Relationship between amylase activity in rye flour and bread quality

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***Abstract*—**As the importance of healthy consumptions increases, the bakery industry tries to adjust to this situation using beneficial raw materials as rye flour. The machinability and baking performance of rye flour absolutely differ from wheat flour and this work deals with the rye bread quality affected by the amylase activity (Hagberg Falling Number – FN) and different type of breads (pan bread and bulk bread) prepared according to the standard baking test. The highest statistical difference between pan and bulk bread volume was found for the sample with FN of 65 s; the volume of bulk bread decreased from 216.7 to 166.7 cm^3 in comparison with pan bread. Concerning the bread weigh the improvement was observed at the samples of FN higher than 150 s. At the both cases (195, and 235 s) the weight of pan bread increased by 6% in comparison with pan bread. Values of FN lower than 150 s caused the dough and consequently sample melting and negatively affected the bulk bread shape which was connected with statistically biggest deterioration of bread shape observed at the samples of the lowest FN; the ratio fell from 0.50 to 0.18 while comparing the way of baking.

***Keywords*—**amylase activity, bulk bread, pan bread, shape, volume, weight

I. Introduction

RYE (*Secale cereale* L.) is in combination with wheat the major bread grain in Europe mainly produced in Russia, Poland, Germany, Belarus and Ukraine [1]. Despite the role of wheat flour in bread production is crucial [2] these days the importance of higher nutritional breads including whole rye breads has become more topical, and nutritionists worldwide recommend consumption of cereal-based products by reason of the health benefits concerning the regulation of blood glucose level, reduction the risk of cardiovascular diseases and certain types of cancer [3]–[7].

Baking performance of rye has been ascribed to the pentosans (arabinoxylans and arabinogalactans). These polysaccharides are thought to stabilize foams by decreasing the gas diffusion, nevertheless rye pastry will never give such volume and shape typical of wheat bread because the absence of gluten proteins, but can improve an intake of dietary fibre and antioxidants, which is far below the recommendations [8]–[10]. Despite growing interest in the health aspects of grain products, good sensory properties still remain a key priority among the consumers' preferences. The previous research proved that the addition of standard rye flour into the mixture with wheat flour caused the deterioration of tested samples' final quality [11]. That is why there is a need of further research that would enhance processing of rye products (breads) which have satisfactory form and good sensory quality [12]. In the rye baking the amount and quality of protein is not as important as in the wheat baking. Instead of gluten, the important quality factors are the quality of starch and cell wall material and the activities of endogenous enzymes modifying them.

It is well known in the milling and baking industry that quality of rye flour can be highly different from one year to another because the amylases activity is significantly affected by the temperature and amount of rain during growing season [13] and it is also closely connected with economic criteria leading to very sophisticated process of plant growing in terms of profit maximization, minimization of herbage irrigation, minimization of the number of agro-technical inputs, minimization of weather influence on the yields and minimization of the previous year influence [14]. The amylases activity is easily measured by Hagberg falling number [15], [16] and it is known that the decreasing values of Hagberg falling number decrease the bread volume. The main purpose of the present study was to quantify the relationship between different Hagberg falling number values and rye bread quality baked as a pan and bulk bread.

II. Material and Methods

A. Material

Rye grain harvested in Czech Republic in 2011 was used in this study. Rye grain with different quality was mixed to obtain five samples of rye flour with different values of Hagberg falling number (FN): 65 s, 110 s, 150 s, 195 s, 235 s, resp. Values of FN were measured according to ISO 3093. Each test was performed on two test portions simultaneously or rapidly one after the other. The arithmetic mean of the two determinations was taken as the result if the conditions of repeatability set by the standards were satisfied. If the absolute difference between two independent single test results was outside standard limits, the two determinations were reduplicated. The farinographic parameters of rye flour can be seen in Fig. 1.

