RHEOLOGICAL PROPERTIES OF TRITICALE (*TRITICOSECALE WITTMACK*) FLOUR BLENDS DOUGH

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Abstract
Triticale is an amphidiploid hybrid between wheat and rye having protein-rich grain. For expanding the range of bakery and pastry production in the world there are being developed various recipes for product enriching with fibre, especially b-glucan, proteins, vitamins and other nutrients for a healthier diet. It can be done making a flour blend from whole grain triticale, rye, hull-less barley, rice and maize flour. The aim of research was to evaluate the rheological properties of dough made from different cereals flour and flour blends. Whole grain flour of triticale, rye, hull-less barley, rice, maize and flour blends were used in this research. Flour blends were made from triticale in a combination with other flour (whole grain rye, hull-less barley flour, rice and maize flour) in various proportions. Wheat flour (Type 405) was used as a control. Rheological properties of mixed flour dough were studied using Farinograph (Brabender Farinograph-AT, GmbH & Co. KG, Germany). Moisture content of flour and flour blends was determined using AACC method 44-15A. Water absorption and dough development time decrease, but dough stability, time of breakdown and farinograph quality number increase, increasing proportion of other flour in triticale flour. The flour blends need less time for dough development comparing with triticale flour. Enriching triticale flour with whole grain rye, whole grain barley, rice and maize flour in various proportions made triticale flour dough more rheologically stable during mixing.
Key words: triticale; wheat; hull-less barley; flour blend; farinograph.

Introduction

Triticale (*Triticosecale wittmack*) is the first man-made cereal produced by crossing wheat (*Triticum spp.*) and rye (*Secale ceral L.*). The future of this crop is bright because it is environmentally more flexible than other cereals and shows better tolerance to diseases, drought, and pests than its parental species (Darvey et al., 2000). To view on triticale from the nutrition point, it has valuable dietary characteristics such as higher amounts of soluble dietary fiber and better total amino acid composition, as compared to wheat (Varughese et al., 1996). In order to extend the product assortment and improve their nutritional value, there can be used triticale, hull-less barley, buckwheat, hull-less oat, and other grain flour that are used elsewhere in the world, and various scientific studies demonstrate their value (Taketa et al., 2004). For expanding the range of bakery and pastry production in the world there are being developed various recipes for product enriching with fibre, especially b-glucan, proteins, vitamins and other nutrients for a healthier diet. It can be done making a flour blend from whole grain triticale, rye, hull-less barley, rice and maize flour (Straumite et al., 2010).

The bread-making process consists of three main sub-processes: mixing, fermentation, and baking. Mixing transforms the combination of flour and water into a homogenous viscoelastic dough, develops the dough and helps the air occlusion (Bloksma, 1990). The mixing process promotes numerous physical, chemical and physico-chemical modifications that conduct to the dough development (Kaddour et al., 2008). And of course, it is one of the most important ways in which to characterise the quality of flour samples.

The wide range of end-products results from different ingredient formulas and/or varying processing conditions. Not every flour type is equally suitable for the production of a specific end-product. Therefore, determination of flour quality is of great importance as it relates to the desired end-product and its manufacturing process (Duyvejonck et al., 2012). A baker will normally knead and stretch the dough by hand to assess its quality. Resistance to stretching and its recoil after stretching have been indicated as key parameters in these subjective assessments. This has led to the widespread belief that the rheological properties of dough, particularly those that measure elasticity, could be used as indicators of dough baking performance (Dobraszczyk and Salmanowicz, 2008).

However, many rheological tests that measure elasticity have proved to be inadequate as methods of predicting the eventual baking performance of dough. Determination of gluten, Falling Number, Zeleny test, the rheological tests, such as the Brabender Farinograph, Mixograph and Chopin Alveograph analyses, which are indicative for dough properties and, thus, flour quality, are used (Duyvejonck et al., 2012). A study of rheological characteristics of dough as influenced by the added ingredients should have great relevance in predicting the machinability of dough as well as the quality of the end-product (Indrani and Venkateswara, 2007).

