JOURNAL OF AGRICULTURE AND PLANT SCIENCES, JAPS, Vol 17, No. 1, 2019

Manuscript received 18.04.2019
Accepted: 20.05.2019

In print: ISSN 2545-4447
On line: ISSN 2545-4455
UDC: 664.641.12.017
Original scientific paper

COMPARISON OF THE RHEOLOGICAL CHARACTERISTICS OF BIO-FORTIFIED FLOUR OBTAINED FROM SOFT WHEAT VARIETIES TRESKA AND RADIKA

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Abstract

The dough rheology is very important for the prediction of the final bakery product quality such as mixing behavior, sheeting and baking performance, and based on starch gelatinization data the overall cooking behavior and product properties can be determined. The aim of this research was to examine the impact of agronomic bio-fortification on the rheological properties of dough. In this research were included 7 samples obtained by adding high quality chelate fertilizers at different stages of wheat growth: Fe soil (1), Fe soil + foliar (2), Fe foliar (3), Control (4), Zn soil (5), Zn soil + foliar (6) and Zn foliar (7). From farinograph data for water absorption it was concluded that all variants for variety Treska and Radika had approximate values with minimal differences compared with variant 4. According to the data obtained for the level of softness, it was concluded that all variants for both varieties of dough are with medium quality. According to the qualitative number, all variants of both varieties belong to quality group B_2, with the exception of variant 2 for the variety Treska and variant 5 for the variety Radika which belonged to the quality group C_1. From the farinographc analysis it can be concluded that bio-fortification did not have a significant effect on the technological quality of the flour. Extensographic analysis showed that for variety Radika from variants 1, 2 and 7 were obtained flour with higher extensibility, resistance and energy in comparison with the variety Treska.

Keywords: *dough, farinograph and extensigraf*

INTRODUCTION

Biofortification is the process of increasing the content and/or bioavailability of essential nutrients in crops during plant growth through genetic and agronomic pathways (Bouis et al., 2011). Genetic biofortification involves either genetic engineering or classical breeding (Saltzman et al., 2013). Agronomic biofortification is achieved through micronutrient fertilizer application to the soil and/or foliar application directly to the leaves of the crop. Biofortification is mainly focused on starchy staple crops (rice, wheat, maize, sorghum, millet, sweet potato and legumes), because they dominate diets worldwide – especially among groups vulnerable to micronutrient deficiencies - and provide a feasible means of reaching malnourished populations with limited access to diverse diets, supplements, and commercially fortified foods (Saltzman et al., 2013). There is evidence that agronomic biofortification can increase yields and the nutritional quality of staple crops, but there is a lack of direct evidence about changes in rheological properties as a result of the application of micronutrient fertilizer.

Rheological properties of dough are very important indices for product development in terms of product quality and process efficiency (Mondal and Datta 2008). Rheology concerns the flow and deformation of a material (Vergnes 2003) and is particularly important technique in revealing the influence of flour constituents and additives on dough behaviour during breadmaking (Dapčević et al., 2014). Among the cereal technologists, rheology is widely recognized as a valuable tool in quality assessment of flour. However, acceptance of biofortificated crops from the producers in the milling and bakery industry is another issue that needs to be paid special attention. This study was aimed to evaluate the rheological changes that take place in the dough as a result of addition of zinc and iron chelating fertilizers during the cultivation of wheat from the variety Treska and Radka.

MATERIAL AND METHODS

Material

Plant material

The variant of the type Radika soft wheat, and Treska soft wheat (Triticum aestivum L.), which belongs to the group of high quality bread varieties was used as a plant material in this research.

Location and setting experiment

On the property belonging to the Agricultural Institute in Skopje (Republic of North Macedonia), in the testing economy "Dolno Lisiche", a test was placed according to the method of randomized block system, with 7 variants, in three replications.

The following variants were included in the test of this research:

- Fe application in soil (variant 1)
- Fe application in soil and foliar (variant 2)
- Fe foliar application (variant 3)
- Control – without fertilizing (variant 4)
- Zn application in soil (variant 5)
- Zn application in soil and foliar (variant 6)
- Zn foliar application (variant 7)

Basic characteristics of the fertilizers

Yara Vera™ Amidas is a highly qualitative granular fertilizer which contains nitrogen and sulfur. Nutrichem folifer-Fe EDTA chelate product, which is used for a foliar nutrition of the plants.Yara Vita Rexolin is a product for prevention of a shortage of zinc formulated in the form of EDTA chelate. The nutrition of the wheat is conducted in the different stages of development (Menkinoska et.al., 2018)

Methods

Determination of the rheological properties of the biofortificated dough was carried out with the pharynograph and extensograph from the company BRABENDER.