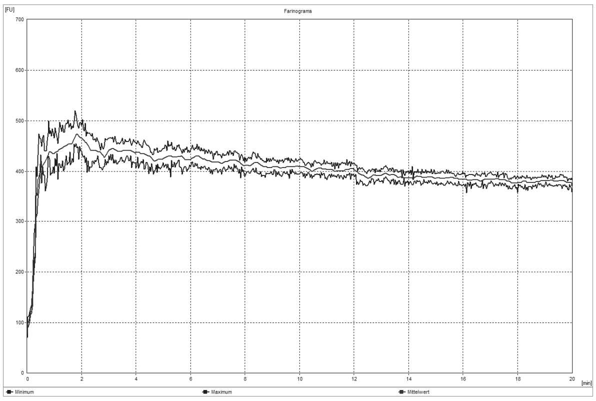

Fig. 1 Farinographic parameters of rye flour

B. *Baking test*

Baking test was conducted on 300 g flour samples using a straight-dough baking formula and short fermentation time in accordance with ICC standard no. 131 [17] and Dvořáková *et al*. [18]. High speed dough mixing and a short fermentation time are typical of this method. Bread loaves were evaluated in relation to volume, shape (loaf height/width ratio) and weight. Dough was prepared from flour 300 g; 1.8% dry yeast, 1.5% salt, 1.86% sugar, 0.005% ascorbic acid related to flour weight and water according to farinographic parameters measured in conformity with ICC standard no. 115 [19]. Prepared doughs were baked in the forms (pan bread) and in a shape of bun (bulk bread) to compare the bread parameters.

C. *Statistical analyses*

Effect of FN and method of baking on bread quality were analysed using one-way and two-way analysis of variation (ANOVA) and the test of Fisher's least significant difference at a significance level of 0.05. These tests were realized in Statistica 9 software (StatSoft, Inc.).

III. Results and Discussion

Bread quality is known to be affected by activity of cereal enzymes which are able to alter the starch properties [20]. Gelatinization of native starch grains is essential to from a porous and elastic crumb. Many factors can affect the starch gelatinization: milling, water availability, time, and temperature relationship during baking. Gelatinized starch grains are much easier accessible for the amylases [21] therefore the effect of both starch and enzymes via FN on final bread quality was evaluated in this experiment.

The highest statistical difference between pan and bulk bread volume was found for the sample with FN of 65 s; the volume of bulk bread decreased from 216.7 to 166.7 cm^3 in comparison with pan bread (Fig. 2). A very similar trend could be observed while regarding the sample with FN of 110 s. On the other hand the middle value of FN (150 s) did not affect the bread volume. The increase of the sample volume can be seen for the bulk bread of FN 110 s; the volume was enhanced by 17 cm^3. The highest value of FN did not influence the volume as it was in case of the middle sample (FN 150 s). It is evident that low values of FN caused deterioration of bread volume while baking without a form, contrariwise the volume of bulk bread increased with higher FN, but the results showed that FN higher than 195 s had no positive effect on volume of bulk bread.

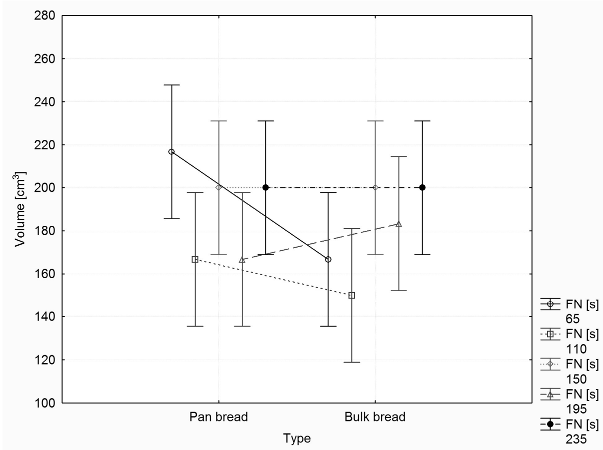

Fig. 2 Bread volume

Even if obtained results were not significant, the bread volume showed not regular but increasing tendency with raising FN. The difference between the lowest and highest FN (65 and 235 s) among the samples of the bulk bread was calculated as 20%, however, the biggest improvement of the pan bread volume was observed between the samples of the two highest FN (195 and 235 s) that reached 20% too (Fig. 3).

