OPEN ACCESS

Potravinarstvo® Scientific Journal for Food Industry

Potravinarstvo, **vol. 10, 2016, no. 1, p. 157-163**
doi:10.5219/555
Received: 8 October 2015. Accepted: 15 December 2015.
Available online: 24 January 2016 at www.potravinarstvo.com

ISSN 1337-0960 (online)

EFFECT OF THE ADDITION OF HYDROCOLLOIDS ON THE RHEOLOGICAL AND BAKING PROPERTIES OF THE PRODUCTS WITH ADDED SPELT FLOUR (*TRITICUM SPELTA* L.)

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ABSTRACT

The paper presents the results of the evaluation of the effect of additives on the rheological properties of composite flour made of wheat flour in the amount of 70% and spelt flour at 30%. As additives guar gum (0.5% by weight of flour) and xanthan gum (0.16% by weight of flour) were used. Properties of produced control dough and doughs with hydrocolloids were evaluated by means of rheological appliances by Farinograph, Extenzograph, Amylograph and Rheofermentometer. Based on the observed results it can be concluded that the addition of xanthan gum has a positive effect on increasing of farinographic water absorption capacity, extension of dough development time and dough stability and generally positively affected farinographic properties. The addition of guar gum has improved especially extensographic properties as extensographic energy and extensographic resistance. Based on amylographic evaluation of control doughs and doughs with additives it can be stated that in the dough with guar gum the amylographic maximum has slightly increased. Hydrocolloid guar gum contributed to an increased retention capacity of dough observed. Based on our measurements we can indicate that addition of guar and xanthan gum contributed to an increased rheological quality of doughs prepared with addition of flour from spelt wheat. With reference to the baking experiment it was found that the use of hydrocolloids has a positive effect on the improvement of the baking properties, in particular larger volume, specific volume, and the volume yield of the dough with the addition of guar and xanthan gum compared to the control. Our results showed that aditives significantly influenced rheological qualities of dough and a baking quality of products. These findings thus allow optimizing the recipe in order to increase the technological quality of leavened bakery products.

Keywords: hydrocolloids; guar gum; xanthan gum; rheological properties; frozen dough

INTRODUCTION

Spelt wheat (*Triticum spelta* L.), family (Poaceae) is like common wheat (*Triticum aestivum* L.) classified as hexaploid wheat with 42 chromosomes and a six-rowed ear. Contrary to the common wheat spelt wheat has the husk that protects the grain against pests, insects and microbial contamination **(Krkošková et al., 2011; Filipčev et al., 2014)**. Spelt wheat can be described as old European cultural wheat that is currently grown in Western Europe, in Austria, Germany, Belgium, Switzerland and northern Spain. Its popularity is increasing due to the lower cultivation demands, and it is also suitable to be grown in foothill areas with poor soil and excess rainfall. It is used in various forms - such as grains, also for production of pasta, crackers, bread and beer **(Bojňanská et al., 2002)**.

The dry matter of common wheat grain is composed of saccharides in an amount of about 70%, with the most important part of the saccharides being starch at 60% – 65%, which consists of amylose (26% – 28%) and amylopectin (72% – 74%). The proportion of oligosaccharides of the total saccharides content is about 2% to 3%. The amount of total dietary fibre in grains varies from 9% to 12%, of which about 2% are made up of soluble fibre and the rest being insoluble fibre **(Feillet, 2000; Pruska-Kedzior et al., 2008; Escarnost et al., 2012)**.

The seed of spelt wheat contains about 15% of protein and the albumin portion is 13% of the total protein content, 3% is of globulins, 40% of prolamins, and 45% glutelins **(Krkošková et al., 2005; Pruska-Kedzior et al., 2008)**. It was found that the digestibility of spelt proteins is better in comparison to wheat protein, but the difference is minimal **(Ranhotra et al., 1995)**. The amount of essential amino acids of the total amino acids in common wheat and spelt wheat differs only marginally, and this difference is not statistically significant suggesting a very similar protein quality **(Grela, 1996; Abdel-Aal et Hucl, 2002). Bojňanská et al. (2002)** indicated that the amount of gluten varies in the range from 30% to 52%.

