ^b
BH ₁₅	291.67 ± 34 ^b (increase 36.4 cm ³)	74.67 ± 0.25 ^c	1.84 ± 0.08 ^b	26.44 ± 0.04 ^b	15.2 ± 1.1 ^c	0.77 ± 0.01 ^b	11.86 ± 0.12 ^b	6.14 ± 0.14 ^d
BUH ₂₀	188.83 ± 65 ^d	73.67 ± 2.1 ^d	1.69 ± 0.23 ^{bc}	27.14 ± 0.44 ^b	23.73 ± 0.1 ^a	0.49 ± 0.1 ^c	12.77 ± 0.12 ^a	8.99 ± 0.65 ^a
BH ₂₀	276.67 ± 42 ^b (increase 87.8 cm ³)	72.63 ± 1.7 ^c	2.01 ± 0.28 ^a	28.02 ± 0.47 ^a	19.1 ± 0.1 ^b	0.57 ± 0.1 ^d	11.48 ± 0.55 ^c	6.74 ± 0.55 ^c

L* = lightness (zero = black, 100 = white), a* (− a* = greenness, + a* = redness) and b* (− b* = blueness, + b* = yellowness)

WWB, fino bread with white wheat flour; BUH, fino bread enriched with unheated wheat bran and unheated wheat germ; BH, fino bread enriched with heated wheat bran and heated wheat germ; heated and unheated bran levels 5, 10, 15 and 20 g/100 g, heated and unheated wheat germ level 3 g/100 g

Data are presented as means ± SDM (n = 3) and means within a column with different letters are significantly different at $P \leq 0.05$

produced FB loaves that were 36.43–87.84 cm³ larger in volume than untreated-counterparts, showing the positive effect of the dry heat treatment of wheat bran and germ on the bread baking quality.

There was a significant ($P \leq 0.05$) decrease in lightness values and a significant ($P \leq 0.05$) increase in yellowness and redness values of FB crumb loaves contained, UWB, UWG, HWB, and HWG. Wherein, the HWB and HWG showed higher significant ($P \leq 0.05$) changes in crumb color values than UWB and UWG values, especially with the steady increase of their levels. These results are in agreement with the findings of of Ertaş (2016), Gajula (2017) and Wang et al. (2017a, b). These changes in crumb color of FB loaves were due to the potential color of wheat germ and wheat bran and their fiber contents (Gómez et al. 2012; Nandeesh et al. 2011). Besides, the dry heat treatment destroys carotenoids and forms Millard brown pigments that may increase the darkness and redness of the heated fractions and in turn, affects the crumb color of the bread (Majzoobi et al. 2012; Wang et al. 2017a, b).

FB contained wheat germ and wheat bran showed a significant ($P \leq 0.05$) increase in firmness, and gumminess, and a significant ($P \leq 0.05$) decrease in cohesiveness, especially with the steady increase of wheat bran levels. Chewiness also showed a significant ($P \leq 0.05$) increase, except for BUH₅ and BH₅ the values were the same of control (WWB). However, the HWB and HWG showed lesser significant ($P \leq 0.05$) changes in the texture of FB than the unheated fractions. These results confirm the validity of this trend with those of Nandeesh et al. (2011), Majzoobi et al. (2012), Cai et al. (2014), Gajula (2017) and Wang et al. (2017a, b). Gluten protein plays a significant role in bread texture and volume (Singh et al. 2011). Therefore, adding wheat bran and wheat germ may reduce the amount of gluten in the dough, lead to a harder bread texture (Majzoobi et al. 2012). Liu et al. (2017) indicated that the firmness, gumminess, and chewiness correlate to the degree of starch gelatinization. Therefore, adding wheat bran and wheat germ may disrupt the reaction between starch and protein, resulting in FB loaves being firmer, chewy, and gummy. The change in cohesiveness of bread loaves is because of the decreased loaf volumes and the increased average cell wall thickness and air cell size led to reduction in the dough cohesive molecular forces and poor texture quality (Wang et al. 2017a, b).

