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Technological properties of dough from wheat flour and fermented bran

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Protein quality and quantity are related with dough properties and loaf form. However, an important factor for dough quality is the composition of flour mix. Nowadays, scientists develop new products with the increasing nutritive value, using oatmeal, buckwheat flour, bran. Wheat bran is a composite material formed from different histological layers, and three different strips can be obtained from the soaked outer layers. The investigations suggest that enzymatic treatments of wheat bran are effective methods to improve the concentration of bioactive compounds, antioxidant activity and water-soluble dietary fibre. The aim of the study is to estimate the technological properties of wheat dough with bran and fermented bran.

Wheat flour was substituted with bran and fermented bran (5, 7, 10, 15 %). The following quality parameters were analysed using standard methods: the rheological properties of dough were analysed using Brabender Farinograph-AT (GmbH&Co.KG., Germany), and the moisture content of flour samples was determined according to the AACC 44-15A (2000).

The results of the present research demonstrate that the rheological properties of dough decrease is wheat flour substituted with 15 % of fermented bran. Water absorption and dough development time of dough with fermented bran addition is less than the parameters of control wheat flour.

Key words: wheat dough, rheological properties, bran.

Introduction

Wheat bran is a fraction derived from the roller milling and contains the outer layers (pericarp) in addition to the hyaline and aleuronic layers.

The outer strip corresponds to outer pericarp (epidermis and hypodermis), the inner one corresponds to the aleurone layers, and the intermediate one remains a composite of several tissues (inner pericarp, testa, and nuclear tissue) [1]. The starchy endosperm (80–85 % of the grain) is mostly composed of starch and proteins, while most of the fibre, vitamins, minerals and antioxidants are concentrated in the outer layers (12–17 % of the grain) and the wheat germ (3 % of the grain) [1]. After milling, a composite material that contains all these different layers is obtained and is commonly called bran. The current wheat grain milling process aims at recovering white flour (mostly composed of starchy endosperm), with bran and germ being discarded. This pre-treatment, also called “conditioning”, consists of two steps: damping, followed by a resting period. It is often regarded by millers as inducing “bran toughening”, which results during milling in a better separation from the endosperm, with the recovery of the bran as coarser pieces and with less small bran specks in the flour. Indeed, the rheological properties vary greatly according to the moisture content of the outer layers [2].

Regarding the different types of bran fraction, there are quantitative and qualitative differences among the different cereal grains [3]. Different types of bran have a different chemical composition; it depends on grain genetics, the agricultural background, and the milling process [3].

On the moisture-free basis, bran contains about 17 % of protein and 70 % of carbohydrates. Bran has a high fibre content formed principally of cellulose, and higher vitamin and mineral contents than the endosperm [4, 5]. Most of the bran protein and other nutrients are contained in the aleurone cells [6].

Wheat bran is thus mostly used for animal feeding, even though – due to its high nutritional potential – it could be used to produce ingredients to increase the nutritional quality of human foods [7].

Bread can be enriched with dietary fibre, including bran, such as wheat and rye, β-glucans, carob and pea fibres [8]. However, the addition of fibres causes the neglected effect on the final bread quality [9]. Wheat bran is more detrimental to loaf volume of bread and found to increase dough water absorption [10, 11, 12, 13, 14]. Jeltema has reported that hemicelluloses increase dough water absorption, too [15]. Mongeau and Brassard reported that the addition of wheat and maize bran progressively reduced all bread quality characteristics [16]. Katina has reported that in baking, however, addition of wheat bran results in bread with an inferior quality, low volume poor crumb structure, poor shelf-life, and a bitter flavour [17].

The existing bran dry fractionation processes take advantage of different properties such as particle size and density, in using sieving and air-classification of ground bran. However, these processes give insufficient results due to the low differentiation in size and density of the particles generated from each bran tissue after grinding [7].