The grain of spelt wheat contains approximately 3% of fat, predominantly located in the embryo, aleurone, and at the lesser degree in endosperm (about 1.5% of the total lipids) **(Delcour et Hoseney, 2010)**. Fatty acids are represented mainly by linoleic acid (60%) and palmitic acid (17%), and these are lower amounts compared to their content in common wheat. Another major fatty acid is oleic acid (18% in spelt wheat which is 6% more than in common wheat) **(Escarnot et al., 2012)**.

Spelt wheat is similarly to the common wheat a source of B group vitamins with approximately 1.5% concentrated mainly in germ. **Ranhort et al., (1995)** found out comparable amounts of thiamine and riboflavin in the grains of spelt wheat and common wheat. According to findings by **Bojňanská et al., (2002)** the amount of minerals varies between 1.8% and 2.3% depending on the variety and the year. The similar results reported also **Ranhort et al., (1995)** and **Ruibal-Mendiet et al., (2005)**.

Based on these findings it can be concluded that spelt wheat is therefore technologically and nutritionally suitable raw material for the use in bakery products affecting also their sensory characteristics.

Hydrocolloids are high molecular and hydrophilic biopolymers performing several functions in the food industry. The most significant features are their ability to control the rheological properties and texture of food. In the baking industry they are added in particular to stabilize emulsions, suspensions and foams and to improve the processing properties. Among other properties they have the ability to inhibit starch retrogradation, retain moisture, improve the overall structure, and slow down aging of products. They can be used as a substitute for fat and eggs **(Arozarena et al., 2001; Collar et al., 1999; García - Ochoa et al., 2000; Příhoda et al., 2003; Kohajdová et al., 2008 a, b; Magala et al., 2011; Rodge et al., 2012; Šedivý et al., 2013; Eduardo et al. 2014; Qiu et al., 2015)**. An important positive feature is that the use of hydrocolloids even in small quantities (less than 1% by weight of flour), has a significant impact on enhanced ability of dough to bind water, increase the volume of products, slow retrogradation of starch and thus extend the shelf life of bakery products **(Collar et al., 1999; Khan et al., 2007; Škara et al., 2013)**.

Guar gum is defined as the ground endosperm of the seeds of natural strains of the guar plant, *Cyamopsis tetragonolobus* (L.) Taub. (family *Leguminosae*) and it consists of hydrocolloidal polysaccharides of high molecular weight composed of galactopyranose and mannopyranose combined through glycosidic linkages, which may be described chemically as galactomannan **(FC SR, Decree 1)**. The plant grows mostly in India and Pakistan, but since 1950 it has also been grown in Texas and Arkansas as a commercial commodity **(Achayuthakan et Suphantharika, 2008). Kohajdová et al., (2008a)** reported that bread with addition of guar gum had after baking better baking properties, such as a higher volume and improved sensory quality, particularly more attractive appearance and aroma, softer crumb and firmer crust.

Xanthan gum is an exocellular polysaccharide of microbial origin that is produced by aerobic fermentation of sugar by the bacterium *Xanthomonas campestris.* China is its largest producer in the world **(Hojerová et al., 2005; Achayuthakan et Suphantharika, 2008; FC SR Decree 2; Tao et al., 2012)**. The main chain of xanthan gum is formed by β-D- (1,4) glucose units and the side chains are composed by residues of D-glucuronic acid and two mannose moieties D **(Velíšek, 2002)**. Xanthan gum has an impact on strengthening links between flour proteins and thereby firming the dough structure. Baked products with a xanthan gum have larger volume, and optimum shape in comparison to products without this additive. During dough preparation xanthan gum binds to the starch and by that slows down its retrogradation, which is to be said by experts one of the main reasons of products staling **(Collar et al., 1999; Arozarena et al., 2001; Rosell et al., 2001; Gimeno et al., 2004; Ashwini et al., 2009)**.

