AgroLife Scientific Journal - Volume 8, Number 2, 2019
ISSN 2285-5718; ISSN CD-ROM 2285-5726; ISSN ONLINE 2286-0126; ISSN-L 2285-5718

INFLUENCE OF GINGER POWDER ON DOUGH RHEOLOGICAL PROPERTIES AND BREAD QUALITY

Iuliana APRODU, Lavinia ŞERBAN, Iuliana BANU

Dunărea de Jos University of Galaţi, Faculty of Food Science and Engineering, Domnească Street 111, 800201, Galaţi, Romania

Corresponding author email: iuliana.banu@ugal.ro

Abstract

In this study the rheological properties of wheat flour dough with different levels of ginger powder (0, 2, 4 and 6%) were investigated. Mixolab and Alveograph devices were used for evaluating the rheological properties of the dough. The bread making test was further performed, and the specific volume, firmness, sensorial analysis, phenolic contents and radical scavenging activity were determined for breads characterization. The increase of addition level of ginger into wheat flour impacted the water absorption, dough development time, stability and dough resistance to deformation. Moreover, the starch gelatinization, stability of the gel during heating and starch retrogradation after dough cooling decreased with the increase of the levels of wheat flour substitution by ginger. Lower specific volume and higher crumb firmness were obtained for breads with higher levels of ginger. Among the investigated samples the highest total phenol contents and radical scavenging activity were registered for bread with 6% ginger.

Key words: *wheat flour, ginger, Mixolab, alveograph, bread.*

INTRODUCTION

The flour made in low extraction rate has lower amounts of nutrients because of their removal during milling process. Thus, the white wheat flour has low contents in proteins, vitamins, minerals, fibers and phenolic compounds that are considered the main functional antioxidants (Dewettinck, 2008). According to Hung et al. (2009), the white flour has three times lower antioxidant activity than wholemeal flour. The most applied methods used for improving the antioxidant activity of wheat bread are those based on use of cereal by-products, pseudo-cereals and other cereal sources (Dziki et al., 2014). In recent years, in order to improve the health benefits of white wheat bread, different herbs and spices were included in the white bread recipe (Dziki et al., 2014; Ibrahim et al., 2015). Coriander, turmeric and ginger are the most important herbs and spices that were used in order to improve the functional profile of bread, especially due to the antioxidant compounds presents in these ingredients.

Ginger is an important spice originating from Asia, used over 2000 years. In recent years ginger rhizomes were increasingly used in the United States of America and Europe (Ibrahim et al., 2015; Stoilova et al., 2007) as fresh or preserved product, powder or oils and oleoresins (Balestra et al., 2011). Besides using the ginger to obtain ginger cakes, a traditional food in Central Europe (Penas et al., 2013; Zielinski et al., 2010), the powder of this herb can be used as ingredient in white wheat bread, but also for preparing vegetarian and non-vegetarian food, soft drinks, confectioneries and curry (Balestra et al., 2011; Crassina and Sudha, 2015; Martinez-Villaluenga et al., 2009). Ginger is appreciated for the pungency property that is mainly due to the gingerols found in ginger and to the shogaols that result during thermal processing through dehydration of gingerol (Balestra et al., 2011). Additionally, ginger has antioxidant, anti-inflammatory, antibacterial and anti-apoptotic properties (Balestra et al., 2011; Malu et al., 2009; Stoilova et al., 2009). According to Parthasarathy et al. (2008) quoted by Przygodzka et al. (2014), the chemical constituents with antioxidant capacity in ginger are: α-zingiberene, geranial, geraniol, β-bisabolene, nerol, 1.8-cineol, α-terpineol, borneol, β-phellandrene, linalool,methyl nonyl ketone, camphene.

The aim of the present study was to investigate the effect of ginger powder addition on rheological properties of white wheat flour dough and bread characteristics. The rheological properties were investigated with Mixolab and Alveograph devices, while the breads were analyzed in terms of physical characteristics, phenolic contents and antioxidant properties.

MATERIALS AND METHODS

Materials

Commercial white wheat flour and ginger powder purchased in the local market (Galaţi, Romania) were used in the study. In order to evaluate the effect of ginger powder addition on rheological properties of white wheat flour dough and on bread making properties, different blends were obtained by replacing 2, 4 and 6% of the white wheat flour by ginger powder.