Among such methods we can certainly include the farinograph and extensograph methods which have a dominant position based on eight decades

Table 1

Sample composition per 100 g of flour blend

Flour type	Flour blend			
	A	B	C	D
Whole grain triticale, g	90.00	80.00	70.00	60.00
Flour blend which consists of:				
whole grain rye, g	3.75	7.50	11.25	15.00
whole grain hull-less barley, g	3.75	7.50	11.25	15.00
rice, g	1.25	2.50	3.75	5.00
maize, g	1.25	2.50	3.75	5.00
Triticale and flour blend ratio, %	90:10	80:20	70:30	60:40

of experience in the baking technology (Bloksma and Bushuk, 1988). The Brabender Farinograph, as demonstrated by the results of numerous studies (Anil, 2007; Peressini and Sensidoni, 2009; Sudha et al., 2007; Skendi et al., 2009; Wang et al., 2002; Mis et al., 2012), is a sensitive tool for the study of modifications caused at the stage of development and mixing of bread dough. The farinograph is a dynamic physical dough testing instrument involving the measurement of torque. The results of farinograph tests are analysed primarily in the aspect of the dynamics of changes in the consistency of dough during its mixing (D'Appolonia and Kunerth, 1984; Mis et al., 2012). The farinograph with Z-arm mixers can characterise the quality of flour sample, appear to form the dough with a gentle kneading or shearing action in which the dough is squeezed between the mixer blade and the mixer body (Haraszi et al., 2008).

The aim of research was to evaluate the rheological properties of dough made from different cereals flour and flour blends.

Materials and Methods

Experiments were carried out in the Department of Food Technology at the Latvia University of Agriculture. Triticale, rye and hull-less barley crops of 2011 cultivated at the Priekuli Plant Breeding Institute (Latvia), rice and maize flour purchased from Joint Stock Company (JSC) *Ustukiu Malunas* (Lithuania), as well as wheat flour (Type 405) purchased from JSC "Dobeles Dzirnavnieks" (Latvia) were used in the current study. Triticale, rye and hull-less barley were ground in the laboratory mill *Hawos* (Hawos Kornmühlen GmbH, Germany) obtaining fine whole grain flour. For this study were made 4 samples of flour blends, based on triticale flour mixed with whole grain rye hull-less barley, rice and maize flour (Table 1). The composition of flour blend was developed in earlier studies based on the rheological properties evaluation using Mixolab (Sabovics et al., 2011).

Moisture content of individual flour samples and flour blends was determined using air-oven method (AACC, Method 44-15A, 2000).

Farinograph analysis were done for wheat flour (control), whole grain triticale, whole grain rye, whole grain hull-less barley, rice and maize flour, and for flour blend samples (A, B, C, and D). For analysis of rheological properties there was used Brabender ICC BIPEA 300 method. The farinograph test measures and records the resistance of dough during the mixing time

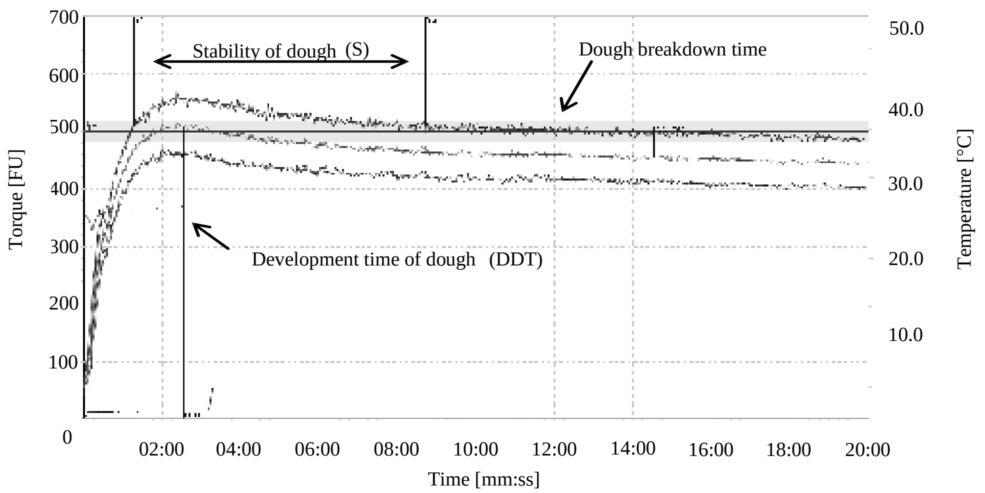

Figure 1. Typical curve from Farinograph analysis of wheat flour.

using paddles. For all samples there were determined the following parameters: water absorption (WA) of flour and flour blends, development time of dough (DDT), stability of dough (S), breakdown time, and farinograph quality number (FQN). The typical curve from Farinograph analysis of wheat flour is shown in Figure 1.

