ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume LIX 33 Number 6, 2011

THE EFFECT OF PECTIN FROM APPLE AND ARABIC GUM FROM ACACIA TREE ON QUALITY OF WHEAT FLOUR DOUGH

P. Pečivová, K. Juříková, I. Burešová, M. Černá, J. Hrabě

Received: June 22, 2011

Abstract

PEČIVOVÁ, P., JUŘÍKOVÁ, K., BUREŠOVÁ, I., ČERNÁ, M., HRABĚ, J.: *The effect of pectin from apple and arabic gum from acacia tree on quality of wheat flour dough.* Acta univ. agric. et silvic. Mendel. Brun., 2011, LIX, No. 6, pp. 255–264

The influence of hydrocolloids on the qualitative properties of wheat flour dough was monitored by farinograph. The addition of arabic gum from acacia tree to the dough decreased water absorption and the degree of softening but the development time of the dough increased. The improvement in quality of the doughs occurred only after the addition of 15.0 g.kg^{-1}. The addition of pectin from apple increased water absorption of the dough. Dough stability was increasing until the addition of 5.0 g.kg^{-1} but then it decreased. The degrees of softening were decreasing until the addition of 5.0 g.kg^{-1} but then they increased. Farinograph quality number was increasing until the addition of 5.0 g.kg^{-1} pectin from apple but then it decreased to the value of 149. These hydrocolloids are able to modify different qualitative properties of dough depending on their amount.

dough, hydrocolloid, quality, stability

Bread dough is a viscoelastic material with explicit nonlinear behaviour that exhibits intermediate rheological behaviour between a viscous liquid and an elastic solid (Weipert, 1990). The viscoelastic properties of wheat flour doughs have profound effects on dough machinability, textural characteristics and keepability of the finished product (Uthayakumaran *et al.*, 2000). Consequently, a proper measurement of dough viscoelasticity with suitable rheological techniques is of key importance in linking the composition and structure of the raw materials – basic and added ingredients, additives and technological aids – with the functionality of the dough in the bakery (Bloksma, 1990; Walker and Hazelton, 1996; Bollaín and Collar, 2004).

The gluten matrix is a major determinant of important rheological characteristics of the dough such as elasticity, extensibility, resistance to stretch, mixing tolerance and gas holding ability. Several rheological techniques, including oscillation, stress relaxation, creep and creep – recovery measurements have been used in many studies to probe the fundamental mechanical properties of gluten (Janssen *et al.*, 1996a; Lee and Mulvaney, 2003) and wheat doughs (Weipert, 1990; Janssen *et al.*, 1996b; Baltsavias *et al.*, 1997; Phan-Thien and Safari-Ardi, 1998; Safari-Ardi and Phan-Thien, 1998; Edwards *et al.*, 1999; Edwards *et al.*, 2001; Edwards *et al.*, 2003; Lazaridou *et al.*, 2007) as well as to establish the relations between the properties and quality attributes of the end – product (Autio *et al.*, 2001; Carson and Sun, 2001; Wang and Sun, 2002; Dobraszczyk and Morgenstern, 2003; Lazaridou *et al.*, 2007).

Apparently, several different instruments, including farinograph, extensograph, mixograph, alveograph, maturograp, etc. can be used for measuring the rheological properties of dough.

Additives are used in the bakery to modify the properties of raw materials (especially flour), to guarantee a constant quality and to preserve freshness.

Hydrocolloids have been widely used in food products to modify texture, improve moisture retention, control water mobility and maintain the overall product quality during storage (Stampfli *et al.*, 1996; Bhattacharya *et al.*, 2006). They have also shown good properties as a fat mimetic in different products (Albert and Mittal, 2002; Guarda *et al.*, 2004). The effects of hydrocolloids on the functional properties of wheat bread have been investigated; in such products gums improve dough stability, bread performance and bread shelf life (Christianson *et al.*, 1974; Mettler and Seidel, 1993; Davidou *et al.*, 1996; Yoshimura *et al.*, 1996; Collar *et al.*, 1999; Rojas *et al.*, 1999; Rosell *et al.*, 2001; Guarda *et al.*, 2004; Ribotta *et al.*, 2005). The effects of hydrocolloids on the functional properties of dough and bread quality depend on the nature, origin and particle size of the hydrocolloid as well as the dosages of the hydrocolloid incorporated into dough formulations. Protein and polysaccharide functions are greatly affected by their interactions with each other and with other components of food systems (Ribotta *et al.*, 2005).

Arabic gum has been used as a gluten substitute in the formation of gluten – free breads (Toufeili *et al.*, 1994). Arabic gum has also been an effective improver, decreasing crumb hardness and increasing specific volume of the bread obtained from frozen doughs (Asghar *et al.*, 2006; Bárcenas *et al.*, 2009). Arabic gum does not affect hydration properties of the gluten. Arabic gum has a branched but compact structure that could inhibit possible interaction between its polar groups with the peptide chains of the gluten. Arabic gum act primarily on the viscometric properties of starch (Bárcenas *et al.*, 2009).

