INFLUENCE OF PARTIAL WHEAT FLOUR SUBSTITUTION BY BUCKWHEAT FLOUR ON DOUGH RHEOLOGICAL CHARACTERISTICS MEASURED USING MIXOLAB

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Abstract: *Rheological properties of wheat flour, wheat flour/unhusked buckwheat flour and wheat flour/husked buckwheat flour dough using Mixolab were investigated. Mixtures of 50% wheat flour and 50% unhusked buckwheat flour and 25% wheat flour and 75% unhusked buckwheat flour were prepared. Also in the same ratios were prepared the mixtures containing husked buckwheat flour. All the rheological measurements were performed on Mixolab. It was confirmed that increasing both unhusked buckwheat flour and husked buckwheat flour resulted in weakening of protein structure. Also it was concluded that addition of buckwheat flour decreased both the rate of gelatinization and maximum torque (viscosity) and also lowered the degree of retrogradation which may be beneficial for bread with postponed antistailing effects.*

Key words: *Buckwheat flour, dough rheology, Mixolab*

INTRODUCTION

Buckwheat belongs to the family of *Polygonaceae* but because of its functional properties and usage it is also classified as a pseudocereals with Amaranth and Quinoa. There are two types of buckwheat that are being used: common buckwheat (*Fagopyrum escelentum*) and tartary buckwheat (*Fagopyrum tataricum*). Common buckwheat is the most prevalent type of buckwheat and it has advantages in sweet taste, large seed size and easy dehulling process, whilst tartary buckwheat posses minor disadvantages that are connected to a bitter taste, small seed size and tight seed coat which makes the process of dehulling more complicated (Gawlik-Dziki et al., 2009). Despite the mentioned disadvantages of tartary buckwheat it was reported that it contains more rutin in seeds than the common buckwheat (Jiang et al., 2007). Common buckwheat is generally grown in Europe, USA, Canada, Brasil, South Africa and Australia while the tartary buckwheat is generally grown in mountainous regions (southwest China, Austria, Slovenia, Italia etc.) (Bonafaccia et al., 2003). The main

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products of buckwheat are buckwheat flour and groats. Also pasta and other buckwheat products are commonly used in Italy, Slovenia and Asia. Other buckwheat products are buckwheat honey, green buckwheat tea, buckwheat sprouts etc. It is well known that buckwheat has nutritional properties and health promoting components that makes it very important supplement in various food products especially in bakery goods, most commonly in bread products.

Present phenolic compounds in buckwheat are considered to have high antioxidative activity (Halosava et al., 2002; Sensoy et al., 2006). The buckwheat seeds contain rutin and isovitexin while hulls contain even more phenolic compounds (rutin, orientin, vitexin, quercetin, isovitexin and isorientin) that possess antioxidative activity (Dietrych-Szostak and Oleszek, 1999). Rutin has antioxidant, anti-inflammatory and anti-cancer properties and also posses the ability to prevent the arteriosclerosis etc. (Sun and Ho, 2005).

It is also found that buckwheat has prebiotic properties because it could increase lactic acid bacteria in intestine (Prestamo et al., 2003). The addition of buckwheat to food products, due to its antioxidative stability, provides beneficial health effects and makes the food resistant to oxidation during the food processing and storage. Very important nutritional value of buckwheat also arise from its protein characteristics due to well balanced amino acid composition that is more favorable than the protein composition of commonly used cereals (Pomeranz et al., 1972; Wei et al., 1995). It was confirmed that buckwheat proteins are consisted mostly of albumins and globulins (Skerrit, 1986) that is the major difference compared to wheat protein composition. Thereby buckwheat does not contain gluten proteins and thus can be used in gluten-free formulations (Schoenlechner et al., 2008). As it is well known gluten complex present in wheat flour significantly impacts on rheological properties of wheat dough systems and on final product characteristics. It has most important role in building a protein network with well known characteristics which are substantial in dough processing and ability to retain gasses formed during the fermentation process (Auerman, 1998). Also gluten complex impacts on the structure and final product volume. As it was already determined by numerous different measurements, protein complex of buckwheat flour is consisted mainly from albumins and globulins with minor percentage of glutelin and prolamin. This is the major difference between the protein complex of buckwheat and wheat flour which is consisted of mainly prolamin and glutelin (Guo et Yao, 2006).