MATERIAL AND METHODOLOGY

In the study, the effect of the addition of hydrocolloids of xanthan and guar gum to composite flour from spelt wheat on the rheological properties of dough was addressed. The results were compared with objective baking properties of baked products.

To prepare control loaves wheat flour T 650 was used. The second group of loaves was made from composite flour, based on wheat flour T 650 in an amount of 70% (Mlyn Pohronský Ruskov a.s., Hlavná 76, 935 62 Pohronský Ruskov, Slovakia) with an addition of spelt wholemeal flour at 30% (company J. Vince s.r.o., 925 91 Kráľová nad Váhom 320, Slovak Republic). According to recipe fresh compressed yeast was used (Trenčianske droždie, Old Herold Hefe, s.r.o., Bratislavská 36, 911 05 Trenčín, SR). In wheat and composite flour, the moisture was determined (%) **(ICC Standards No. 110/1 (1976))**, as well as content of crude protein (%) **(ICC Standard No. 105/2, (1994))** and content of ash (%) **(ICC Standard No. 104/1 (1990))**. Rheological measurements of prepared composite flour and wheat flour were made by means of *Farinograph-E*, Brabender OhG, Duisburg, Germany **(ICC Standrd 115/1 (1992), AACC Method 54-21 (1995))**. Based on these measurements following characteristics were determined: farinographic flour water absorption capacity (%), dough development time (min), dough stability (min), farinographic quality number. By means of *Extensograph-E*, Brabender OhG, Duisburg, Germany **(ICC - Standard 114/1 (1992), AACC Method 54-10 (1995))** extensographic energy (cm^2), extensographic tensibility (mm) and extensographic maximum (EU) were determined. By means of *Amylographe-E,* Brabender OhG, Duisburg, Germany **(ICC-Standard 126/1, AACC Method 22-10 (1995))** the initial gelatinization temperature (°C), the maximum gelatinization temperature (°C) and the amylographic maximum (AU) were determined.

The recipe of dough, which was tested in rheofermentometer consisted of 250 g of composite flour, fresh yeast in an amount of 2.8%, which was dispersed in water and added to flour during dough preparation in farinograph. After the first minute salt was added in an amount of 2%, and mixing continued for six minutes. The volume of added water depended on flour water absorption capacity to produce dough of optimal consistency. 315 g of dough was then inserted into Rheofermentometer Rheo F4 (Tripette & Renaud Chopine, Villeneuve-la-Garenne, France) **(AACC Method 89-01.01)** in order to determine during a three-hour test *total volume* (cm^3), *volume of CO_2 lost* (cm^3), *retention volume* (cm^3), *retention coefficient R* (%) (ratio of the volume that was detained in the dough to the total volume of produced CO_2).

Experimental loaves were prepared from a mixture of flour (350 g of wheat and 150 g of soy flour), sucrose (5 g), salt (9 g), yeast (20 g) and water addition based on farinographic water absorption capacity. Bread experiment was carried out without the use of enzyme-active substances and other improvement agents. The development of dough took place in a laboratory mixer Diosna SP 12. After that the dough was elaborated and formed into loaves that stayed yeasted in a yeasting room for 20 minutes at temperature of 30 °C and were baked in an oven Miwe Condo at 240 °C with steaming (baking time 20 min). The baked loaves were evaluated by objective methods and the volume of products (cm^3), a specific volume of products ($cm^3.100g^{-1}$), volume yield ($cm^3.100g^{-1}$ flour), cambering (the ratio between height and width) were determined.

RESULTS AND DISCUSSION

The function of hydrocolloids lies in their ability to modify dough and improve its rheological properties, thus contribute to the maintenance of its quality **(Yaseen et al., 2010)**. Another important function of the gums is their ability to enhance the absorption of water in the baked products **(Mandala et al., 2008)** resulting in effecting the rheological properties of the dough and the extended shelf life of the products as they prevent migration of water during the staling of bread **(Fanta et al., 1996; Collar et al., 1999, Kohajdová et al., 2009)**.