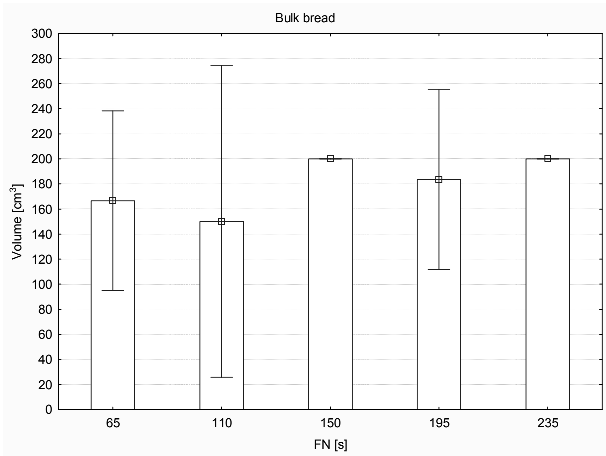

Fig. 3 Bulk bread volume

When regarding the volume of bread baked in a form (pan bread) the biggest volume was measured at the sample of FN 65 s. Generally baking with a form provides relatively stable results as all of the samples are baked in the same form under the same conditions which assure same evaparation thu controlled moisture loss. The biggest decrease of pan bread volume was detected between the two lowest FN, specifically 23%. On the other hand the comparison of the samples with FN 150 and higher revealed rather similar bread volume with only 15% differnce (Fig. 4).

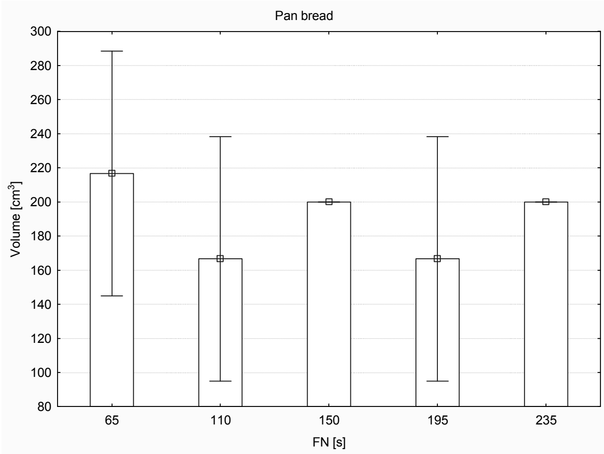

Fig. 4 Pan bread volume

Concerning the bread weight (Fig. 5) the results proved that the flours with FN lower than 110 s had no positive effect on the bulk bread weight and in addition the lowest FN (65 s) deteriorated the final bulk bread quality. The improvement of the bulk bread weight could be observed at the remaining samples of FN higher than 150 s. At the both cases (195 and 235 s), the weight increased by 6%.

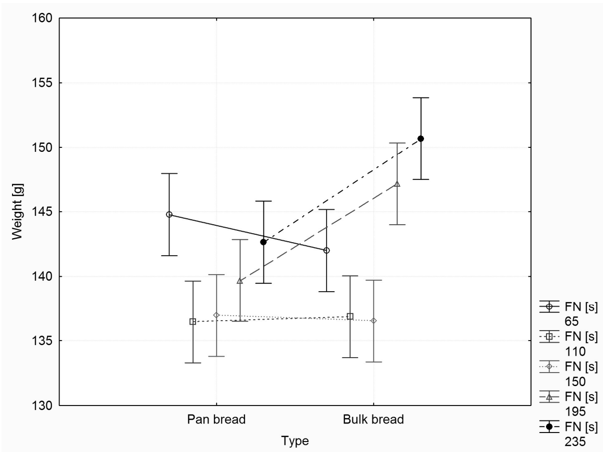

Fig. 5 Bread weight

The overall evaluation of the bulk and pan bread showed the weight differences among the samples. The highest increase of the bread weight (by 8%) was found between the samples of FN 110 s, 150 s, resp., and the sample with the highest FN (235 s) concerning the samples of bulk bread (Fig. 6).