Physical and chemical characteristics

Analysis of the physical and chemical characteristics of white wheat flour and ginger powder were performed as follow: moisture content using the method SR EN ISO 712: 2005 (ASRO, 2008), ash content using the method SR ISO 2171: 2002 (ASRO, 2008), protein content using the semimicro-Kjeldahl method (Aprodu and Banu, 2015), fat content using the Soxhlet method (Aprodu and Banu, 2015), wet gluten using the method SR ISO 21415-2: 2007 (ASRO, 2008), crude fiber using Fibretherm Analyser (C. Gerhardt GmbH & Co. KG, Germany), and Zeleny sedimentation using the method SR ISO 5529: 1997 (ASRO, 2008).

In order to measure the colour parameters, such as brightness value (L*), redness value (a*) and yellowness value (b*) of the flour blends, the Chroma Meter CR-410 (Konica Minolta Business Solutions Europe GmbH) was used. Additionally, the hue angle (h°) was calculated according to Kane et al. (2003).

Rheological properties

The rheological characteristics of dough were tested using Chopin Mixolab device (Chopin Technologies, Villeneuve La Garenne, France) with the Chopin+ and Simulator protocols, according to Dubat and Boinot (2012) and using NG Chopin Alveograph device, according to SR ISO 5530-4:2005 (ASRO, 2008). The main Mixolab parameters recorded when running the Chopin+ protocol were: water absorption (WA, %) required for a torque of 1.1 ± 0.05 Nm (C1), protein weakening when the dough is knead and heated (C2, Nm), starch gelatinization (C3, Nm), stability of the gel during heating (C4, Nm), starch retrogradation after the cooling of dough (C5, Nm) (Dubat and Boinot, 2012). The parameters registered from the Simulator curves were: development time (DT, min), stability (S, min) and weakening (Wk, Nm) (Dubat and Boinot, 2012). The following Alveograph parameters were recorded: maximum over pressure (P, mm), average abscissa at rupture (L, mm), deformation energy of dough (W, 10^{-4} x J) and curve configuration ratio (P/L) (SR ISO 5530-4:2005) (ASRO, 2008).

Bread making procedure

The one stage method was used for dough preparation (Banu et al., 2010). In order to prepare the dough, the white wheat flour was blended with ginger powder (2, 4, 6%), water (function of the water absorption capacity measured by Mixolab), salt (1.5%) and compressed yeast (*Saccharomyces cerevisiae*) (3%), were mixed in a mixing device (HR7915; Philips, Shanghai, China). After fermentation for 150 min at 30°C, the dough was divided in two pieces, molded and placed in baking trays. The samples were then proofed for 30 min at 30°C, and finally were baked for 30 min at 230°C (Micro 4T, Mondial Forni, Italy).

Bread characterization

After cooling for 2 h at ambient temperature (22 ± 1°C) the bread samples were characterized in terms of specific volume, hardness of the bread crumb, total phenolic contents and antioxidant activity.

The specific volume of the bread (cm^3/100 g of bread) was measured using the rapeseed displacement method (SR 91: 2007) (ASRO, 2008).

The hardness of the bread crumb was determined using MLFTA apparatus (Guss, Strand, South Africa) and a 7.9 mm diameter probe. Two different slices taken from the center of every sample and a 25 mm wide penetration of the bread slices at a testing speed of 5 mm/s with a trigger threshold force of 1.96

N were considering. For every slice three measurements were made.
The phenols were extracted from the samples with acidified methanol, and the total phenolic content (TFC) of the extracts was estimated using the Folin Ciocalteu method described by Singleton and Rossi (1965) and modified by Gao et al. (2002). Ferulic acid was used as standard, and the results were expressed as mg ferulic acid equivalent (FAE) per g dry weight.
For measuring the 2.2-diphenyl-1-picrylhydrazyl radical scavenging activity (DPPH-RSA) the extraction was performed with ethanol according to the procedure described by Dordevic et al. (2010). DPPH-RSA was measured using the method of Brand-Williams et al. (1995) and modified by Beta et al. (2005).