- Pharographic analysis with the method AACC 54-21 (American Association for Cereal Chemistry - AACC 1995)
- Extensographic analysis with the method AACC 54-10 (American Association for of Cereal Chemistry - AACC 1995)

Grinding and testing of the flour was carried out in the farinological laboratory of "Zito Luks AD"- Skopje. (Menkinoska et.al., 2018)

RESULTS AND DISCUSSION

There are many test methods available to measure rheological properties, which are commonly divided into empirical (descriptive, imitative) and fundamental (basic) (Weipert, 1990). According to the empirical rheological parameters it is possible to determine the optimal flour quality for a particular purpose. The empirical techniques used for dough quality control are generally recognized as standard methods by ICC, AACC, ISO and different national standards. In comparison to rheological methods generally applicable in food quality control, dough rheological tests are probably the most diverse (Dapčević et al., 2014).

The most popular and accepted device for measuring dough physical properties is Brabender Farinograph. It measures and records the mechanical resistance of the dough during mixing and kneading. In this research the rheological properties of two soft wheat cultivars Treska and Radika were analyzed and evaluated. Rheological testing included empirical rheological methods with farinograph.

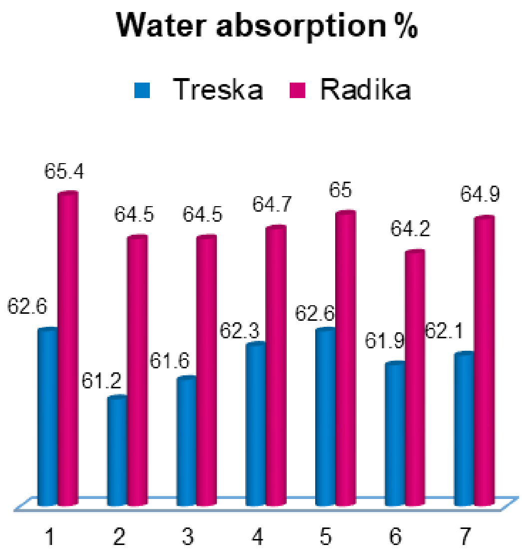

Figure 1. Comparison of water absorption values flour samples.

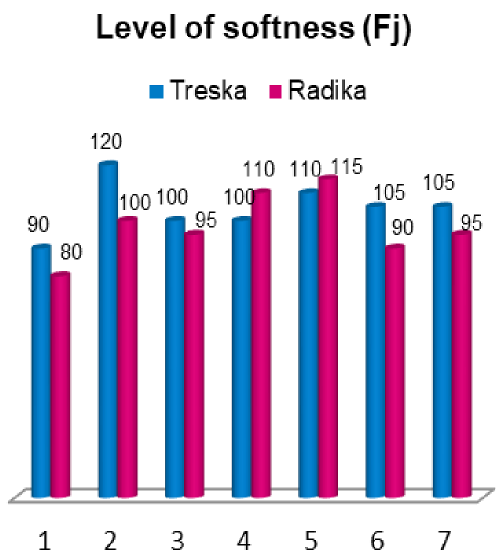

Figure 2. Comparison of level of softness values of flour samples.

The Farinogram parameter with the greatest practical value is the water absorption. Water absorption is directly related to the yield of final bakery product and it is one of the most important parameters in assessing the "flour strength" and in product price calculations. Farinograph water absorption is mainly influenced by the properties of flour main components: gluten and starch. In order to be properly interpreted, it must be compared to the other Farinograph parameters

The results presented in the Figure 1, showed that all variants have approximate values with minimal differences in relation to variant 4. However, the variety Radika showed higher values of water absorption compared to the variety Treska.

Another important technological feature for the baking industry is the degree of softening the dough, expressed in Farinoghraphic units (in Fj). If the degree of softening is higher, the flour, i.e. the dough is harder to tolerate fermentation and vice versa. It is considered that the 75 Fj softening grade flour is of good quality, from 75 to 125 Fj with medium and over 125 Fj of poor quality. The lower the value, dough has better quality. Thus, high water absorption, combined with low degree of softening indicates good quality flour, whereas a high water absorption combined with a high degree of softening indicates poor quality flour.

According the results presented on Figure 2, dough for all varieties was within the limits of 80 to 120 Fj and belongs to the dough group with medium quality. The comparison of the results of Figure 1 and 2 show that the highest value of water absorption and the lowest degree of softening were noted for the variant 1 variety Radka, which indicates good quality flour. Farinograph also enables monitoring the influence of additives, and thus allows optimization of flour processing in terms of standardization of flour quality produced from raw materials of variable quality. Flour quality is defined and classified differently in European countries depending on its end-use purpose (Dapčević et al., 2014).