The characterization of rheological properties of dough is effective in predicting the processing behaviour and in controlling the quality of food products [18]. When wheat flour is mixed with water, with the required amount of energy, dough is formed. The behaviour of the resulting dough when submitted to mechanical energy input is determined by dough rheological properties. Dough experiences different stresses during the successive stages of bread making in which it is subjected to different types of deformations, varying between deformations from shear to elongation [19]. Although the production of baking products is considered the most accurate method in quality evaluation [20], in order to assess flour-quality attributes, several predictive tests which are closely related to wheat flour quality are frequently used in wheat industry [21]. Gluten is the main base of the wheat dough and is the protein that only exists in wheat and rye, and many baking properties of wheat flour are related with this protein. Wheat flour dough simultaneously exhibits characteristics of a viscous liquid and of an elastic solid and hence is classed as a viscoelastic material. Dough mechanical properties depend on a large variety of factors including flour cultivar, mixing time, rest period, etc. [22]. Thus, it is necessary to look for the suitable methods of evaluating gluten quality and dough rheology with which we can select the proper flour for the aimed purpose [23]. Starch occurs as highly organized structures known as starch granules. Starch has unique thermal properties and functionality that have permitted its wide use in food products and industrial applications. Starch gelatinization is a process that breaks down the intermolecular bonds of starch molecules in the presence of water and heat, allowing the hydrogen bonding sites (the hydroxyl hydrogen and oxygen) to engage more water [24]. Starch granules containing amylose and amylopectin are formed in the amyloplast during grain filling [25] under interactions among ADP-glucose pyrophosphorylase (AGP), starch synthase (SS), starch branching enzymes (BE) and starch de-branching enzymes (DBE), and the different morphologies and changes in the physiochemical properties of starch isolated from different cultivars during grain filling might reflect diversities in the grain quality [26].

Bran supplementation usually weakens the structure and baking quality of wheat dough and decreases bread volume and the elasticity of the crumb. The effect has been attributed to the dilution of gluten, which would affect the gas-holding capacity of the dough [9, 8, 6]. As the specific volume of bread is one of the important characteristics determining acceptability, different bran pre-treatments have been used to improve the volume of bread supplemented with bran. For example, washing the bran to remove harmful components, grinding the bran to obtain a smaller particle size, using various heat treatments to inactivate enzymes, or prefermentation of bran with yeast or with yeast and lactic acid bacteria have been successfully used to improve the quality of bread supplemented with bran [9, 8], added that the pre-fermentation of wheat bran with yeast or yeast and lactic acid bacteria have improved the loaf volume, crumb structure and shelf-life of bread supplemented with bran. The positive effect of bran fermentation on bread quality was evident in changes of protein network structure of breads. Pre-fermentation of the bran with yeast and lactic acid bacteria had the greatest effect on the structure of starch. The bread also had added flavour, and a good homogeneous crumb structure and elasticity were excellent [17, 6]. Also, some of the negative effects of bran on gluten development can be compensated by using some additives such as gluten or baking enzymes [8].

The aim of the study is to estimate the technological properties of wheat dough with wheat bran and fermented wheat bran by α-amylase and the enzymatic complex Viscozyme-L.

Materials and methods

Experiments were done at the Latvia University of Agriculture. The research has been made during the years 2014–2015. Commercial wheat flour (gluten 31 %, ash matters 0.47 %, moisture 14 %) was obtained from JSC "Rigas Dzirnavnieks" (Latvia), wheat bran with a large particle size (1.6–1.8 ± 1,7 mm) from JSC "Dobeles Dzirnavnieks" (Latvia). For fermented wheat bran, were used two commercial preparations of enzymes: α-amylase from *Bacillus amyloliquefaciens* by "Novozyme Corporation" (Bagsvacrd, Denmark) and the enzymatic complex Viscozym-L from *Aspergillus* spp. from Sigma-Aldrich.

Wheat flour was mixed with 5, 7, 10, 15 % wheat or fermented wheat bran.

For the analysis of rheological properties, Brabender Farinograph-AT (GmbH&Co.KG., Germany) was used according to the international standard method (AACC No. 54-21, ICC No. 115/1). The results of farinograph tests were analysed primarily in the aspect of the dynamics of changes in the consistency of dough during the mixing [27]. For all samples, the following parameters were determined: water absorption (WA), stability of dough (S), development time of dough (DDT), degree of softening (DS).

The moisture content of flour samples was determined using the air-oven method (AACC 44-15A from 2000).

The *Microsoft Excel* software was used for the research purpose to calculate the mean arithmetical values and standard deviations of the obtained data. The ANOVA analyses were used to explore the impact of factors and their interaction, and the significance effect (*p-value*).