Sensorial analysis
The bread samples were evaluated for following sensorial descriptors: appearance, texture, taste and overall acceptability. The sensory evaluation was performed using a 9-point hedonic scale (from 0 - lowest intensity to 9 - highest intensity) by a panel of 10 judges familiarized with the sensory descriptors and their intensities.

Statistical analysis
All experiments were carried out in triplicate and mean values were reported together with standard deviations (SD). Analysis of variance was used to identify significant differences. Statistical relationships were established by calculating Pearson's correlation coefficients. The differences were quantified using one-way ANOVA and Tukey's test with a 95% confidence interval, after assessing the normality and variance equality conditions. The coefficients of determination between different parameters ($p<0.05$) were also calculated using Microsoft Excel software.

RESULTS AND DISCUSSIONS

Physical-chemical characteristics of wheat flour and ginger powder
The chemical composition of wheat flour and ginger powder is presented in Table 1. The wheat flour used in the experiment had protein content of 8.27%, ash content of 0.57% and sedimentation index of 32 ml. Compared to the wheat flour, the ginger powder used in the experiment had significantly higher ash (6.35%), fat (9.34%) and crude fiber (7.12%) contents.

Table 1. Physical and chemical characteristics of wheat flour and ginger powder

Characteristics	Wheat flour	Ginger powder
Moisture, %	12.5 ± 0.07	12.7 ± 0.07
Ash, %	0.57 ± 0.01	6.35 ± 0.01
Protein, %	8.27 ± 0.08	10.07 ± 0.10
Fat, %	1.34 ± 0.06	9.34 ± 0.06
Crude fiber, %	2.09 ± 0.06	7.12 ± 0.06
Wet gluten, %	28.88 ± 0.17	-
Sedimentation index, ml	32 ± 0.71	-

The colour parameters (L*, a* and b* values) of the blends varied significantly with the level of ginger powder added to the wheat flour ($p<0.05$). The addition of 6% ginger powder to the wheat flour resulted in the decrease of L* value from 99.43 to 93.96, while the b* value increased from 14.30 to 17.97. The a* value varied from negative value for wheat flours to positive value for the blend with 6% ginger powder (Table 2). Regarding the colour hue (h°) and saturation (C*), these values increased with addition of ginger powder to the wheat flour (Table 2), suggesting the capacity of ginger powder to confer a brownish colour to the wheat flour.

Table 2. Colour properties of the wheat flour (WF) supplemented with different percentages of ginger powder (G)

Propertie	WF	WF + 2%G	WF + 4%G	WF + 6%G
L*	99.43 ± 0.10^a	98.97 ± 0.10^b	96.01 ± 0.07^c	93.96 ± 0.13^d
a*	-1.27 ± 0.01^d	-0.60 ± 0.01^c	-0.23 ± 0.01^b	0.09 ± 0.00^a
b*	14.30 ± 0.11^d	16.07 ± 0.08^c	16.89 ± 0.09^b	17.98 ± 0.04^a
C*	14.35 ± 0.11^d	16.08 ± 0.08^c	16.89 ± 0.09^b	17.98 ± 0.04^a
h°	84.95 ± 0.01^d	87.88 ± 0.04^c	89.24 ± 0.03^b	89.71 ± 0.00^a

Means on the same row that do not share a letter are significantly different at $p<0.05$.

Effect of ginger powder addition on the dough rheology of wheat flour
The effect of ginger powder addition on the rheology of wheat flour dough was investigated with Mixolab (Chopin+ and Simulator protocols) and Alveograph devices. The

rheological parameters measured are indicated in Tables 3 and 4.

Table 3. Thermo-mechanical properties of wheat flours (WF) supplemented with different levels of ginger powder (G)