The aim of this study was to determine the influence of addition of unhusked and husked buckwheat flour on rheological properties of wheat-buckwheat dough using Mixolab.

MATERIAL AND METHODS

Material

Wheat flour (moisture content 12.8%, protein 11.8%, ash 0.56%), unhusked buckwheat flour (moisture content 9.76%, protein 12.38%, ash 2.19% cellulose 3.02%, lipid content 2.77% and starch 67.38%) and husked buckwheat flour (moisture content 10.11%, protein 7.5%, ash 1.09%, cellulose 0.43%, lipid content 1.75% and starch 68.24%) were used. Four flour mixtures were prepared containing 50% and 75% husked buckwheat flour and unhusked buckwheat flour respectively.

Methods

Dough rheological investigations were performed by Mixolab (Chopin, Tripette et Renaud, Paris, France) which simultaneously determinates dough characteristics during the process of mixing at constant temperature, as well as during the period of constant heating and cooling. Required amount of flour for analysis was calculated by Mixolab software according to input values of flour moisture as well as water absorption. All the measurements were performed using the Mixolab ´Chopin +´ protocol which parameters are presented in Table 1.

Table 1.
Mixolab parameters used in Chopin+ protocol

Settings	**Values**
Mixing speed	80 rpm
Dough weight	75 g
Tank temperature	30 °C
Temperature 1st step	30 °C
Duration 1st step	8 min
1st temperature gradient	15 min – 4 °C/min
Temperature 2nd sep	90 °C
Duration 2nd step	7 min
2nd temperature gradient	10 min – 4 °C/min
Temperature 3rd step	50 °C
Duration 3rd step	5 min
Total analysis time	45 min

In order to make this parameters more understandable, a common Mixolab profile is shown in the Figure 1:

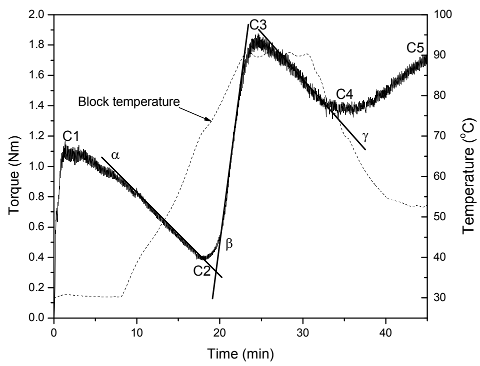

Figure. 1. Common Mixolab profile

Water absorption (%) represents the amount of water that is required to produce a dough with consistency of 1.1 ± 0.07 Nm (point C1). This value is equivalent to dough consistency of 500FU obtained by Brabender Farinograph. The dough development time is the time measured from initial dough mixing until the C1 point is reached. The stronger the flour is, the dough development time is longer. Stability (min) represents the resistance of dough to applied mixing forces (time during the measurement when the dough consistency is not lower than 11% of value of torque at C1 point). If the resistance is higher, the dough is stronger. Amplitude (Nm) can be interpreted as curve width at C1 point and it represents dough elasticity. By increasing the value of amplitude, dough elasticity increases too. The slope α can be observed as the rate of weakening of the protein structure due to the effects of temperature increase and applied forces during the dough mixing. The value C2 represents the minimum torque recorded during the period of mixing and increasing the system temperature. This value is also dependent on protein structure characteristics. The rate of starch gelatinization can be observed as the slope β, while the value of maximum viscosity correspondents to the value of the maximum torque at the point C3 representing gelling ability of starch. Enzymatic degradation of starch and its rate can be indicated by the slope γ and the value of the second minimum in the recorded curve, C4 point, showing the stability of hot paste. Starch retrogadation is measured at the end of the cooling period at point at point C5 (Mixolab Chopin, 2006).