The influence of dry heat treatment of wheat bran and wheat germ on the nutritional quality of FB

Table 5 presents the nutritional quality of FB samples. Data showed no significant differences ($P \leq 0.05$) between white FB and FB enriched with heated and unheated fractions, in terms of moisture contents. However, FB

Fig. 1 Fino Bread Loaves. **a** WWB- fino bread with white wheat flour of 72 g/100 g extraction rate; **b** BUH₅- fino bread with 5 g/100 g unheated bran and 3 g/100 g unheated germ; **c** BH₅- fino bread with 5 g/100 g heated bran and 3 g/100 g heated germ; **d** BUH₁₀- fino bread with 10 g/100 g unheated bran and 3 g/100 g unheated germ; **e** BH₁₀- fino bread with 10 g/100 g heated bran and 3 g/100 g heated germ; **f** BUH₁₅- fino bread with 15 g/100 g unheated bran and 3 g/100 g unheated germ; **g** BH₁₅- fino bread with 15 g/100 g heated bran and 3 g/100 g heated germ; **h** BUH₂₀- fino bread with 20 g/100 g unheated bran and 3 g/100 g unheated germ; **i** BH₂₀- fino bread with 20 g/100 g heated bran and 3 g/100 g heated germ

enriched with heated and unheated fractions had higher significant ($P \leq 0.05$) contents of crude protein, crude fat, ash, SDP, IDP and TDF, than white FB. Moreover, no significant differences ($P \leq 0.05$) were observed between FB enriched with heated and unheated fractions in the above-mentioned values.

More crude protein may improve the nutritional quality of the FB, wherein, wheat bran and wheat germ are rich sources of proteins with balanced amino acids, especially, lysine, methionine, and threonine (Majzoobi et al. 2012; Demir and Elgün 2014). More crude fat indicates FB being more palatable, with condensed source of energy. More ash means more mineral content (Ertaş 2016).

Data in Table 5 showed that the TDF provided about (9.0–21.5%) and (9.3–23.3%) of the DFI for the adult from FB enriched with heated and unheated fractions, respectively (calculated as 30 g/day). The recommended dietary fiber intake (DFI) are not the same in all countries, it depends on the energy consumed, and a fiber intake of 25 to 40 g/day is desirable in adults (EFSA 2010).

Dietary fibers have many health benefits including pre-biotic activity, modulate hunger and satiety moods, and influence the glycemic and lipidic indexes. Besides reducing the risk of inflammations, obesity, type 2 diabetes, cardiovascular disease, and some types of cancers; especially colorectal cancer (Hemdane et al. 2016).

The phytic acid contents ranged from 116.57 to 1045 mg/100 g in different FB samples. FB enriched with HWB, HWG, UWB, and UWG had higher significant ($P \leq 0.05$) phytic acid contents compared with white FB. The increased level of wheat bran led to proportionate increases in phytic acid content. These results are in agreement with the findings of García-estepa et al. (1999), Demir and Elgün (2014) and Ertaş (2016). However, FB enriched with HWB and HWG showed significant loss of phytic acid contents from 30 to 34% than their counterparts did.

Phytic acid is the major abundant dietary factor mainly present in the bran and germ of the wheat kernel that inhibits the mineral absorption and their bioavailability (García-estepa et al. 1999). Demir and Elgün (2014) and