The technological quality of the flour based on farinograph is evaluated in three quality groups. In quality group A belong strong flours with optimal baking ability; in quality group B belong medium flours with good baking characteristics, while in quality group C belong weak flours, i.e. with poorer quality and lower absorption power (Albrecht, 2010).

From the presented results in Table 1 it is noted that all variants belong to the quality group B_2, with the exception variant 2 variety Treska and variant 5 variety Radika, which belongs to the quality group C_1.

Table 1. Comparison of qualitative number and quality group values of flour samples.

	Qualitative number		**Quality group**	
Variant	**Treska**	**Radika**	**Treska**	**Radika**
1	53.7	54.4	B_2	B_2
2	43.5	48.6	C_1	B_2
3	50.2	49.6	B_2	B_2
4	52	48.8	B_2	B_2
5	49.2	43.4	B_2	C_1
6	50.6	53.3	B_2	B_2
7	48.4	52	B_2	B_2

The Brabender Extensograph is an internationally accepted standard method that is in compliance with ISO 5530-2, ICC 114/1, AACC 54-10. It is applicable for measurement of physical properties of dough subjected to mechanical handling and resting. Precisely, an extensograph provides information about dough resistance to stretching and extensibility by measuring the force to pull a hook through a cylindrically shaped piece of dough (Dapčević et al., 2014). During the measurement of resistance of dough to stretching and the distance the dough stretches before breaking is recorded in the form of diagram extensogram. The shape of extensogram curve gives an indication of results that could be expected for baking performance (Freund and Kim, 2006).

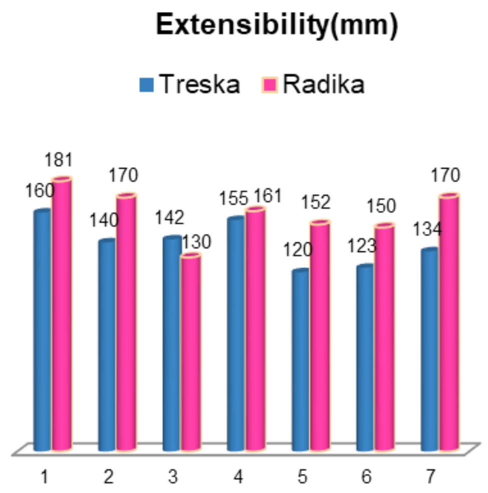

Figure 3. Comparison of extensibility (mm) values of flour samples.

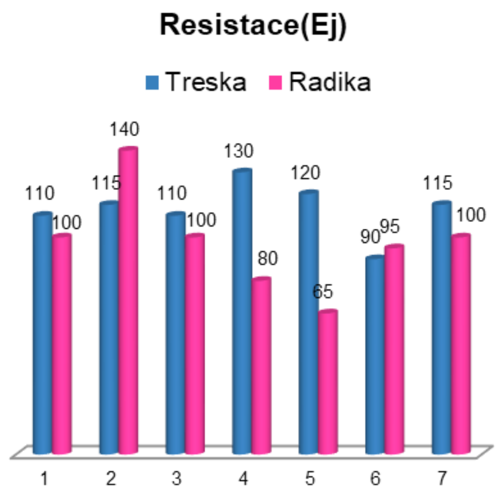

Figure 4. Comparison of resistance (Ej) values of flour samples.

As shown in Figure 3, for the variety Treska variant 1 had a higher value of dough extensibility as compared to control variant 4, while variant 2 and 3 had lower values. Significantly less extensibility showed the variants 5, 6 and 7 as compared to variant 4. Also, for variety Radika it was noted that the varieties 1, 2 and 7 have higher dough extensibility as compared to variant 4, while variant 5, 6 and 3 have lower values. Generally, the variety Radika showed higher extensibility compared to the variety Treska for all variants, with an exception of variant 3.

The resistance was expressed in extensiographic units and for good quality it is desirable a higher value of this parameter. Curves characterized by low resistance to extension indicates a small baking volume and vice versa.

The energy, the same the resistance, is desirable to be a higher value, because it is an indicator of the volume, i.e. the strength of the dough.

According the results presented in Figure 4 and Figure 5, the greatest resistance and energy for the variety Treska were measured in control variant 4, and the lowest value in variant 6. The variants 1, 2, 3, 5 and 7 showed lower values in relation to variant 4. Regarding the variety Radika, the highest resistance and energy were measured in variant 2, and the lowest value for variant 5. In all other variants, higher values were found in relation to the variant 4, with the exception of the variant 3.