All flour samples were weighed and placed into the corresponding farinograph mixing bowl (model 827505, Brabender Farinograph-AT, GmbH & Co. KG, Germany). Water was added automatically from the farinograph water container to flour and mixed to form dough. The farinograph was connected to a circulating water pump and a thermostat which operated at 27±2 °C. The mixing speed of the farinograph was 63 rpm; experiment run for 20 min. All analyses were performed in triplicate. The results (mean, standard deviation, p value) were processed by mathematical and statistical methods. Data were subjected to one-way analysis of variance (ANOVA) and two-way analysis of variance (ANOVA) by Microsoft Office Excel 2007; significance was defined at $p<0.05$.

Results and Discussion

In the processing of grain for flour and other food products, moisture content of the flour sample is important information for efficient processing and in obtaining desired high-quality products (Nelson et al., 2000). Moisture content in flour and flour blends is presented in Table 2.

The optimum moisture content of wheat flour is 14.0%. In case the moisture content is higher it is difficult to maintain the quality during storage, whereas, if moisture content is low (9-10%), during dough formation it would not bind sufficient amount of water (Kunkulberga and Seglins, 2010).

Dough is a macroscopically homogeneous mixture of starch, protein, fat and other components. At optimum mixing, the dough is fully hydrated and has the highest elasticity. Water plays an important role in determining the viscoelastic properties of dough (Masi et al., 1998). The farinograph profiles of flour and flour blends are shown in Figure 2.

The amount of water (absorption) required to centre the farinogram curve on the 500 FU (Farinograph Units) for wheat flour (control) was 61.87±0.21%, but for triticale flour and flour blends A, B, C, and D it was 57.70±0.10%, 57.53±0.21%, 57.20±0.01%, 56.77±0.06%, and 56.57±0.15%, respectively. Water absorption in triticale flour comparing to flour blend D decreased only by 1.13%. Wherewith, triticale flour blending with other flour in various proportions (whole grain hull-less barley, whole grain rye, rice and maize flour) did not have relevant effect ($p>0.05$) on its water absorption (WA). Moisture content in wheat flour was smaller than in triticale flour and flour blends, which can result in a higher water absorption in wheat flour. While several factors affect the water absorption value of flour, dough that absorbs more water typically has higher protein content (Figoni, 2007).

Table 2

Moisture content in flour and flour blend samples

No.	Sample	Moisture, %
1.	Wheat flour (control)	9.84±0.01
2.	Whole grain triticale flour	10.98±0.01
3.	Whole grain rye flour	11.03±0.01
4.	Whole grain hull-less barley flour	10.13±0.04
5.	Rice flour	12.45±0.01
6.	Maize flour	11.73±0.02
7.	Flour blend A	11.59±0.05
8.	Flour blend B	11.65±0.01
9.	Flour blend C	11.73±0.01
10.	Flour blend D	11.78±0.03

Water absorption for whole grain hull-less barley flour, rice and maize flour was 75.0±0.1%, 67.8±5.9%,