Results and discussion

The results of farinograph tests are analysed primarily in the aspect of the dynamics of changes in the consistency of dough during the mixing [27]. Nowadays, researchers obtain digital results of measurements and use them for the determination of farinographic elasticity indices. It is desirable, therefore, to conduct studies confirming the applicability of those indices in the estimating the quality of bread dough for various applications, including the production of breads with enhanced health-promoting values.

Table 1. Farinograph parameters of samples

Samples	WA, %	DDT, min	S, min	DS, FU
Control (C)	62.3	2.16	6.3	43
Wheat flour + wheat bran, 5 % (WB 5)	63.1	2.14	-	20
Wheat flour + wheat bran, 7 % (WB 7)	63.0	2.14	18.05	3
Wheat flour + wheat bran, 10 % (WB10)	64.0	14.45	-	6
Wheat flour + wheat bran, 15 % (WB 15)	64.8	9.57	17.22	1
Wheat flour + fermented wheat bran, 5 % (FWB 5)	60.3	1.48	16.28	30
Wheat flour + fermented wheat bran, 7 % (FWB 7)	59.8	1.56	14.39	27
Wheat flour + fermented wheat bran, 10 % (FWB 10)	58.5	1.48	14.51	8
Wheat flour + fermented wheat bran, 15 % (FWB 15)	54.9	10.4	13.54	4

The dough water absorption (WA), dough development time (DDT), dough stability (S) and the degree of softening (DS) of wheat flour and experimental samples are summarized in Table 1. The obtained results show that wheat bran additive increases WA and DDT, but the fermented bran additive decreases water abortion and DDT time and increases dough stability. Generally, flour with good bread-making characteristics has a higher absorption, takes longer time to mix, and is more tolerant to overmixing than the poor-quality bread flour.

Water absorption relates to the volume of water required for the dough to reach the 500 farinograph unit line at the point of optimum development (Fig. 1). It is expressed as a percentage of the flour (14 % moisture base).

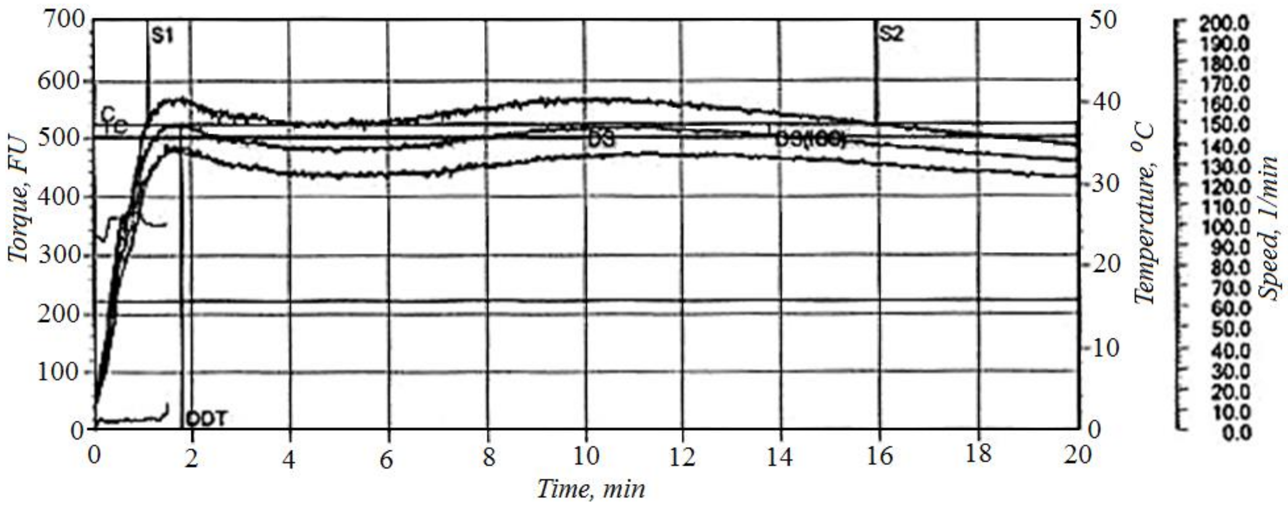

Fig. 1. Farinogram of wheat flour and 10 % fermented wheat bran

Water absorption is an indicator of baking quality. This is generally considered as the amount of water needed for a flour to be optimally processed into its end products [28].