Table 5 Nutritional quality of fino bread

Samples	Moisture (g/100 g)	Crude protein (g/100 g)	Crude fat (g/100 g)	Ash (g/100 g)	SDF (g/100 g)	IDF (g/100 g)	TDF (g/100 g)	PA (mg/100 g)	TPC (mg/100 g)	AOA* (%)
WWB	39.06 ± 0.01 ^a	9.14 ± 0.01 ^c	5.91 ± 0.06 ^c	1.18 ± 0.01 ^e	0.25 ± 0.14 ^c	1.46 ± 0.24 ^e	1.71 ± 0.06 ^c (5.7% DFI)	116.57 ± 1 ^b	80.1 ± 0.08 ^e	15.0 ± 1.5 ^f
BUH ₅	39.06 ± 0.14 ^a	9.19 ± 0.01 ^{bc}	6.18 ± 0.12 ^d	1.37 ± 0.01 ^d	0.24 ± 0.04 ^c	2.55 ± 0.13 ^d	2.79 ± 0.09 ^d (9.3% DFI)	269.99 ± 4.1 ^f	92.31 ± 0.5 ^c	20.44 ± 2 ^f
BH ₅	39.05 ± 0.01 ^a	9.28 ± 0.01 ^{bc}	6.36 ± 0.11 ^d	1.45 ± 0.01 ^d	0.28 ± 0.03 ^c	2.43 ± 0.07 ^d	2.71 ± 0.11 ^d (9% DFI)	183.59 ± 4.3 ^g (32% loss)	109.2 ± 0.48 ^d	40.17 ± 2 ^c
BUH ₁₀	39.03 ± 0.01 ^a	9.45 ± 0.02 ^b	6.95 ± 0.15 ^c	1.49 ± 0.01 ^c	0.42 ± 0.11 ^b	4.01 ± 0.1 ^c	4.43 ± 0.1 ^c (14.8% DFI)	447.94 ± 6 ^e	126.44 ± 0.8 ^d	25.23 ± 1.5 ^e
BH ₁₀	39.02 ± 0.04 ^a	9.48 ± 0.01 ^b	7.3 ± 0.05 ^c	1.54 ± 0.01 ^c	0.44 ± 0.05 ^b	3.55 ± 0.08 ^c	3.99 ± 0.17 ^c (13.3% DFI)	295.64 ± 4.6 ^f (34% loss)	146.9 ± 0.77 ^c	43.46 ± 1 ^b
BUH ₁₅	38.98 ± 0.06 ^a	10.51 ± 0.28 ^a	7.48 ± 0.11 ^b	1.57 ± 0.01 ^b	0.60 ± 0.09 ^a	4.95 ± 0.1 ^b	5.55 ± 0.23 ^b (18.5% DFI)	956.82 ± 6 ^b	137.15 ± 2 ^c	32.73 ± 1 ^d
BH ₁₅	38.94 ± 0.07 ^a	10.58 ± 0.31 ^a	7.65 ± 0.06 ^b	1.62 ± 0.01 ^b	0.61 ± 0.08 ^a	4.63 ± 0.11 ^b	5.24 ± 0.25 ^b (17.5% DFI)	631.5 ± 9 ^d (34% loss)	156.2 ± 3.32 ^b	43.85 ± 1.5 ^b
BUH ₂₀	39.04 ± 0.01 ^a	9.30 ± 0.01 ^{bc}	8.53 ± 0.06 ^a	1.72 ± 0.02 ^a	0.69 ± 0.09 ^a	6.34 ± 0.2 ^a	7.0 ± 0.1 ^a (23.3% DFI)	1045 ± 9 ^a	161.95 ± 2.2 ^b	39.83 ± 1 ^c
BH ₂₀	39.08 ± 0.15 ^a	9.39 ± 0.15 ^{bc}	8.71 ± 0.05 ^a	1.87 ± 0.02 ^a	0.77 ± 0.11 ^a	5.69 ± 0.15 ^a	6.46 ± 0.09 ^a (21.5% DFI)	731.51 ± 9 ^c (30% loss)	198.2 ± 2.04 ^a	47.46 ± 0.5 ^a

SDF, soluble dietary fiber; IDF, insoluble dietary fiber; TDF, total dietary fiber; DFI, dietary fiber intake calculated as 30 g/day for adults; PA, phytic acid; TPC, total phenolic contents expressed as milligrams of Gallic acid equivalents (GAE); AOA, antioxidant activity—*calculated as percent discoloration of 2,2-diphenyl-1-picrylhydrazyl (DPPH); WWB, fino bread with white wheat flour; BUH, fino bread enriched with unheated wheat bran and unheated wheat germ; BH, fino bread enriched with heated wheat bran and heated wheat germ, heated and unheated bran levels 5, 10, 15 and 20 g/100 g, heated and unheated wheat germ level 3 g/100 g