Mixolab parameter	Dough samples			
	WF	WF + 2%G	WF + 4%G	WF + 6%G
Chopin+ protocol				
WA, %	60.4 ± 0.07[d]	61.5 ± 0.07[c]	62.6 ± 0.07[b]	63.3 ± 0.07[a]
C2, Nm	0.46 ± 0.02[a]	0.38 ± 0.02[b]	0.37 ± 0.02[b]	0.33 ± 0.01[b]
C3, Nm	2.06 ± 0.03[a]	1.98 ± 0.02[a,b]	1.91 ± 0.02[b]	1.81 ± 0.01[c]
C4, Nm	1.95 ± 0.02[a]	1.86 ± 0.02[b]	1.79 ± 0.02[b,c]	1.72 ± 0.02[c]
C5, Nm	2.95 ± 0.03[a]	2.82 ± 0.04[b]	2.79 ± 0.03[b]	2.58 ± 0.02[c]
Simulator protocol				
DT, min	2.50 ± 0.02[d]	3.50 ± 0.02[c]	4.00 ± 0.00[b]	4.65 ± 0.00[a]
S, min	3.00 ± 0.02[d]	3.50 ± 0.02[c]	4.00 ± 0.00[b]	5.00 ± 0.00a
Wk, Nm	0.17 ± 0.01[a]	0.16 ± 0.01[a,b]	0.16 ± 0.01[a,b]	0.14 ± 0.00[b]

Means on the same line that do not share a letter are significantly different at p<0.05.

Table 4. Alveograph parameters of wheat flours (WF) supplemented with different levels of ginger powder (G)

Dough sample	P, mm	L, mm	W, 10^{-4} x J	P/L
WF	102 ± 1.41[a]	60 ± 0.71[a]	217 ± 2.83[a]	1.71 ± 0.00[d]
WF + 2%G	91 ± 1.41[b]	49 ± 0.71[b]	161 ± 2.12[b]	1.88 ± 0.06[c]
WF + 4%G	78 ± 1.41[c]	39 ± 0.71[c]	100 ± 1.41[c]	2.03 ± 0.00[b]
WF + 6%G	73 ± 0.71[d]	33 ± 0.71[d]	81 ± 0.71[d]	2.23 ± 0.03[a]

Means on the same column that do not share a letter are significantly different at p<0.05.

The WA needed to obtain dough with consistency of 1.1 ± 0.05 Nm increased from 60.4 to 63.3% with the increase of the addition level of ginger powder to wheat flour (Table 3). These results might be due the high crude fiber content of ginger powder (Rosell et al., 2001; Crassina and Sudha, 2015).
The dough development time (DDT) and dough stability (S) during kneading at 30ºC increased from 2.50 to 4.65 min., and from 3 to 5 min., respectively, with increasing the level of ginger power in the blends. In the same time, the dough weakening during kneading at 30ºC (Wk) slowly decreases from 0.17 to 0.14 Nm, when adding 2-4% of ginger powder to the wheat flour. According to Crassina and Sudha (2015) the high content of fiber can explain the delayed formation of gluten network, while the Balestra et al. (2011) noted that ginger addition caused the rise of the density of cross-links in the dough network. The presence of bioactive compounds from ginger powder such as gingerol, dehydroginger-dione and shogaol having hydroxyl/methoxy phenyl residues and an activated double bond might induce important changes in the dough rheology because of their cross-linking ability (Daramola and Osanyinlusi, 2006).
The value of tenacity (P), extensibility (L) and strength (W) of the dough decreased and the P/L increased with the increase of the level of ginger powder. The high P/L values corresponding to samples with higher amounts of ginger (Table 4) suggest that stronger dough with moderate extensibility (Bordes et al., 2008) were obtained with increasing the level of ginger powder. In their research Balestra et al. (2011) found that the addition of ginger powder (with 8% ash and 4% fat) to the moderately strong wheat flour (W of 240 x 10^{-4} J, 0.65% ash and 12.9% protein) caused the increase of dough resistance to deformation, most probably because of the interactions between fibers and wheat proteins. Similar observations were reported by Crassina and Sudha (2015). Moreover, addition of ginger powder resulted in more elastic doughs. According to our results, positive correlations were established between S and P/L (R^2 = 0.98, p<0.05), DT and P/L (R^2 = 0.92, p<0.05), and DT and W (R^2 = 0.96, p<0.05).
The C2 values measured on Chopin+ curves decreased from 0.46 Nm, corresponding to the wheat flour, to 0.33 Nm, for sample with 6% G. This decrease suggests that the dough with increasing levels of ginger powder is more susceptible to weakening during kneading while increasing the temperature from 30 to 50-55ºC. Most probably this behavior is due to the fiber brought by ginger powder, which caused weakening of the protein network. The same effect was reported by Rosell et al. (2010) when substituting the wheat flour with the sugar beet fiber.
In a similar manner the C3, C4 and C5 values decreased when substituting wheat flour with ginger powder (Table 3). The reduction of