Higher starch, dietary fibre and protein content in flour result in a higher water absorption [28]. In the present experiment (Fig. 2), it has been obtained that water absorption decreases (from 62 % to 55 %) of flour samples with fermented wheat bran additives. It could be explained by structural changes of bran during the fermentation time. The enzymatic fermentation of bran leads to a decrease in TDF combined with a shift from insoluble (IDF) to soluble fibre (SDF). The changes are more pronounced for fibre sources high in pectin substances than for substrates rich in cellulose and hemicelluloses. The proportion of soluble fibre could be increased to approximately one third. Changes of bran in the fermentation time influence water absorption in a flour mix [29, 30, 31, 32]. This ability is mainly determined by the presence in the fibre structure of a large number of hydroxyl groups which enter into interactions with water via hydrogen bonds [33]. Varied doses of bran addition to wheat flour influence the water absorption, the run of dough development and its rheological stability, both in terms of its consistency and elasticity.

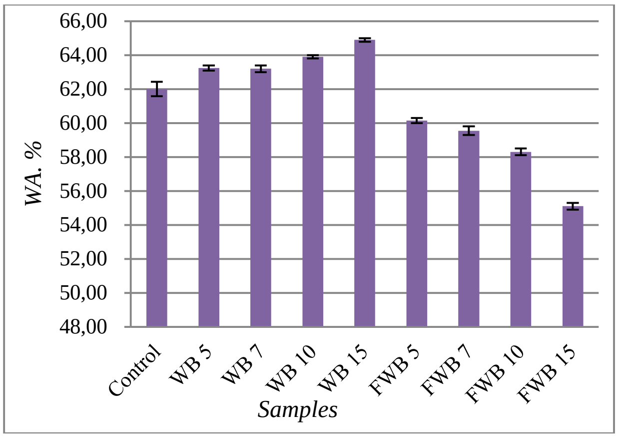

Fig. 2. Water absorption of experimental samples

Dough development time (DDT) is the time from water addition to the flour until the dough reaches the point of the greatest torque. During the mixing phase, water hydrates the flour components and the dough is developed. For wheat dough, DDT is 1.5–2.0 min. The scientist Anton Mis reported that DT increased from 1.8 min (no addition) to 2.4 min at 2 % addition of carob fibre and to 6.4 min at 5 % addition of oat wholemeal. An increased dosage of the additions above those levels caused a gradual shortening of the dough development time to 1.8 min and 4.9 min, respectively.

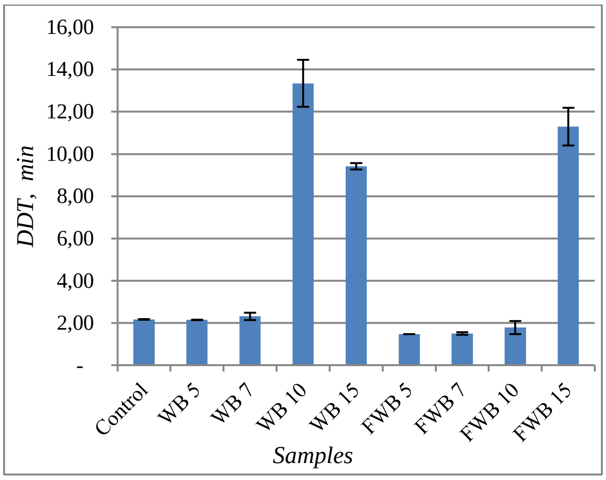

Fig. 3. Dough development time (DDT) of experimental samples

The present results show that 10 % and 15 % wheat bran addition significant by increases DDT from 2 min to 12.5 min. The obtained results could be explained by the dietary fibre content of wheat bran. The dough development mechanism is a complicated process. Gluten is the major component, but a large role play starch and dietary fibre. Wheat bran addition to wheat flour increases the level of dietary fibre and change the properties of dough. Dietary fibres slowly absorb water and increase the developing time. Changes of the dough development time of samples with a fermented wheat bran additive 10 % are not significant ($p > 0.005$) as compared with the control and 10 % wheat bran additives. A wheat flour sample with 15 % fermented bran additives show a significant ($p < 0.005$) higher dough development time as compared with the control sample.