Pectin has become highly valued since it is a dietary fibre. Accumulating evidence suggests that it can reduce cholesterol (Brown *et al.*, 1999), delay gastric emptying, and induce apoptosis of colon cancer cells. When used in food products, pectin functions as a gelling and thickening agent to modify texture and rheology. However, due to the strong gelling and thickening characteristics, there are considerable difficulties in incorporating high levels of pectin into foods (Theuwissen and Mensink, 2008). Therefore, the development of foods with higher levels of pectin acceptable to consumers is being pursued. There have been previous studies which reported a possible use of the pectin - enriched materials from plant sources. Fissore *et al.* (2009) produced pectin – enriched products from butternut with the assistance of cell wall hydrolytic enzymes for thickeners in the food industry. Pectin was also used as a fat replacer in low - fat frankfurters (Pappa *et al.*, 2000; Candogan and Kolsarici, 2003) and cheeses (Lobato-Calleros *et al.*, 1999; Lobato-Calleros *et al.*, 2001) but fat replacement with pectin has not yet been extended to other types of food. Pectin mainly affect gluten hydration, modifying its quantity and quality. Pectin decreased the viscoelastic moduli during heating and cooling, yielding a weakening effect on gluten (Bárcenas *et al.*, 2009).

The aim of this study was to determine the effect of two hydrocolloids (pectin from apple, arabic gum from acacia tree) with different chemical structure on the complex rheological properties of wheat flour dough and thus its quality.

MATERIALS AND METHODS

Materials

Flour

For the assessment, common commercial wheat flour T 530 (quantitative parameters: moisture content 143 g.kg^{-1}, wet gluten in dry matter 313 g.kg^{-1}, gluten index 91, falling number 424 s, water absorption 600 g.kg^{-1}) provided by Penam, Kroměříž, Czech Republic was used.

Additives

NaCl and redistilled water were used for measuring. The following hydrocolloids were used: pectin from apple (Specification: synonym: Poly - D - galacturonic acid methyl ester, loss on drying < OR = 10.0%, lead < OR = 5 PPM, sugars and organic acids < OR = 20 MG, assay for methoxy groups (dry basis) > OR = 6.7%, assay for galacturonic acid (dry basis) > OR = 74.0%) from Sigma-Aldrich, Germany in the additions of 2.0 g.kg^{-1}, 3.0 g.kg^{-1}, 4.0 g.kg^{-1}, 5.0 g.kg^{-1}, 6.0 g.kg^{-1}, 7.0 g.kg^{-1} and 10.0 g.kg^{-1}, and arabic gum from acacia tree (Specification: appearance (colour) - off white, appearance (form) – powder, loss on drying ≤ 15 %) from Sigma - Aldrich, Germany in the additions of 2.0 g.kg^{-1}, 5.0 g.kg^{-1}, 10.0 g.kg^{-1}, 15.0 g.kg^{-1}, 20.0 g.kg^{-1}, 25.0 g.kg^{-1} and 30.0 g.kg^{-1}.

METHODS

Chemical analysis

Determination of moisture of the dough was done according to the ISO norm 712 (2009).

Within the analysis, pH was measured by means of a pH-meter (Gryf 209 S) at a temperature of 22 ± 1 °C during the farinograph measurement. Within the farinograph measurement, pH was determined in the dough which consisted only of redistilled water and flour. In order to discover if the addition of particular hydrocolloids influenced the key values, the results were compared with the values of the control sample which did not contain any additives.

Rheology

The individual measurements were performed in two hydrocolloids (arabic gum from acacia tree, pectin from apple) in 7 different additions. The amounts of the hydrocolloids were selected according to their chemical structure and their effect on the rheological properties of dough.

Higher amounts were used in the case of arabic gum from acacia tree because the differences between the control sample and the addition of 10.0 g.kg^{-1} were not very significant. Therefore the

I: *Results of chemical analysis of control sample and samples with additions of arabic gum from acacia tree*

Chemical characteristic	Control sample	Arabic gum from acacia tree (g.kg^{-1})						
		2.0	5.0	10.0	15.0	20.0	25.0	30.0
pH – farinograph	6.15	6.13	6.08	6.14	6.05	6.15	6.07	6.12
Dry matter (%)	46.42	46.33	46.05	45.70	45.05	44.72	44.34	44.15

additions of 2.0 g.kg^{-1}, 5.0 g.kg^{-1}, 10.0 g.kg^{-1}, 15.0 g.kg^{-1}, 20.0 g.kg^{-1}, 25.0 g.kg^{-1} and 30.0 g.kg^{-1} were used.

Farinograph measurement

Before the actual farinograph measurement, determination of moisture is necessary. The measurement was performed by means of ISO norm 5530-1 (1997). The moisture of flour was determined according to ISO norm 712 (2009). The measurement of water absorption, dough development time, dough stability, degree of softening and farinograph quality number were carried out on a Brabender® Farinograph (Brabender® GmbH & Co, Duisburg, Germany). Visual comparison of the curves was performed in Farinograph Data Correlation program (Brabender® GmbH & Co, Duisburg, Germany).

Statistical analysis

The results of the basic chemical analysis were statistically evaluated. The results of the farinograph measurement were statistically evaluated by analysis of variance (ANOVA) using Statgraphics (Anonymus, 1991).