starch pasting ability (C3) is most probably due to the higher fat content coming from the ginger powder (9.34%) (Table 1). Our results are in agreement with Zaidul et al. (2007) who reported that the decrease of paste viscosity is due the complex formed between lipid and amylose during heating. On the other hand, Crassina and Sudha (2015) suggested that the decrease of peak viscosity with addition of mango ginger powder might be due to replacement of starch from wheat flour by fiber from ginger powder. There are important differences in the ability of the two macromolecular components of the dough to uptake the water available in the system, the fibers being able to retain higher amounts of water in a shorter time compared to the starch granules.

The higher fiber content of the samples with ginger powder explains the further decrease of gel stability during heating (C4) and starch retrogradation after cooling of dough (C5). The fibers alter starch behavior at hydrothermal treatment by limiting the amount of available water required for starch pasting and by interfering with the specific interaction between amylopectin chains (Rosell et al., 2010).

Effect of ginger powder addition on the bread characteristics

The characteristics of the bread samples with different amounts of ginger powder are shown in Table 5. The specific volume of the bread samples gradually decreased with addition of ginger powder, the most important decrease being registered for the sample with 6%. These results may be related to the increase of dough resistance to deformation when increasing the levels of ginger powder in blends used to prepare the dough. Regarding crumb texture, according to our results the crumb firmness increased with the level of ginger powder in wheat flour due to the higher proportions of fiber. In particular, the bread sample with 6% ginger powder had over twice harder texture compared to the control bread sample.

The sensory analysis highlighted that the wheat bread with ginger powder addition had lower overall quality than wheat bread (Table 5).

The panelist did not found very agreeable all sensory attributes of the ginger containing breads. In particular, the taste was not well appreciated because of the strong pungent hint caused by the ginger powder. Anyway, the taste of bread with 2% ginger powder was appreciated by the panelists, the score being rather close of the wheat bread (Table 5).

Table 5. Quality evaluation of bread samples containing different levels of ginger powder

Properties	WF	WF + 2%G	WF + 4%G	WF + 6%G
Physical parameters				
Specific volume, g/cm^3	2.39 ± 0.07^a	2.12 ± 0.04^b	2.01 ± 0.03^b	1.66 ± 0.04^c
Crumb firmness, g force	2753.23 ± 14.47^d	3276.34 ± 17.90^c	5006.80 ± 18.38^b	5667.56 ± 35.36^a
Sensory parameters				
Appearance	8.6 ± 0.28^a	8.1 ± 0.21^a	7.1 ± 0.21^b	7.0 ± 0.00^b
Texture	8.5 ± 0.21^a	7.8 ± 0.28^a	6.5 ± 0.28^b	6.1 ± 0.07^b
Taste	8.6 ± 0.21^a	8.4 ± 0.21^a	6.7 ± 0.28^b	6.0 ± 0.00^b
Overall quality	8.6 ± 0.28^a	8.1 ± 0.21^a	6.8 ± 0.21^b	6.4 ± 0.14^b

Means on the same row that do not share a letter are significantly different at $p<0.05$.

Moreover, the score of the texture of the bread samples with 4 and 6% was significantly lower compared to the control sample ($p<0.05$). Similar observations regarding taste and overall quality were reported by Crassina and Sudha (2015). They also suggested that the perception of this attribute can be improved by using potassium bromate, glycerol monostearate and vital gluten in the bread formulation. On the other hand, Balestra et al. (2011) reported that the bread with 3 to 4.5% ginger powder had good overall quality.

Effect of ginger powder addition on the total phenolic contents and antioxidants properties of wheat flour, ginger powder and breads

The total phenolic contents (TPC) and antioxidants properties in terms of radical scavenging activity (DPPH-RSA) of wheat flour, ginger powder and bread with and without ginger powder addition are shown in Table 6. The extract of ginger powder had significantly higher antioxidant activity (DPPH-RSA of 89.13%) compared to the wheat flour (DPPH-RSA of 3.30%). According to Zielinski et al. (2010) the antioxidant activity of ginger is mainly due to the gingerol compounds and diarylheptanoids. The ginger powder addition increased the DPPH-RSA of bread from 2.91% corresponding to the control sample to 6.23% in case of the bread with 6% ginger powder.