Table 1 shows the effect of the addition of guar and xanthan gum on farinograph characteristics of composite flour. The addition of 0.5% of guar gum reduced farinograph water absorption capacity and development of dough compared to samples without this additive. **Rodge et al., (2012)** found that the addition of guar gum worked on shortening the time of dough development and extending dough stability. The application of 0.16% of xanthan gum we have implemented within our experiments did not significantly affect the water absorption capacity of the mixture, but contributed to the prolongation of the dough development. We have found that the addition of guar and xanthan gum had a positive effect on the stability of the dough extension and on the farinographic quality number, which was significantly higher (by 30) than in the control sample. The fact that the xanthan gum in the recipe contributes to increase of farinographic water absorption capacity, extension of dough development and its stability was also confirmed by **Rosell et al., (2001)** and **Davari-Ketilateh et al., (2013)**.

Time of dough development depends on the amount and quality of gluten, granularity of flour and the level of grinding and is determined primarily by the process of gluten hydration **(Dodok et Szemes, 1998)**. Strong flour is according **Muchová (2007)** defined as one that will during processing bind large amount of water, will reach optimum rheological properties slowly and retains them for a long time.

The results presented in Figure 1, which expresses amylographic evaluation of samples, show that the addition of guar gum and xanthan gum in all observed samples caused a slight decrease in the initial gelatinization temperature in comparison to a control sample without the gums. Hydrocolloids according to **Mandala (2012)** impact the acceleration of gelatinization and slow down the retrogradation and our results are consistent with these findings. We also noted that the addition of xanthan gum did not affect the maximum temperature of gelatinization.

The optimum value of amylographic maximum should vary in wheat flours between 300 AU and 650 AU, which is a sign of optimum amylase activity and products from these flours are identified as technologically very good **(Dodok et Szemes, 1998; Šedivý et al., 2013)**. Very high curve values of amylographic maximum above 800 AU predict flours with low amylase activity, and thus we can assume that the products from them would have very dry crumb with potential cracks and bland taste.

The results presented in Figure 2 describing extensographic parameters of composite flour with the addition of spelt flour and hydrocolloids show that with increasing time of maturing the value of extensographic energy has increased. Optimal values according to **Šedivý et al., (2013)** are between 90 cm^2 and 300 cm^2. After thirty minutes of maturing the highest value of extensographic energy was in the sample with guar gum at 94 cm^2, then the sample with xanthan gum at 84 cm^2 and lowest in the control sample without hydrocolloids at 80 cm^2. After thirty minutes of maturing the highest value of extensographic energy was in the sample with guar gum at 94 cm^2, then the sample with xanthan gum at 84 cm^2 and lowest in the control sample without hydrocolloids at 80 cm^2. Based on our findings it can be concluded that the best value of extensographic energy was in samples with guar gum.

Table 1 Farinographic parameters of composite flour (70% T 650 and 30% spelt wheat flour with addition of hydrocolloids).

Flour sample	farinographic flour water absorption capacity %	dough development time min	dough stability min	farinographic quality number
70%T650 + 30% T. spelt flour control	62.0	5.3	7.7	101
70%T650 + 30% T. spelt flour +0,5% guar gum	51.0	3.8	9.6	131
70%T650 + 30% T. spelt flour +0,16% xanthan gum	62.1	7.2	10.6	131