RESULTS AND DISCUSSION

The obtained Mixolab profiles of wheat flour as well as the prepared flour mixtures (wheat flour/unhusked buckwheat flour) are presented in Figure 2:

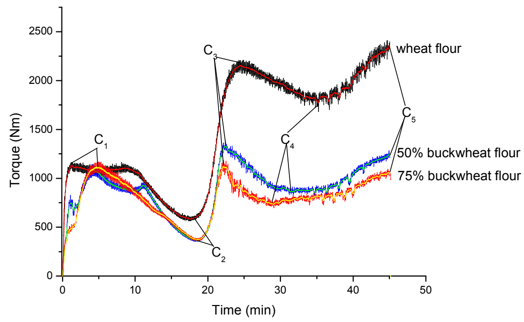

Figure 2. Mixolab profiles of wheat flour and mixtures containing 50% and 75% of unhusked buckwheat flour

By observing the first part of the curve, which mainly depends on the physical characteristics of protein matrix, it can be seen that the increasing amount of unhusked buckwheat flour in the mixture resulted in weaker protein network in comparison to the characteristics of system containing wheat flour solely. Thereby, by increasing the amount of the unhusked buckwheat flour, dough stability of tested system decreased (Table 2). On the contrary the dough elasticity expressed by the values of amplitude (Nm) were higher with larger amounts of unhusked buckwheat flour in mixtures due to higher content of hydrocolloids in unhusked buckwheat flour in comparison to wheat flour. It is observed that addition of unhusked buckwheat flour lead to the increase of water absorption as a consequence of the higher cellulose content and the composition and the nature of the buckwheat flour, as well. Also dough development time increased in mixtures containing larger amounts of unhusked buckwheat flour due to different water absorption capacities of the present components of the buckwheat flour (mainly cellulose and hydrocolloids).

Mixture containing 50% of unhusked buckwheat flour expressed significantly lower value of minimum torque C2 compared to pure wheat flour system. This was the consequence of dilution of wheat gluten complex and inability of buckwheat flour to form dough with similar physical characteristics to one obtained using the wheat flour solely due to the different protein compositions of these two types of flours.

The increasing amount of unhusked buckwheat flour to 75% did not have impact on further weakening of protein complex compared to mixture containing 50% of unhusked buckwheat flour.

Second part of the curve follows the changes in dough structure caused by increasing temperatures and mechanical forces of mixing. These changes are mainly influenced by starch and enzymatic characteristics present in flour system. From the resulted slope β it can be concluded that highest rate of the starch gelatinization showed wheat flour dough which also had the maximum value of torque at the point C3 (Table 2). Measurements performed by Bra-bender Amylograph (ICC, 1996) showed that tested wheat flour possess low enzymatic activity and relatively high value of peak viscosity (810 AU). The increase of amount of unhusked buckwheat flour in mixtures resulted in decrease of the gelatinization rate and in lower value of maximum torque at point C3. Lower value of torque at point C3 can be consequence of starch nature present in buckwheat flour as well as of milling process which can be responsible for causing larger amount of damaged starch having poorer pasting properties. Also it can be observed that the time needed to reach the value of maximum torque (C3 point) was longer for system containing wheat flour compared to flour mixtures with buckwheat flour. So it can be concluded that starch present in buckwheat flour has lower resistance to increasing temperatures than in the wheat dough system.

The degree of starch retrogradation, which can be expressed as a difference between measured torques at C4 and C5, decreased by increasing the amount of unhusked buckwheat flour. That value for wheat dough was 0.58, while for dough containing 50% and 75% of unhusked buckwheat flour were 0.39 and 0.32 respectively. This could have the positive effect on bread stailing effect which is proved to be due to a starch retrogradation. It is assumed that the reason for such behaviour arise from different structure of amylose and amilopectin fraction of buckwheat starch in comparison to wheat starch (different ratio between amylose and amilopectin, branching of these polymers and their molecular weight). husked buckwheat flour. Furthermore, the increasing amount of buckwheat flour in tested mixtures did not have significant changes in dough development time. flour.

Characteristics of wheat flour and husked buckwheat flour mixtures in two different ratios (50:50 and 25:75) are presented in Figure 3:

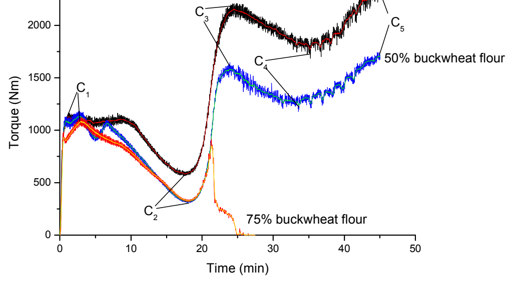

Figure 3. Mixolab profiles of wheat flour and mixtures containing 50% and 75% of husked buckwheat flour

The profile of the first part of the recorded curve was similar to the profile of the curve obtained with the mixture containing unhusked buckwheat flour. Dough development time i.e. time required until the first maximum value is reached (C1) was also longer for mixtures containing buckwheat flour compared to wheat systems.