Stability is the indication of the flour tolerance to mixing. Stronger flours show higher stability values [27, 34, 35]. Mailhot and Patton recommend a minimum dough stability of 7.5 min and a degree of softening of less than 75 farinograph units as appropriate for bread making [36].

Obviously, the addition of wheat bran will change the flour characteristics significantly. These changes in a characteristic can be seen in the farinograph results for different flour and wheat bran blend ratios (Figs. 4, 5).

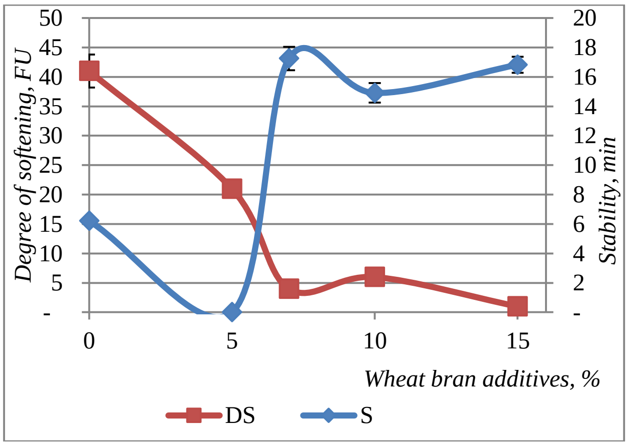

Fig. 4. Effect of wheat bran addition on dough stability (S) and degree of softening (DS)

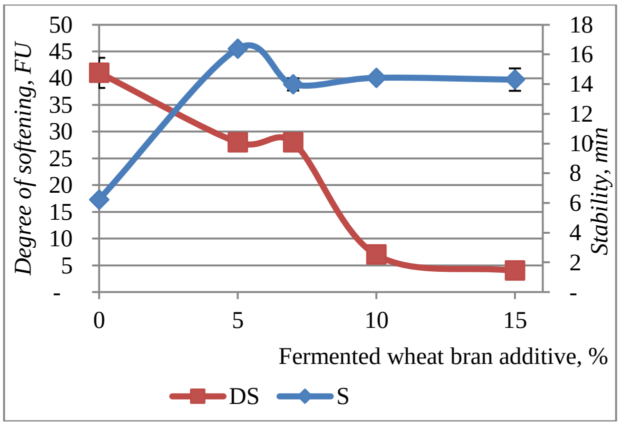

Fig. 5. Effect of fermented wheat bran addition on dough stability (S) and degree of softening (DS)

Wheat bran and fermented wheat bran additives to flour increase dough stability and decrease the degree of softening. The reason for this may be that the addition of bran dilutes the gluten in blends, thereby weakening the crosslink between the proteins, and reducing the interactions between the chains, influencing the formation and expansion of the gluten network. All of these factors contribute to a decrease in dough strength.

Conclusions

In the present research, a significant difference among flour, wheat bran and fermented wheat bran blend was established. Water absorption decreases in a sample with fermented wheat bran (15 %), but increases dough development time and dough stability. A higher water absorption was found in samples with wheat bran. A significant increase of dough development time was in the sample with 10 % wheat bran. Experimental data show that the optimal amount of wheat bran to be added to wheat flour is 7 %, but of fermented wheat bran it is 10 %.

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TECHNOLOGINĖS KVIETINIŲ MILTŲ TEŠLOS SU FERMENTUOTŲ SĖLENŲ PRIEDU SAVYBĖS

S a n t r a u k a

Darbo tikslas – įvertinti kvietinių miltų tešlos su fermentuotų sėlenų priedu technologines savybes. Kvietinių miltų dalis buvo pakeista fermentuotomis kvietinėmis sėlenomis atitinkamu kiekiu (5, 7, 10, 15 proc.). Tešlos technologinės savybės įvertintos Brabenderio farinografu. Rezultatai parodė, kad sėlenų 15 proc. priedas blogino tešlos technologines savybes. Vandens absorbcija ir tešlos su fermentuotomis sėlenomis susidarymo trukmė trumpesnė nei kontrolinės kvietinių miltų tešlos susidarymo trukmė.