Table 6. Total phenolic compounds and antioxidants properties of bread samples containing different levels of ginger powder

Bread sample	TFC, mg FAE/g d. w.	DPPH-RSA, %
WF	92.9 ± 2.7[d]	2.91 ± 0.05[d]
WF + 2%G	173.1 ± 3.0[c]	4.15 ± 0.07[c]
WF + 4%G	197.5 ± 2.6[b]	5.17 ± 0.05[b]
WF + 6%G	226.6 ± 1.6[a]	6.23 ± 0.05[a]

Means on the same column that do not share a letter are significantly different at p<0.05.

Our results indicated that the ginger powder is a good source of phenolic compounds, the TPC being 824.8 mg FAE/g d.w., much higher compared to wheat flour, 107.5 mg FAE/g d.w. (Table 6). Through substituting the wheat flour with 2 to 6% of ginger powder the TPC of the bread samples increased from 92.9 to 226.6 mg FAE/g d.w. In our study a positive correlation was found between TPC and DPPH-RSA, $R^2 = 0.97$ ($p<0.001$), while Balestra et al. (2011) reported a correlation of $R^2 = 0.98$ ($p<0.001$).

CONCLUSIONS

The addition of different levels of ginger powder (0 to 6%) to the wheat flour changed the thermo-mechanical properties of dough, as well as dough behaviour under large deformation. The dough resistance to deformation increased with the level of ginger powder, while the stability of the gel during heating and the starch retrogradation after the cooling of dough decreases. When performing the baking test, our results showed that the specific volume of the bread decreased and crumb firmness increased with the increase of the ginger powder level. Ginger powder addition to wheat bread samples improved the levels of biologically active compounds. The total phenols content and radical scavenging activity increased from 92.9 to 226.6 mg FAE/g d.w. and from 2.91 to 6.23%, respectively, when the levels of ginger powder addition increase from 0 to 6%. Although the ginger powder is a good source of phenolic compounds, the improvement of the bread recipe is required such as to obtain final products well accepted by the consumers. The taste and overall quality of bread with 2% ginger powder were well appreciated by the panelists.

REFERENCES

Aprodu, I., Banu, I. (2015). Rheological, thermo-mechanical, and baking properties of wheat-millet flour blends. Food Science and Technology International, 21(5), 342-353.

Balestra, F., Cocci, E., Pinnavaia, G.G., Romani, S. (2011). Evaluation of antioxidant, rheological and sensorial properties of wheat flour dough and bread containing ginger powder. LWT - Food Science and Technology, 44, 700-705.

Banu, I., Stoenescu, G., Ionescu, V., Aprodu, I. (2010). Physicochemical and Rheological Analysis of Flour Mill Streams. Cereal Chemistry, 87(2), 112-117.

Beta, T., Nam, S., Dexter, J., Sapirstein, H. (2005). Phenolic content and antioxidant activity of pearled wheat and roller milled fractions. Cereal Chemistry, 82, 390-393.

Bordes, J., Branlard, G., Oury, F.X., Charmet, G., Balfourier, F. (2008). Agronomic characteristics, grain quality and flour rheology of 372 bread wheats in a worldwide core collection. Journal of Cereal Science, 48, 569-579.

Brand-Williams, W., Cuvelier, M.E., Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. LWT Food Science and Technology, 28, 25-30.

Crassina, K., Sudha, M.L. (2015). Evaluation of rheological, bioactives and baking characteristics of mango ginger (*Curcuma amada*) enriched soup sticks. Journal of Food Science and Technology, 52(9), 5922-5929.

Daramola, B., Osanyinlusi, S.A. (2006). Investigation on modification of cassava starch using active components of ginger roots (*Zingiber officinale* Roscoe). African Journal of Biotechnology, 5(10), 917-920.

Dewettinck, K., Van Bockstaele, F., Kuhne, B., Van de Walle, D., Courtens, T.M., Gellynck, X. (2008). Nutritional value of bread: Influence of processing, food interaction and consumer perception. Journal of Cereal Science, 48, 243-257.

Dordevic, T.M., Marincovic, S.S., Brankovic, S.D. (2010). Effect of fermentation on antioxidant properties of some cereals and pseudo cereals. Food Chemistry 119, 957-963.