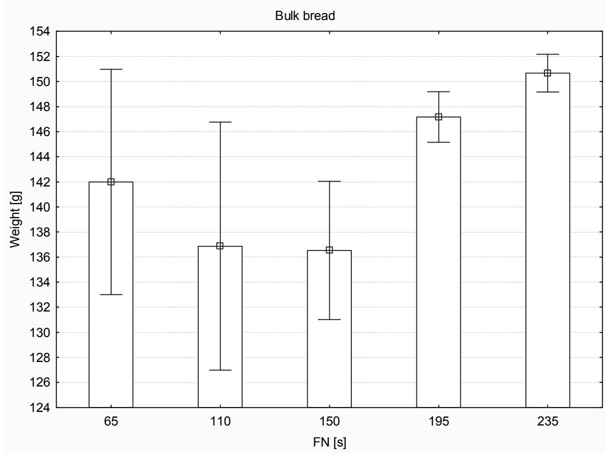

Fig. 6 Bulk bread weight

The samples baked in a form showed increasing trend with growing FN; the biggest increase of bread weight (by 8%) was calculated between the samples with FN of 195 and 235 s, resp. (Fig. 7). Lower activity of amylases caused smaller degradation of the rye starch, thus affected its water absorption and migration [20]. Taking all these results into account it is obvious that the FN was closely connected with the final product weight.

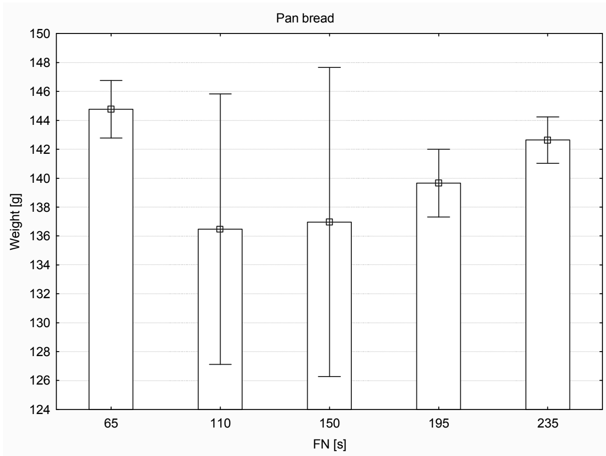

Fig. 7 Pan bread weight

The height/width ratio can be generally called as a shape of the final product. Lower values of FN caused the dough and consequently sample melting and negatively affected the bulk bread shape (Fig. 8) which is in agreement with Hansen et al. [13] who proved the connection between low values of FN and pasty breads. Statistically biggest deterioration was observed at the sample of the lowest FN; the ratio fell from 0.50 to 0.18 comparing the way of baking, because the level of amylase activity in grains influenced viscosity of starch thus pasting properties of their flours during processing [12]. The enhancing trend could be seen from the lowest to the highest FN and the smallest decrease of bread shape (bulk vs. pan bread) was detected for the sample of the highest FN (from 0.45 to 0.40). The influence of enzymes on undamaged starch granules at normal fermentation temperature was very small. After gelatinization, the starch was more easily attacked by the amylases and might be hydrolyzed rapidly [16], [22].