RESULTS AND DISCUSSIONS

Chemical analysis of the dough with the addition of arabic gum from acacia tree

With the increasing addition of arabic gum from acacia tree, the value of dry matter in the sample was decreasing in comparison with the control sample. The difference between the lowest addition (2.0 g.kg^{-1} arabic gum from acacia tree) and the control sample is not significant. Our results are not in agreement with the work of Bárcenas *et al.* (2009) who investigated that the presence of arabic gum does not affect hydration properties of the gluten. But on the other hand, our results are in agreement with works of authors (Yoshimura *et al.*, 1996; Rojas *et al.*, 1999; Rosell *et al.*, 2001) who state that hydrocolloids immobilize water molecules, resulting in an increase of the effective starch concentration.

The highest addition (30.0 g.kg^{-1} of arabic gum from acacia tree) resulted in a difference of 2.27 % in comparison with the control sample. The decrease in dry matter in the sample with the addition of arabic gum from acacia tree is caused by a drop in the flour absorption. The flour absorption was decreasing with the increasing amount of the additive.

The comparison of the pH results in Tab. I shows that the values of the samples with the addition of arabic gum from acacia tree obtained during the farinograph measurement were practically the same as the pH values of the control sample. Arabic gum did not influence pH significantly. Average pH was 6.11 and S.D. was 0.04. There was no obvious trend.

Chemical analysis of the dough with the addition of pectin from apple

In the sample with the addition of pectin from apple, dry matter was increasing in comparison with the control sample. The difference between the lowest addition (2.0 g.kg^{-1} pectin from apple) and the control sample was also not significant. The difference between the highest addition (10.0 g.kg^{-1} pectin from apple) and the control sample was 1.77 %. The increase in dry matter was caused by an increased flour absorption in the samples with the addition of pectin from apple. The absorption increased due to the presence of hydroxyl groups within the hydrocolloid molecule. They facilitated an increased formation of hydrogen bonds and thus a higher water absorption. Our results are in agreement with the work of Stampfli *et al.* (1996) who investigated that hydrocolloids are widely used in food products to improve moisture retention and control water mobility.

During the farinograph measurement, the samples with the addition of pectin from apple showed a slight decrease in pH. It might have been caused by the chemical structure of pectin from apple, which contains polygalacturonic acid in its molecule. For that reason, there was a shift of pH to more acidic values.

The effect of arabic gum from acacia tree on the farinograph measurements

The results of the farinograph measurements show the influence of hydrocolloids (pectin from apple, arabic gum from acacia tree) on the qualitative properties of the dough, which are important during its processing.

From the viewpoint of dough absorption, statistical significance was found between the control sample (without the addition of arabic gum from acacia tree) and the samples of dough with the additions of arabic gum from acacia tree (5.0, 10.0, 15.0, 20.0, 25.0, 30.0 g.kg^{-1}) ($P < 0.05$). Our results are not in agreement with the work of Bhattacharya *et al.* (2006) who stated that the ability of gum to hold high volume of water and thereby increasing the plasticising effect of the dough. Moreover, statistical significance was determined in the dough sample with the lowest addition (2.0 g.kg^{-1}), which has a higher absorption than the samples with the additions of arabic gum from acacia tree (10.0–30.0 g.kg^{-1}) ($P < 0.05$), between the dough sample with the addition of 5.0 g.kg^{-1} arabic gum from acacia tree and the dough samples with the additions of (15.0–30.0 g.kg^{-1}) and also between the dough sample with the addition of 10.0 g.kg^{-1} and the dough samples with the additions of arabic gum from acacia tree (15.0–30.0 g.kg^{-1}). The results shown in Tab. III reveal that the control dough sample has a higher absorption than the samples with the additions of arabic gum from acacia tree and also that with the increasing amount of arabic gum from acacia tree the absorption is gradually decreasing.

From the viewpoint of development time, statistically significant difference was found between the control sample and the doughs with additions of arabic gum from acacia tree (10.0–30.0 g.kg^{-1}), between the dough with the lowest addition (2.0 g.kg^{-1}) and the dough with the additions of (5.0–30.0 g.kg^{-1}) and also between the dough with the addition of 5.0 g.kg^{-1} and the doughs with the additions of (20.0, 25.0 g.kg^{-1}) arabic gum from acacia tree ($P < 0.05$). Tab. III clearly shows that in comparison with the control sample, the development time increased with the rising addition of arabic gum from acacia tree. The increasing development time illustrates that the dough with the addition of arabic gum from acacia tree needs a longer relaxation time (the dough is tougher). Our results are not in agreement with the work of Bárcenas *et al.* (2009) who said that the addition of arabic gum decreased the elastic modulus at 25 °C.

A statistically significant difference was also found in the degree of softening measured 10 minutes after the beginning of measurements between the control sample and the dough samples with the additions of arabic gum from acacia tree (15.0–30.0 g.kg^{-1}) and also between the dough sample with the addition of 2.0 g.kg^{-1} and the dough samples with the additions of (15.0–30.0 g.kg^{-1}) arabic gum from acacia tree ($P < 0.05$). The degree of softening measured 10 minutes after the beginning of measurements was decreasing with the increasing amount of arabic gum from acacia tree (Tab. III), which was caused by the rising development time because the degree is calculated as the difference between the value of consistency in maximum and the value of consistency after 10 minutes. Our results are in agreement with the work of Bhattacharya *et al.* (2006) who investigated that cohesiveness and adhesiveness increased with an increase in gum content. The result is consistent with finding by Bárcenas *et al.* (2009) who said that the addition of arabic gum decreased the viscous modulus. Our results are in agreement with the work of Lazaridou *et al.* (2007) who stated the same conclusion in gluten free doughs.