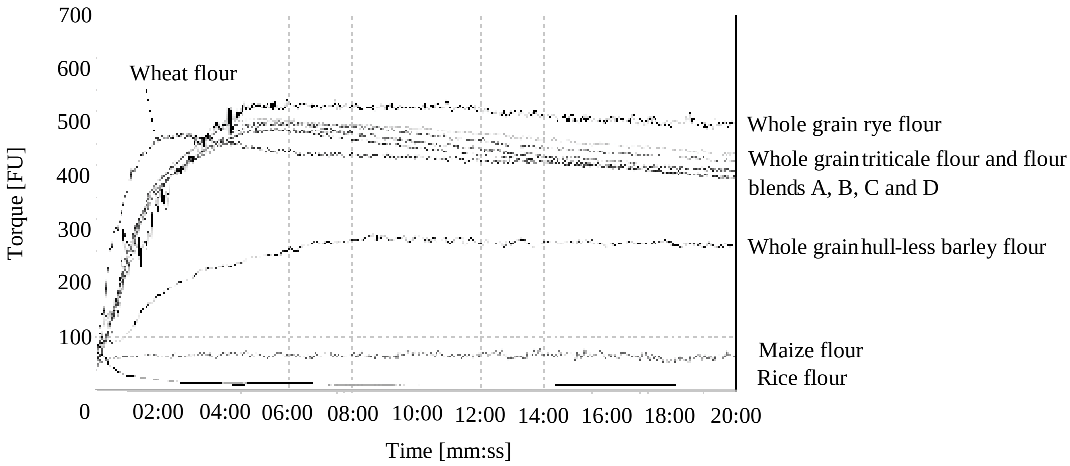

Figure 2. Farinograph profiles of flour and flour blends.

and 58.8±0.2%, respectively. But none of these flour samples reached the farinogram curve at the 500 FU.

Whole grain hull-less barley flour, rice and maize flour do not contain components that can form quality dough therefore the farinograph test is not suitable for their evaluation. In the farinograph test, whole grain hull-less barley and maize flour dough stuck around the kneading arms and showed rubberlike texture.

Dough development time and stability of triticale flour and flour blend samples are shown in Figure 3, but dough breakdown time and farinograph quality number are shown in Figure 4.

Dough development time (DDT) is the time required for water absorption in the flour until the dough mixing reaches the point of the greatest torque (500 FU). During the mixing phase, water hydrates the flour components and the dough is developed. Wheat flour (control) showed the lowest dough development time (2.40 min), but the highest development time (5.95 min) was for triticale flour (Fig.3-A). In bread-making, the mixing of dough is generally considered a critical step that is important for the overall bread quality (Bushuk et al., 1997). The optimum mixing times can be different depending on the flour composition, mixer type, and dough formulation. Thus, the correct amount of mixing energy to achieve optimum bread quality depends not only on the characteristics of the flour but also on the type of mixer used in the process (Oliver and Allen, 1992; Hwang and Gunasekaram, 2001; Haraszi et al., 2008).

Dough development time for the flour blend samples decreased – A (5.42±0.08 min), B (5.27±0.06 min), C (5.00±0.05 min) and D (4.74±0.05 min) – with increasing proportions of other flours used in combination with triticale flour (Fig.3-A). If the dough development time is shorter, less time is regained to mix the dough.

Dough stability (DS) is defined as the time difference between the point where the top of the curve first intercepts the 500 FU line and the point where the top of the curve leaves the 500 FU line. Commonly, it indicates the time when the dough maintains maximum consistency and is a good indication of dough strength, and good quality dough has stability of 4–12 min (Koppel and Ingver, 2010).

The wheat flour gave the highest dough stability value 9.24±0.04 min (Fig.3-B) among studied samples. The next highest dough stability (S) value

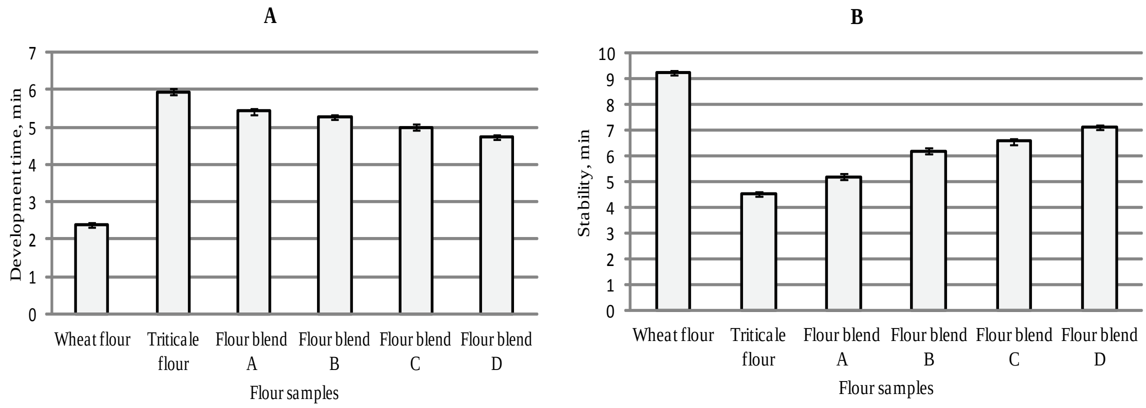

Figure 3. Dough development time (A) and stability (B) for wheat, triticale flour and flour blends samples.