Dubat, A., Boinot, N. (2012). Mixolab applications handbook. Rheological and enzymes analyses, Chopin Technology, Villenueve, France, 10-15, 148-149.

Dziki, D., Rozlo, R., Gawlik-Dziki, U., Swieca, M. (2014). Current trends in the enhancement of antioxidant activity of wheat bread by the addition of plant materials rich in phenolic compounds. Trends in Food Science and Technology, 48-61.

Gao, L., Wang, S., Oomah, B.D., Mazza, G. (2002). Wheat quality: Antioxidant activity of wheat millstreams. In: Ng P. and Wrigley C.W. (Eds.), Wheat quality elucidation, AACC International, Inc. St. Paul. MN, 219-233.

Hung, P.V., Maeda, T., Miyatake, K., Morita, N. (2009). Total phenolic compounds and antioxidant capacity of wheat graded flours by polishing method. Food Research International, 42, 185-190.

Ibrahim, U.K., Salleh, R.M., Maqsood-ul-Haque, S.N.S. (2015). Bread towards Functional Food: An Overview. International Journal of Food Engineering, 1(1), 39-43.

Kane, A.M., Lyon, B.G., Swanson, R.B., Savage, E.M. (2003). Comparison of two sensory and two instrumental methods to evaluated cookie color, Journal of Food Science, 68, 1831-1837.

Malu, S.P., Obochi, G.O., Tawo, E.N., Nyong, B.E. (2009). Antibacterial activity and medicinal properties of ginger (*Zingiber officinale*). Global Journal of Pure and Applied Sciences, 15(3), 365-368.

Martinez-Villaluenga, C., Horszwald, A., Frias, J., Piskula, M., Vidal-Valverde, C., Zielinski, H. (2009). Effect of flour extraction rate and baking process on vitamin B1 and B2 contents and antioxidant activity of ginger-based products. European Food Research Technology, 230, 119-124.

Parthasarathy, V.A., Chempakam, B., Zachariah, T.J. (Eds.) (2008). Chemistry of spices. Oxfordshire.

Penas, E., Martinez-Villaluenga, C., Vidal-Casero1, C., Zielinski, H., Frias, J. (2013). Protein Quality of Traditional Rye Breads and Ginger Cakes as Affected by the Incorporation of Flour with Different Extraction Rates. Polish Journal of Food Nutrition and Science, 63(1), 5-10.

Przygodzka, M., Zielinska, D., Ciesarova, Z., Kukurova, K., Zielinski, H. (2014). Comparison of methods for evaluation of the antioxidant capacity and phenolic compounds in common spices. LWT - Food Science and Technology, 58, 321-326.

Rosell, C.M., Rojas, J.A., Debarber, B. (2001). Influence of hydrocolloids on dough rheology and bread quality. Food Hydrocolloids, 15, 75-81.

Rosell, C.M., Santos, E., Collar, C. (2010). Physical characterization of fiber-enriched bread doughs by dual mixing and temperature constraint using the Mixolab. European Food Ressearch Technology, 231, 535-544.

Singleton, V.L., Rossi, J.A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungistic acid reagents. American Journal of Enology and Viticulture, 16, 144-158.

Stoilova, I., Krastanov, A., Stoyanova, A., Denev, P., Gargova, S. (2007). Antioxidant activity of a ginger extract (*Zingiber officinale*). Food Chemistry, 102, 764-770.

Zaidul, I.S.M., Yamauchi, H., Kim, S., Hashimoto, N., Noda, T. (2007). RVA study of mixtures of wheat flour and potato starches with different phosphorus contents. Food Chemistry 102, 1105-1111.

Zielinski, H., Amigo-Benavent, M., Del Castillo, M.D., Horszwald, A., Zielinska, D. (2010). Formulation and baking process affect Maillard reaction development and antioxidant capacity of ginger cakes. Journal of Food and Nutrition Research, 49(3), 140-148.

***ASRO (2008). Romanian standards catalog for cereal and milling products analysis. SR EN ISO 712: 2005, SR ISO 2171:2002, SR ISO 21415-2:2007, SR ISO 5529:1997, SR ISO 5530-4:2005, SR 91:2007, Bucharest.