The development time neared 10 minutes, the shorter was the time during which the curve dropped. Therefore, the slowest softening was observed in the addition of 25.0 g.kg^{-1} which had the development time of 9.5 minutes (Tab. III).

A statistically significant difference was also found in the farinograph quality number between the dough sample with the lowest addition of arabic gum from acacia tree (2.0 g.kg^{-1}) and the dough samples with the additions of (15.0–30.0 g.kg^{-1}) ($P < 0.05$). According to the farinograph quality number (FQN), an improvement in the quality of the doughs occurred only after the addition of 15.0 g.kg^{-1} when the FQN value increased in comparison with the control sample (Tab. III). FQN determines the quality of dough and thus influences the quality

II: *Results of chemical analysis of control sample and samples with additions of pectin from apple*

Chemical characteristic	Control sample	Pectin from apple (g.kg^{-1})						
		2.0	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**10.0**
pH – farinograph	6.15	5.99	5.85	5.87	5.80	5.84	5.90	5.79
Dry matter (%)	46.42	46.52	46.64	46.93	47.04	47.26	47.50	48.19

III: *Farinograph results of control dough and dough with addition of arabic gum from acacia tree*

	Control sample	Arabic gum from acacia tree (g.kg^{-1})						
		2.0	**5.0**	**10.0**	**15.0**	**20.0**	**25.0**	**30.0**
Water absorption (%)	60.0^{a}	59.7^{a}	59.3^{a,c}	58.9^{b,c}	57.9^{d}	57.4^{d}	57.5^{d}	57.3^{d}
Development time (min)	3.5^{a,d}	4.8^{a}	6.0^{b,d}	7.2^{b,c}	8.4^{b,c}	8.9^{c}	9.5^{c}	8.5^{b,c}
Stability (min)	12.3^{a}	14.6^{a}	9.2^{a}	13.2^{a}	14.5^{a}	14.9^{a}	14.8^{a}	15.0^{a}
Degree of softening (10 min after max., FU)	21^{a}	18^{a}	10^{a,c}	10^{a,c}	8^{b,c}	5^{b,c}	3^{b,c}	4^{b,c}
Degree of softening (12 min after max., FU)	30^{a}	31^{a}	32^{a}	35^{a}	41^{a}	42^{a}	46^{a}	45^{a}
Farinograph quality number	159^{a,c}	142^{a}	148^{a,c}	148^{a,c}	168^{b,c}	168^{b,c}	171^{b,c}	171^{b,c}

The same letter within a row are not significantly different ($P \leq 0.05$)

of the final bakery product. Therefore, in order to improve the quality of bakery products, higher additions of arabic gum from acacia tree to dough are more recommended in this case.

Within the observed characteristics such as stability and degree of softening measured 12 minutes after the maximum, no statistically significant difference was found between the control sample and the dough samples with the additions of arabic gum from acacia tree or among the individual dough samples with the additions of arabic gum from acacia tree ($P > 0.05$).

During the measurement, an increased stickiness of the dough was observed. The stickiness was increasing linearly with the addition of arabic gum from acacia tree. The stickiness might have been caused by the presence of galactose in arabic gum from acacia tree which slightly increases the content of simple sugars.

The effect of pectin from apple on the farinograph measurements

As far as the absorption in pectin from apple is concerned, it is the other way round. A statistically significant difference was found between the control sample (without the addition of pectin from apple) and the dough samples with all additions of pectin from apple ($P < 0.05$), between the sample with the lowest addition of pectin from apple (2.0 g.kg^{-1}) and the dough samples with the additions of (4.0, 5.0, 6.0, 7.0, 10.0 g.kg^{-1}) ($P < 0.05$), between the dough sample with the addition of (3.0 g.kg^{-1}) and the dough samples with the additions of (5.0–10.0 g.kg^{-1}), between the dough sample with the addition of (4.0 g.kg^{-1}) and the dough samples with the additions of (6.0–10.0 g.kg^{-1}), between the dough sample with the addition of (5.0 g.kg^{-1}) and the dough samples with the additions of (7.0–10.0 g.kg^{-1}), between the dough sample with the addition of (6.0 g.kg^{-1}) and the dough samples with the additions of (7.0–10.0 g.kg^{-1}) and between the dough sample with the addition of 7.0 g.kg^{-1} and 10.0 g.kg^{-1} ($P < 0.05$). The results in Tab. IV clearly show that the addition of pectin from apple, water absorption in the dough was increasing. The difference between the control sample and the highest addition (10.0 g.kg^{-1}) was 4.4%. Also, the stickiness of the dough was rising proportionately with the increasing absorption, which made the manipulation with the dough more difficult (Tab. IV).

From the viewpoint of stability, a statistically significant difference was found between the dough sample with the lowest addition of pectin from apple (2.0 g.kg^{-1}) and the dough sample with the highest addition (10.0 g.kg^{-1}) and between the dough sample with the addition of (5.0 g.kg^{-1}) and the dough sample with the highest addition (10.0 g.kg^{-1}) ($P < 0.05$). In the samples with the addition of 7.0 g.kg^{-1} pectin from apple and mainly in the dough sample with the addition of 10.0 g.kg^{-1}, an increased stickiness of the dough was observed, which led to a significant drop in the quality of the dough and thus to a decrease in stability of the dough (Tab. IV).