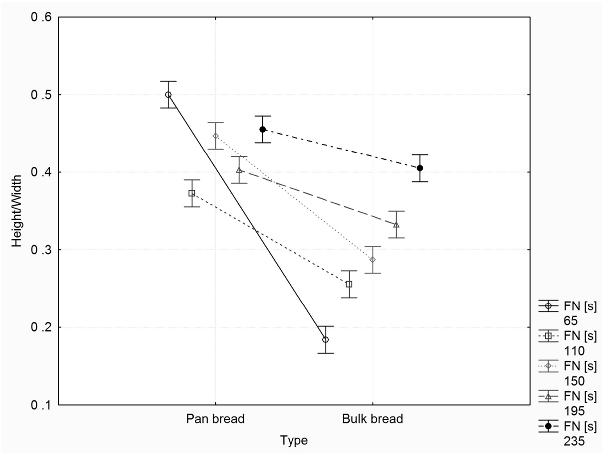

Fig. 8 Bread shape

Evaluating the results among bulk and pan bread separately, the parameter showed increasing trend with rising FN. Concerning the bulk bread the lowest value was measured for the sample with FN of 65 s (0.18) contrariwise the highest value for the sample of the highest FN 235 s (0.41) which was an increase by 127% (Fig. 9)

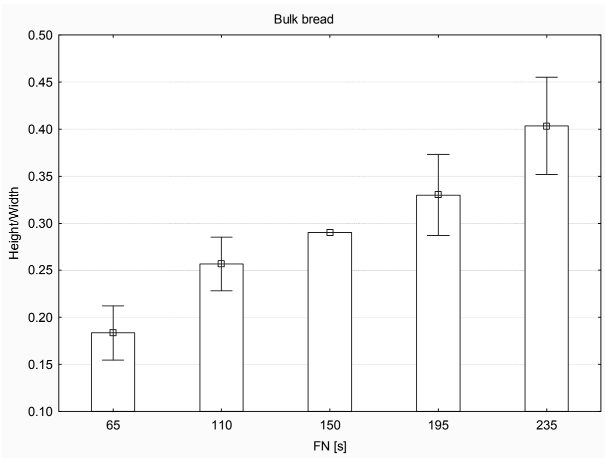

Fig. 9 Bulk bread shape

The pan bread revealed the biggest improvement (15%) between the samples with FN 195 and 235 s and the highest decrease (26%) was calculated between the samples of the two lowest FN (Fig. 10).

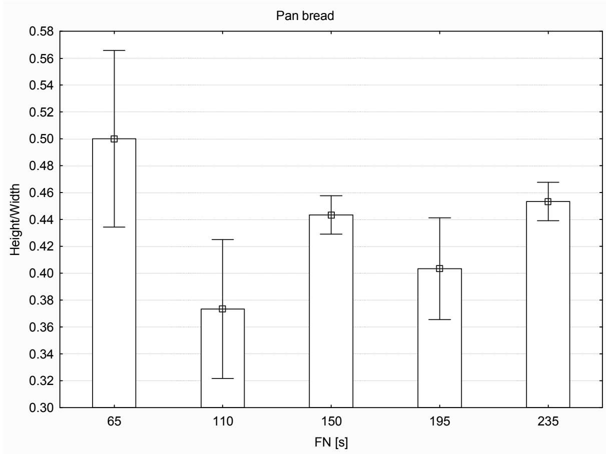

Fig. 10 Pan bread shape

IV. Conclusions

The results evaluation showed enhancing trend of measured values with FN higher than 110 s thus it could be concluded that rye flour with FN ≥150 s is optimal for bread making. The assessment of differences between bulk and pan bread volume revealed the biggest increase (by 30%) for the sample of the lowest FN (65 s), contrariwise the highest FN did not have any positive/negative effect on the samples. The samples of FN 195 and 235 s proved an improving trend regarding the bulk and pan bread weight; in the both cases the weight of pan bread increased by 6% in comparison with bulk bread. Lower values of FN caused the dough melting which negatively affected the final bread shape, thus the biggest deterioration of bread shape comparing the bulk and pan bread was measured for the sample of the lowest FN (by 64%).

Acknowledgment

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