Table 2.
Results obtained by Mixolab measurements of the systems containing unhusked buckwheat flour

	C1	C2	C3	C4	C5	W.abs (%)	Stab. (min:s)	Amp. (Nm)	α (Nm/min)	β (Nm/min)	γ (Nm/min)
Wheat flour	1,13	0,58	2,16	1,77	2,35	56,5	10:39	0,07	-0,088	0,56	-0,038
50Wh:50 Unh.B.F	1,09	0,36	1,33	0,85	1,24	57,8	4:00	0,1	-0,018	0,272	-0,022
25Wh:75Unh.B.F	1,11	0,37	1,12	0,73	1,05	60,4	5:07	0,1	-0,07	0,194	-0,094

This was due to higher content of cellulose (0.43%) and nature of used Dough stability also decreased with increasing the amount of husked buckwheat flour. It can be observed that the addition of buckwheat flour caused weakening of protein structure (lower value of slope α and of the measured torque at the minimum, point C2) due to dilution of gluten complex of wheat flour. Water absorption did not change importantly by addition and further increasing of husked buckwheat flour due to the absence of component which could increase water absorption, in contrast to unhusked buckwheat During the heating period of the system with 75% of husked buckwheat flour due to starch gelatinization of buckwheat starch and its specific characteristics resulted in dough stickiness on mixing element so further measurement of resulted torque could not be performed i.e. measured value of torque was 0. So the both mixing elements were covered by gelatinized flour and there was no dough between the mixing elements which is in a fact responsible for registration of obtained torque. In order to overcome the incurred problem it was necessary to increase the flour mass i.e. the dough mass so the measurements would have been performed according to the modification of standardised Chopin+ protocol.

Table 3.
Results obtained by Mixolab measurements of the systems containing husked buckwheat flour

	C1	C2	C3	C4	C5	W.abs (%)	Stab. (min:s)	Amp. (Nm)	α (Nm/min)	β (Nm/min)	γ (Nm/min)
Wheat flour	1,13	0,58	2,16	1,77	2,35	56,5	10:39	0,07	-0,088	0,56	-0,038
50Wh:50 Hsk.B.F.	1,13	0,32	1,59	1,24	1,71	55,1	3:47	0,11	-0,072	0,428	-0,162
25Wh:75Hsk.B.F.	1,09	0,33	/	/	/	58	4:57	0,08	-0,044	0,138	/

Consequently, further comparisons were performed analysing the wheat dough system and the dough that contained 50% of husked buckwheat flour. Dough prepared with 50% of husked buck-wheat flour had also lower value of ma-ximum torque at point C3 (Table 3), but the difference was smaller in comparison to mixture that contained 50% unhusked buck-wheat flour.

This was due to larger starch content in husked buckwheat flour than in unhusked buckwheat flour. Also the investigated rate of gelatinization was higher observing the dough prepared with 50% husked buck-wheat flour compared to wheat dough. System containing 50% of husked buckwheat flour had higher values of the degree of retrogadation (0.47) expressed as a difference of the torque values at C5 and C4 than in unhusked buckwheat flour (0.39) because of the higher starch content of husked buckwheat flour. However those values were still lower than in wheat dough system.

CONCLUSIONS

The addition of husked buckwheat flour and unhusked buckwheat flour respectively changed investigated rheological parameters significantly. In both cases the addition of buckwheat flour caused weakening of protein structure due to incapability of buckwheat flour protein to form a network in dough system like gluten does in wheat dough systems. Also the parameters which describe the starch characteristics changed too. The addition of both types of buckwheat flour resulted in lower values of maximum torque which is related to starch viscosity i.e. gelling ability. The addition of buckwheat flour caused the decrease in degree of retrogradation which could be beneficial for the production of bread and bakery products with lower stailing effect.

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