A statistically significant difference was found in the degree of softening measured 10 minutes after the beginning of measurements between the control sample and the dough samples with the additions of (3.0–10.0 g.kg^{-1}) pectin from apple, between the lowest addition (2.0 g.kg^{-1}) and the dough samples with the addition of (5.0–10.0 g.kg^{-1}) and also between the dough sample with the addition of 4.0 g.kg^{-1} pectin from apple and 7.0 g.kg^{-1} ($P < 0.05$). Tab. IV illustrates that the degree of softening measured 10 minutes after the beginning was falling with the increasing addition. In this case it was also caused by a longer development time (Tab. IV). Our results are not in agreement with the work of Bárcenas *et al.* (2009) who said that low addition of hydrocolloids decreased the elastic modulus (G') at 25 °C, however further increase of the concentration of arabic gum or pectin (up to 0.013 g of hydrocolloid per gram of gluten) augmented it.

A statistically significant difference was also found in the degree of softening measured 12 minutes after reaching the maximum. A statistically significant difference was found between the control sample and the highest addition of pectin from apple (10.0 g.kg^{-1}) ($P < 0.05$) as well as between the dough samples with lower additions such as 2.0 g.kg^{-1}, 3.0 g.kg^{-1}, 4.0 g.kg^{-1} and 5.0 g.kg^{-1} and the dough samples with the highest additions such as 7.0 g.kg^{-1}, 10.0 g.kg^{-1} ($P < 0.05$). The degree of softening was decreasing until

IV: *Farinograph results of control dough and dough with addition of pectin from apple*

	Control sample	Pectin from apple (g.kg^{-1})						
		2.0	3.0	4.0	5.0	6.0	7.0	10.0
Water absorption (%)	60.0^{g}	60.6^{a}	60.9^{a,b}	61.4^{b,c}	61.9^{c,d}	62.1^{d}	63.0^{e}	64.4^{f}
Development time (min)	3.5^{a}	4.9^{a}	5.3^{a}	4.7^{a}	5.4^{a}	11^{a}	11.2^{a}	11.2^{a}
Stability (min)	12.3^{a,b}	13.5^{a}	12^{a,b}	12.2^{a,b}	13.8^{a}	12.5^{a,b}	11.3^{a,b}	6.8^{b}
Degree of softening (10 min after max., FU)	21^{e}	15^{a,e}	11^{a,b,c}	12^{a,b}	7^{b,c}	7^{b,c}	3^{c,d}	4^{b,d}
Degree of softening (12 min after max., FU)	30^{a,c}	26^{a}	17^{a}	13^{a}	14^{a}	70^{a,b}	85^{b,c}	102^{b}
Farinograph quality number	159^{a,b}	186^{a,b}	200^{a}	200^{a}	191^{a,b}	179^{a,b}	179^{a,b}	149^{b}

The same letter within a row are not significantly different ($P \leq 0.05$)

the addition of 5.0 g.kg^{-1}. Until this addition, the doughs showed improved properties. The doughs were more mechanically resistant, more stable and did not show such a strong stickiness as the doughs with a higher addition of pectin from apple (Tab. IV). With the other additions, the degree of softening increased dramatically – with the highest addition it reached the value of 102 FU. The result is consistent with finding by Bárcenas *et al.* (2009) who investigated that the addition of pectin from apple decreased the viscous modulus.

As it follows from the values, with the additions of 6.0 g.kg^{-1}, 7.0 g.kg^{-1} and 10.0 g.kg^{-1} a deterioration in quality of the dough occurred. The doughs quickly became softer and less resistant to mechanical processing. Therefore, these additions of pectin from apple are not recommended (Tab. IV).

From the viewpoint of the farinograph quality number, a statistically significant difference was found between the dough sample with the addition of 3.0 g.kg^{-1} pectin from apple and that of 10.0 g.kg^{-1} and between the dough sample with the addition of 4.0 g.kg^{-1} pectin from apple and the highest addition of 10.0 g.kg^{-1} ($P < 0.05$). The farinograph quality number is indirectly related to the degree of softening. It is caused by the fact that the FQN refers to the part of time axis from the beginning of the measurement to the point in which the curve drops by 30 FU after reaching the maximum. The fast softening (see the degree of softening (12. min)) led to a rapid fall of the curve and thus a faster decrease of 30 FU, which resulted in a lower FQN value in the case of higher degree of softening. The farinograph quality number was increasing until the addition of 5.0 g.kg^{-1} pectin from apple. From the addition of 6.0 g.kg^{-1} on, the FQN was decreasing with the increasing addition of pectin from apple to the value of 149, which was reached by adding 10.0 g.kg^{-1}. This value was lower in comparison to control sample and thus it can be said that with the addition of 10.0 g.kg^{-1}, the quality of the dough deteriorated. Also, the FQN showed that the addition of pectin from apple improves the properties only until the addition of 5.0 g.kg^{-1}. In the other additions, the above – mentioned undesired qualities (stickiness, lower stability, fast softening) occurred (Tab. IV).