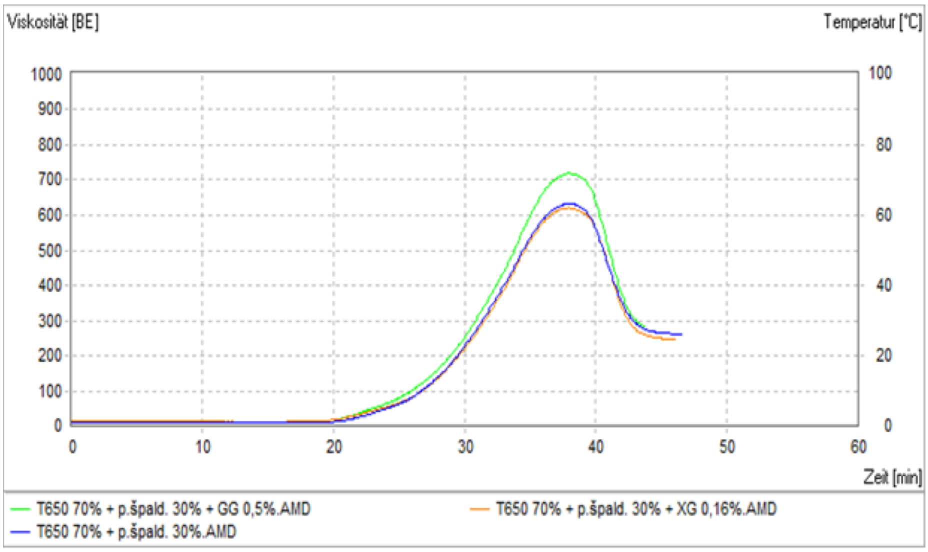


Figure 1 Amylographic parameters of composite flour with addition of spelt wheat and hydrocolloids.

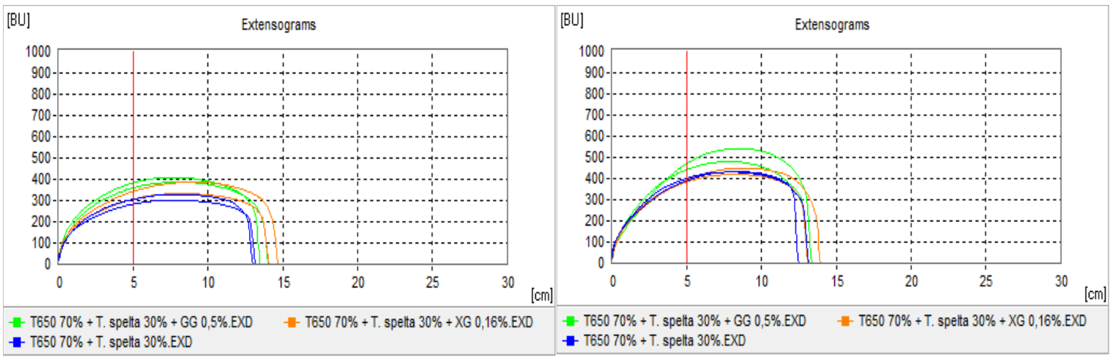
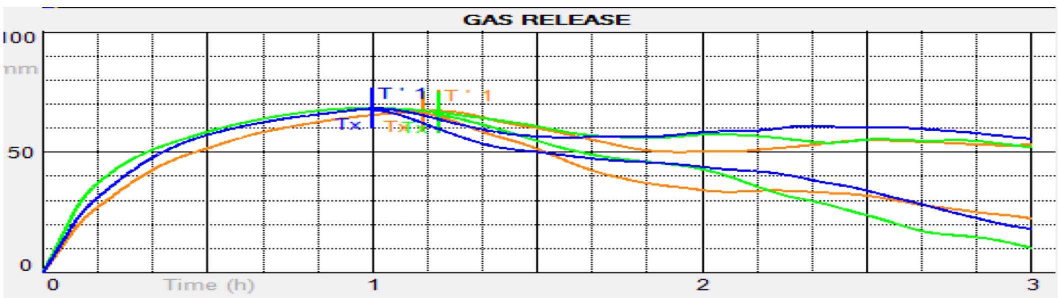


Figure 2 Extensographic parameters of composite flour with addition of spelt wheat and hydrocolloids after 15 and 30 minutes of maturing.