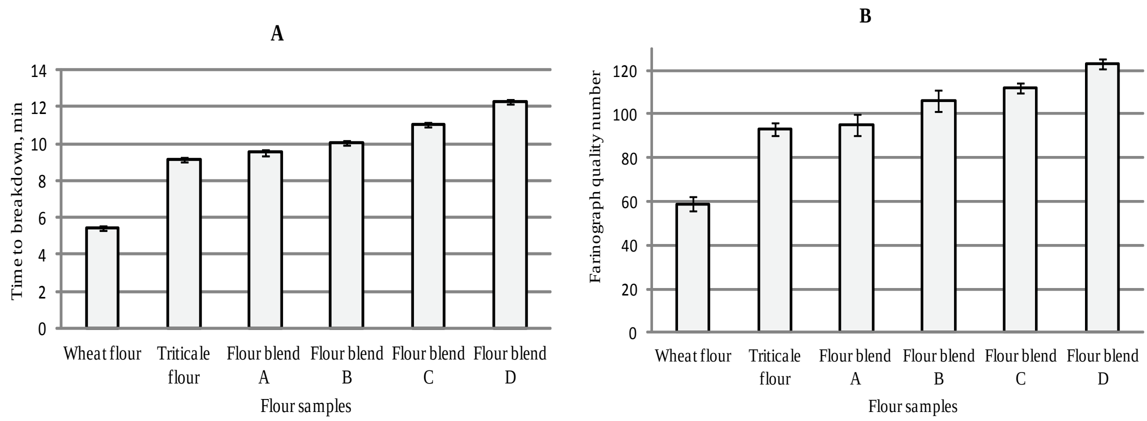

Figure 4. Farinograph breakdown time (A) and quality number (B) for flour and flour blends.

(7.10±0.06 min) was for flour blend D, where the triticale and other flour ratio in flour blend was 60:40. Triticale flour showed the lowest S value – 4.51±0.06 min. According to Koppel and Ingver (2010), it still can make good quality dough.

Comparing dough stability of triticale flour with the dough stability of flour blend samples (A – 5.20±0.06 min, B – 6.20±0.02 min, C – 6.57±0.02 min, and D - 7.10±0.06 min) it was found that the stability of triticale dough increases with the mixing time when proportion of other flour increased in the flour blend. The greater is the stability of the dough, the better is dough resistance in fermentation and mechanical processing time.

The dough breakdown time and farinograph quality number are essentially the same index (Fig. 4-A, B). The farinograph quality number represents the quality of flour in a single value. Weak flour weakens early and quickly shows a low quality number, whereas strong flour weakens late and slowly shows a high farinograph quality number (Miralbes, 2004).

In the farinograph test, wheat flour demonstrated the lowest breakdown time (5.44±0.03 min) and also the lowest FQN (59±3). Increasing other flour proportion in the flour blend, increased the dough breakdown time and the farinograph quality number for flour blends. Breakdown time and farinograph quality number tended to follow the same trend in all four types of flour blend. Breakdown time from flour blend A to D increased by 2.72 min, but FQN increased by 28, which means the flour blend D (ratio 60:40) was stronger flour compared to other flour blends studied in the research.

The dough stability, breakdown time and farinograph quality number of triticale dough increased in the mixing process, but dough development time decreased when proportion of other flour increased in the flour blend. Decreasing of dough development time is quite good for manufacturers, because they need less time for making it.

Conclusions

1. Moisture content in the studied flour was from 12.45±0.01% (rice flour) to 9.84±0.01% (wheat flour), but in flour blend samples - from 11.59±0.05% to 11.78±0.03%.
2. Blending of triticale flour with other flour (whole grain hull-less barley, whole grain rye, rice and maize flour) in various proportions did not have relevant effect (p>0.05) on water absorption.
3. Dough development time decreased, but dough stability increased in the studied flour blend samples with increasing proportion of other flour used in combination with triticale flour.
4. Breakdown time for triticale flour blend with other flour, for ratios 90:10 to 60:40, respectively, increased by 2.72 min, but farinograph quality number (FQN) increased by 28.

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