The improvement in rheological properties of the doughs (as mentioned above) occurred until the addition of 5.0 g.kg^{-1} pectin from apple, when it reached an optimal development time, the stability and FQN had a rising tendency and on the other hand, degree of softening (12 minutes after the maximum) had a tendency to fall. However, with these additions the stickiness of the dough also increased slightly. With the higher additions of pectin from apple, the quality of the doughs was deteriorating. From the addition of 6.0 g.kg^{-1} pectin from apple onwards, an increase in the degree of softening (12 minutes after the maximum) and the development time occurred. A higher addition of pectin from apple required a longer development time in order to reach the maximum consistency when pectin from apple and individual ingredients of the dough blended together. However, afterwards the dough was quickly losing its stability and became softer. From these additions onwards, the FQN had a falling tendency. As it follows, it is recommended to add rather low additions of pectin from apple into the dough in order to improve its quality (Tab. IV).

Within the development time observed, no statistically significant difference was found between the control sample and the dough samples with the addition of pectin from apple or among the individual dough samples with the addition of pectin from apple ($P > 0.05$).

CONCLUSION

The results of the chemical analysis revealed that the addition of arabic gum from acacia tree had no influence on pH of the dough. Only the addition of pectin from apple into the dough led to a slight decrease in pH.

Dry matter of the dough with the addition of pectin from apple was increasing according to rising amount of pectin from apple in the dough. In arabic gum from acacia tree it was the other way round.

As it follows from the results of the farinograph measurement, the addition of arabic gum from acacia tree into the dough led to a decrease in flour absorption. The flour absorption was decreasing linearly and with the highest addition of arabic gum from acacia tree it decreased by 2.7 % in comparison with the control dough.

On the other hand, the addition of pectin from apple resulted in increase of flour absorption. With the highest addition of pectin from apple, the absorption was higher by 4.4 % in comparison to the absorption of the control sample.

With the increasing addition of arabic gum from acacia tree the dough absorption was decreasing. Also, a decrease in the level of softening occurred 10 minutes after the beginning of measurements. On the other hand, development time was increasing with the rising addition of arabic gum from acacia tree. The farinograph quality number increased only from the addition of 15.0 g.kg^{-1} arabic gum from acacia tree onwards.

By contrast, with the rising addition of pectin from apple the dough absorption increased. First, the dough stability was increasing but it began to decrease from the addition of 7.0 g.kg^{-1} onwards. This is also related to increase in the degree of softening 10 minutes after the beginning of measurements and the degree of softening measured 12 minutes after reaching the maximum from the addition of 6.0 g.kg^{-1} onwards. The farinograph quality number was increasing until the addition of 5.0 g.kg^{-1} pectin from apple. From the addition of 6.0 g.kg^{-1} onwards, the FQN was decreasing with the rising addition of pectin from apple till the value of 149, which was reached by the addition of 10.0 g.kg^{-1}. This value was lower in comparison with the control sample, which means that at this value the quality of the dough deteriorated.

From the viewpoint of improvement in the quality of dough, both arabic gum from acacia tree and pectin from apple are suitable additives which can be added into dough in certain concentrations and thus enhance or modify the rheological properties of dough and improve the quality of the final bakery product.

SUMMARY

The aim of this thesis was to monitor the influence of hydrocolloids (arabic gum from acacia tree and pectin from apple) on rheological properties of wheat flour dough by means of farinograph.

The addition of arabic gum from acacia tree to the dough decreased water absorption and degree of softening (10 min after max.). However, development time of the dough increased. According to farinograph quality number, the improvement in quality of the doughs occurred only after the addition of 15.0 g.kg^{-1}, when the FQN value increased in comparison with the control sample. The addition of pectin from apple increased water absorption of the dough. Dough stability was increasing until the addition of 5.0 g.kg^{-1} but then it decreased. The degree of softening 10 min after max. and 12 min after max. were decreasing until the addition of 5.0 g.kg^{-1} but then they increased. Farinograph quality number was increasing until the addition of 5.0 g.kg^{-1} pectin from apple but then it decreased to the value of 149, which was reached by the addition of 10.0 g.kg^{-1}.

If necessary, arabic gum from acacia tree and pectin from apple are able to modify rheological properties of doughs and thus improve the quality of the final bakery product.

This work was kindly supported by a project of the Czech Ministry of Education, Youth and Sports (Grant No. MSM 7088352101).

Appendix

An alphabetical list of abbreviations
FQN, farinograph quality number
FU, farinograph unit
MG, milligrams
NaCl, sodium chloride
OR, operational requirement
pH, pH
S.D., standard deviation

REFERENCES

Anonymus, 1991: User's guide to statgraph, Statistical Graphics Corporation, USA.

ALBERT, S., MITTAL, G. S., 2002: Comparative evaluation of edible coatings to reduce fat uptake in a deep fried cereal produkt. *Food Research International*, 35: 445–458. ISSN 0963-9969.

ASGHAR, A., ANJUM, F. M., BUTT, M. S., HUSSAIN, S., 2006: Shelf life and stability study of frozen dough bread by the use of different hydrophilic gums. *International Journal of Food Engineering*, 2: 1–11. ISSN 1556-3758.

AUTIO, K., FLANDER, L., KINNUNEN, A., HEINONEN, R., 2001: Bread quality relationship with rheological measurements of wheat flour dough. *Cereal Chemistry*, 78: 654–657. ISSN 0009-0352.