Picture 3 Reofermentometric parameters of composite flour with addition:

Spelt wheat, Guar gum, Xantan gum.

Higher value of extensographic resistance is a sign of strong gluten of good quality, which is mechanically resistant during manipulation with dough **(Příhoda et al., 2003)**. We found that with increasing time of maturing the dough resistance and extensographic maximum have increased which can be considered a positive result.

A comparison of the effect of hydrocolloids on extensographic maximum and dough resistance shows that guar gum had a significant impact on increasing of these values and it predicts products with a good volume.

For leavened bakery products the high elongation of dough is not desirable **(Dodok et Szemes, 1998)**. Optimal values for wheat flour are according to **Šedivý et al., (2013)** from 120 mm to 200 mm (±8 mm). With increasing of dough maturing time there was a slight decrease of elongation spotted in a control sample as well as in dough sample with the addition of hydrocolloids. In dough from composite flour with the addition of guar gum after fifteen and thirty minutes of maturing the elongation has increased in comparison to control.

Table 2 Results of bakery experiment with composite flour of 70% T 650 and 30% flour from spelt wheat with addition of hydrocolloids.

	70% T650+30% T. spelt flour control	*70% T650+30% T. spelt flour + 0,5% guar gum*	*70% T650+30% T. spelt flour + 0,16% xanthan gum*
Loaf volume cm^3	200.0	212.5	212.5
Specific loaf volume (cm^3.100g)	226.7	240.0	242.5
Volume recovery (cm^3.100g flour)	320.0	340.0	340.0
Recovery of product (%)	141.1	141.5	140.4
Baking loss %	14.6	13.8	14.6

Similar results describing that the addition of guar gum influenced the increasing of elongation were published by **Ribotta et al., (2004)**. Addition of hydrocolloids increased dough resistance during manipulation, which is from technological view point of significant importance.

Reofermentometric evaluation, the results of which are presented in Figure 3 showed that the addition of guar and xanthan gum does not significantly affect dough retention capacity. It can be regarded as positive that in dough with the addition of xanthan gum the breaking point occurred about nine minutes later, and in dough with guar gum even 12 minutes later than in the control dough without additives. Similar results in which the guar gum demonstrated itself as an additive delaying the time at which a break point occurs, and which increases retention were also found in the previous research with doughs made from flour of common wheat.

Results of experimental baking presented in Table 2 show that guar and xanthan gum positively influenced the total volume of products, the volume yield and specific volume compared with products without hydrocolloids. Similar results regarding the positive impact of hydrocolloids on baking properties were published by **Kohajdová et al., (2008a)**. Table 2 also shows that the addition of hydrocolloids did not influence the baking yield and baking loss during baking, since they were in all variants at a comparable level.

CONCLUSION

Summarizing and comparing the results of rheological evaluation of composite flour with the addition of spelt flour showed that the addition of guar gum extended dough stability time and increased dough farinograph number of quality compared to the control.

Significant improvement of the farinograph characteristics was observed in dough with the addition of xanthan gum, and this finding is very positive. Addition of guar gum in an amount of 0.5% positively influenced and improved extensographic properties of composite flour. Guar gum contributed to the increase of amylographic maximum, but in this case it can be considered as negative because an excessive increase of this value predicts reduced sensory quality of baked products.

The use of xanthan gum, in contrast to guar gum optimised amylographic properties, and thus an excellent quality of the crumb can be predicted. Evaluation of composite flours in reofermentometer showed that using of guar gum may slightly increase dough retention capacity, which is technologically positive finding, because maintaining of fermentation gas is a key factor to ensure sufficient volume of bakery products. Based on the evaluation of baking experiment it can be concluded that the loaves containing added guar and xanthan gum achieved compared to a sample without additives better indicators of bakery quality, which was reflected mainly by higher volume, specific volume and volume yield.

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Acknowledgments:

The research leading to these results has received funding from the European Community under project ITEM 26220220180 Building Research Centre „AgroBioTech" and project VEGA 1/0308/14.

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