Data are presented as means ± SDM (n = 3) and means within a column with different letters are significantly different at $P \leq 0.05$

Ertaş (2016) developed several thermal methods, e.g. hot air oven, autoclave, microwave, infrared and ultraviolet-C, to lower phytic acid in wheat bran during bread making. The authors found that, the bread contained, treated bran with hot air oven showed lower loss of phytic acid than the other thermal methods. Probably, dry heating or roasting is a mild process than the other excessive mechanical treatments (Siljeström et al. 1986), also phytic acid is relatively heat stable, for its destruction; the prolonged or excessive thermal process can be applied effectively (Ertaş 2016). This may support our results regarding the loss of phytic acid by only 30 to 34% after the dry heating process.

Table 5 shows the TPC, mg GAE/100 g and the AOA of different FB samples. The TPC of FB ranged between 80.1 and 198.2 mg GAE/100 g. FB enriched with heated and unheated fractions had higher significant ($P \leq 0.05$) TPC contents than white FB, especially with increased levels of wheat bran. This significant difference ($P \leq 0.05$) is due to that the phenolic compounds are concentrated in the bran and germ fractions of wheat that are removed during the milling of wheat into white flour (Vaher et al. 2010). FB enriched with heated fractions had higher significant ($P \leq 0.05$) TPC contents than their counterparts did. Probably, the dry heat process disrupts the bound phenolic compounds from the cellular constituents and the cell walls which can improve their bioaccessibility and bioavailability (Rose et al. 2008; Demir and Elgün 2014; Wang et al. 2017a, b).

The AOA of different FB samples varied between 15.0 and 47.46%. Otherwise, the AOA of different FB samples underwent the same significant ($P \leq 0.05$) patterns of the TPC. These significant ($P \leq 0.05$) patterns indicate that the FB samples may exhibit different levels of AOA. In addition, FB with a higher content of the TPC possesses higher AOA. These results are in agreement with the values of García-estepa et al. (1999), and with Vaher et al. (2010) who stated that phenolic compounds have antioxidant activities, their TP content significantly associated with different measures of antioxidant activity including DPPH scavenging capacity. Other reasons could be due to form Millard reaction products with antioxidant activities, besides their higher phytic acid contents, where it is evident that, phytic acid has good antioxidant properties (Demir and Elgün 2014).

Conclusion

The effect of combining thermally-treated wheat bran at 5, 10, 15, and 20 g/100 g proportions, and thermally-treated wheat germ at 3 g/100 g proportion, on rheological behavior and quality attributes of FB was examined, against FB containing untreated wheat bran and untreated

wheat germ, and white wheat bread. The thermal treatment indicated minimal implications in the chemical constituents and the dietary fiber contents of wheat bran and wheat germ; however, it was efficient in inactivating lipase enzyme by half in wheat bran, and by 100% in wheat germ. Fino batter containing thermally-treated particles, reduced the percentage of water required for the dough consistency, prolonged the time to reach the maximum torque, showed stability during heating with good proteins, and starch characteristics. Fino loaves containing treated particles had bigger volumes, reduced luminosity, and less hard and crumbly texture. Sensory hedonic scores of FB loaves containing treated particles, showed significant ($P \leq 0.05$) enhance in the taste and flavor, and high OAA. FB met up to 21.5% of the dietary fiber intake (DFI) proposed for the adults, reduced phytic acid content, had significant ($P \leq 0.05$) TPC, and discoloration activity. The proportions of 10 and 15 g thermally-treated wheat bran with 3 g thermally-treated wheat germ exhibited proper results for all studied parameters. Thermal stabilization could be implemented on wheat bran and wheat germ to moderate their negative effects on dough rheology, and to convey functional FB to consumers, with more dietary fibers, and high-dense nutrients and antioxidant effects.

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