BALTSAVIAS, A., JURGENS, A., VAN VLIET, T., 1997: Rheological properties of short doughs at small deformation. *Journal of Cereal Science*, 26: 289–300. ISSN 0733-5210.

BÁRCENAS, M. E., DE LA O-KELLER, J., ROSELL, C. M., 2009: Influence of different hydrocolloids on major wheat dough components (gluten and starch). *Journal of Food Engineering*, 94: 241–247. ISSN 0260-8774.

BHATTACHARYA, S., NARASIMHA, H. V., SUVENDU BHATTACHARYA, S., 2006: Rheology of corn dough with gum arabic: Stress relaxation and two-cycle compression testing and their relationship with sensory attributes. *Journal of Food Engineering*, 74: 89–95. ISSN 0260-8774.

BLOKSMA, A. H., 1990: Rheology of the breadmaking process. *Cereal Foods World*, 35: 228–236. ISSN 0146-6283.

BOLLAÍN, C., COLLAR, C., 2004: Dough viscoelastic response of hydrocolloid/enzyme/surfactant blends assessed by uni- and bi-axial extension measurements. *Food Hydrocolloids*, 18: 499–507. ISSN 0268-005X.

BROWN, L., ROSNER, B., WILLETT, W. W., SACKS, F. M., 1999: Cholesterol-lowering effects of dietary fiber: a meta-analysis. *The American Journal of Clinical Nutrition,* 69: 30–42. ISSN 0002-9165.

CANDOGAN, K., KOLSARICI, N., 2003: Storage stability of low-fat beef frankfurters formulated with carrageenan or carrageenan with pectin. *Meat Science,* 64: 207–214. ISSN 0309-1740.

CARSON, L., SUN, X. S., 2001: Creep-recovery of bread and correlation to sensory measurements of textural attributes. *Cereal Chemistry*, 78: 101–104. ISSN 0009-0352.

COLLAR, C., ANDREU, P., MARTÍNEK, J. C., ARMERO, E., 1999: Optimisation of hydrocolloid addition to improve wheat bread dough functionality: a response surface methodology study. *Food Hydrocolloids,* 13: 467–475. ISSN 0268-005X.

DAVIDOU, S., LE MESTE, M., DEBEVER, E., BEKAERT, D., 1996: A contribution to the study of staling of white bread: effect of water and hydrocolloid. *Food Hydrocolloids,* 10: 375–383. ISSN 0268-005X.

DOBRASZCZYK, B. J., MORGENSTERN, M. P., 2003: Rheology and the breadmaking process. *Journal of Cereal Science*, 38: 229–245. ISSN 0733-5210.

EDWARDS, N. M., DEXTER, J. E., SCANLON, M. G., CENKOWSKI, S., 1999: Relationship of creep-recovery and dynamic oscillatory measurements to durum wheat physical dough properties. *Cereal Chemistry*, 76: 638–645. ISSN 0009-0352.

EDWARDS, N. M., MULVANEY, S. J., SCANLON, M. G., DEXTER, J. E., 2003: Role of gluten and its components in determining durum semolina dough viscoelastic properties. *Cereal Chemistry*, 80: 755–763. ISSN 0009-0352.

EDWARDS, N. M., PERESSINI, D., DEXTER, J. E., MULVANEY, S. J., 2001: Viscoelastic properties of durum wheat and common wheat dough of different strengths. *Rheologica Acta,* 40: 142–153. ISSN 0035-4511.

FISSORE, E. N., PONCE, N. M., WIDER, E. A., STORTZ, C. A., GERSCHENSON, L. N., ROJAS, A. M., 2009: Commercial cell wall hydrolytic enzymes for producing pectin-enriched products from butternut (*Cucurbita moschata*, Duchesne ex Poiret). *Journal of Food Engineering,* 93: 293–301. ISSN 0260-8774.

GUARDA, A., ROSELL, C. M., BENEDITO, C., GALOTTO, M. J., 2004: Different hydrocolloids as bread improvers and antistaling agents. *Food Hydrocolloids,* 18: 241–247. ISSN 0268-005X.

CHRISTIANSON, D., GARDNER, H., WARNER, K., BOUNDY, B., INGLETT, G., 1974: Xanthan gum in protein-fortified starch brad. *Food Technology,* 28: 23–29. ISSN 0015-6639.

ISO Standard No. 5530-1, 1997: Wheat flour – Physical characteristics of doughs – Part 1: Determination of water absorption and rheological properties using a farinograph. Geneva: International Organization for Standardization.

ISO Standard No. 712, 2009: Cereals and cereal products – Determination of moisture content – Reference method. Geneva: International Organization for Standardization.

JANSSEN, A. M., VAN VLIET, T., VEREIJKEN, J. M., 1996a: Rheological behaviour of wheat glutens at small and large deformations. Comparison of two glutens differing in bread making potential. *Journal of Cereal Science,* 23: 19–31. ISSN 0733-5210.

JANSSEN, A. M., VAN VLIET, T., VEREIJKEN, J. M., 1996b: Fundamentals and empirical rheological behaviour of wheat flour doughs and comparison with bread making performance. *Journal of Cereal Science,* 23: 43–54. ISSN 0733-5210.

LAZARIDOU, A., DUTA, D., PAPAGEORGIOU, M., BELC, N., BILIADERIS, C. G., 2007: Effects of hydrocolloids on dough rheology and bread quality parameters in gluten-free formulations. *Journal of Food Engineering,* 79: 1033–1047. ISSN 0260-8774.

LEE, C. C., MULVANEY, S. J., 2003: Dynamic viscoelastic and tensile properties of gluten and glutenin gels of common wheats of different strength. *Journal of Agricultural and Food Chemistry,* 51: 2317–2327. ISSN 0021-8561.

LOBATO-CALLEROS, C., ROBLES-MARTINEZ, J. C., CABALLERO-PEREZ, J. F., VERNON-CARTER, E. J., AGUIRRE-MANDUJANO, E., 2001: Fat replacers in low-fat Mexican manchego cheese. *Journal of Texture Studies,* 32: 1–14. ISSN 1745-4603.

LOBATO-CALLEROS, C., VERNON-CARTER, E. J., SANCHEZ-GARCIA, J., GARCIA-GALINDO, H. S., 1999: Textural characteristics of cheese analogs incorporating fat replacers. *Journal of Texture Studies,* 30: 533–548. ISSN 1745-4603.

METTLER, E., SEIDEL, W., 1993: Effects of emulsifiers and hydrocolloids on whole wheat bread quality: A response surface methodology study. *Cereal Chemistry*, 70: 373–377. ISSN 0009-0352.

PAPPA, I. C., BLOUKAS, J. G., ARVANITOYANNIS, I. S., 2000: Optimization of salt, olive oil and pectin level for low-fat frankfurters produced by replacing pork backfat with olive oil. *Meat Science,* 56: 81–88. ISSN 0309-1740.

PHAN-THIEN, N., SAFARI-ARDI, M., 1998: Linear viscoelastic properties of flour–water doughs at different water concentrations. *Journal of Non-Newtonian Fluid Mechanics,* 74: 137–150. ISSN 0377-0257.

RIBOTTA, P. D., AUSAR, S. F., BELTRAMO, D. M., LEÓN, A. E., 2005: Interactions of hydrocolloids and sonicated-gluten proteins. *Food Hydrocolloids,* 19: 93–99. ISSN 0268-005X.

ROJAS, J. A., ROSELL, C. M., BENEDITO, C., 1999: Pasting properties of different wheat flour-

hydrocolloid systems. *Food Hydrocolloids*, 13: 27–33. ISSN 0268-005X.
ROSELL, C. M., ROJAS, J. A., BENEDITO DE BARBER, C., 2001: Influence of hydrocolloids on dough rheology and bread quality. *Food Hydrocolloids*, 15: 75–81. ISSN 0268-005X.
SAFARI-ARDI, M., PHAN-THIEN, N., 1998: Stress relaxation and oscillatory tests to distinguish between doughs prepared from wheat flours of different varietal origin. *Cereal Chemistry*, 75: 80–84. ISSN 0009-0352.
STAMPFLI, L., NERSTED, B., MOLTEBERG, E. L., 1996: Effects of emulsifiers on farinograph and extensograph measurements. *Food Chemistry*, 57: 523–530. ISSN 0308-8146.
THEUWISSEN, E., MENSINK, R. P., 2008: Water-soluble dietary fibers and cardiovascular disease. *Physiology & Behavior*, 94: 285–292. ISSN 0031-9384.
TOUFEILI, I., DAGHER, S., SHADAREVIAN, S., NOUREDDINE, A., SARAKBI, M., FARRAN, M. T., 1994: Formulation of gluten-free pocket-type flat breads: optimiza-tion of methylcellulose, arabic gum, and egg albumen levels by response surface metodology. *Cereal Chemistry*, 71: 594–601. ISSN 0009-0352.
UTHAYAKUMARAN, S., NEWBERRY, M., KEENTOK, M., STODDARD, F. L., BEKES, F., 2000: Basic rheology of bread dough with modified protein content and glutenin-to-gliadin ratios. *Cereal Chemistry*, 77: 744–749. ISSN 0009-0352.
WALKER, C. E., HAZELTON, J. L., 1996: Dough rheological tests. *Cereal Foods World*, 41: 23–28. ISSN 0146-6283.
WANG, F. C., SUN, X. S., 2002: Creep-recovery of wheat flour doughs and relationship to other physical dough tests and breadmaking performance. *Cereal Chemistry*, 79: 567–571. ISSN 0009-0352.
WEIPERT, D., 1990: The benefits of basic rheometry in studying dough rheology. *Cereal Chemistry*, 67: 311–317. ISSN 0009-0352.
YOSHIMURA, M., TAKAYA, T., NISHINARI, K., 1996: Effects of konjac-glucomannan on the gelatinization and retrogradation of corn starch as determined by rheology and differential scanning calorimetry. *Journal of Agriculture and Food Chemistry*, 44: 2970–2976. ISSN 0021-8561.

Address

Ing. Pavlína Pečivová, Ph.D., Ing. Kateřina Juříková, Ph.D., Mgr. Iva Burešová, Ph.D., Mgr. Monika Černá, PH.D., doc. Ing. Jan Hrabě, Ph.D., Ústav technologie a mikrobiologie potravin, Fakulta technologická, Univerzita Tomáše Bati ve Zlíně, nám. T. G. Masaryka 275, 762 72 Zlín, Česká republika, e-mail: pecivova@ft.utb.cz