The fact that wheat breeders have developed varieties with lower but more intensive protein content we would like to point out that the energy values of the extensogram cannot be interpreted as in previous decades in the evaluation of technological wheat quality (Anderssen et al., 2004; Torbica et al., 2011). On one hand, it stresses the need to increase the understanding of the parameters obtained in extensibility tests and its relevance to baking performance, and on the other hand, to relate the gliadin content and ratio of gliadin and gluten in to extensional properties of wheat dough.

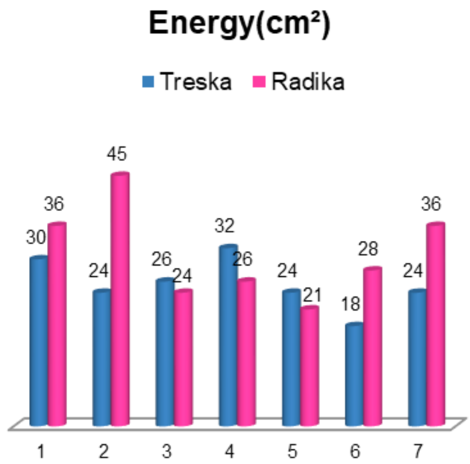

Figure 5. Comparison of Energy (cm^2) values of flour samples.

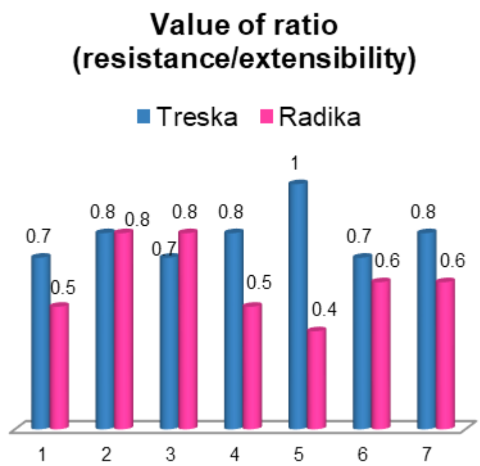

Figure 6. Comparison of resistance / extensibility values of flour samples.

The value of ratio (resistance/extensibility) represents the relationship between the resistance and the extensibility. It gives information on the behaviour of the dough during processing and the best indicates of quality the dough.

As it is shown in Figure 6, the highest value of the ratio resistance/extensibility for variety Treska was measured in variant 5. In all other variants 1, 2, 3, 6 and 7, approximately the same values were found with the control variant 4. In contrast, the variety Radika showed the highest values in variant 2 and 3, and the lowest in the variant 5. For the variants 6 and 7, higher values have been found as compared to the variant 4.

CONCLUDING REMARKS

The effect of using different types of Zn and Fe fertilizers on rheological characteristics may depend on several factors such as climatic conditions and wheat genotypes. However, although both varieties were grown under the same conditions and same agrotechnical measures were applied equally, analyses from pharynograph and extensograph generally showed that there are differences between the varieties resulting from their genetic characteristics.

From the farinograph analysis it can be concluded that:

- bio-fortification did not have a significant effect on the technological quality of the flour for variety Treska and
- bio-fortification with Fe application in soil have an effect on the technological quality of the flour for variety Radika.

From the extensographic analysis it can be concluded that:

- bio-fortification did not have a significant effect on the technological quality of the flour for variety Treska and
- bio-fortification with Fe application in soil, Fe soil + foliar and Zn foliar for variety Radika were obtained flour with higher extensibility, and energy in comparison with the variety Treska and control variant.

Based on the obtained results of the research for determining the effects of agronomic bio-fortification, it can be concluded that variety Radika can considered as a raw material of a suitable quality for baking production.

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СПОРЕДБА НА РЕОЛОШКИТЕ КАРАКТЕРИСТИКИ НА БИОФОРТИФИЦИРАНО БРАШНО ДОБИЕНО ОД МЕКА ПЧЕНИЦА СОРТА ТРЕСКА И РАДИКА

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Резиме

Реологијата на тестото е многу важна за предвидување на крајниот квалитет на пекарските производи како што се однесување при мешање, перформанси на печење и желатинизација на скроб. Врз основа на овие податоци може да се одредат својствата на производот и неговото целокупно однесување при готвење.

Целта на ова истражување беше да се испита влијанието на агрономската биофортификација врз реолошките својства на тестото. Во ова истражување се вклучени 7 варијанти добиени со додавање на висококвалитетни хелатни ѓубрива во различни фази од растот на пченицата: Fe почвено (1), Fe почвено + фолијарно (2), Fe фолијарно (3), Контрола (4), Zn почвено(5), Zn почвено + фолијарно (6) и Zn фолијарно (7). Од анализите добиени од фаринографот за апсорпција на вода може да заклучиме дека сите варијанти за сортите треска и радика имаат приближни вредности со минимални разлики во споредба со варијанта 4. Според добиените податоци за степенот на омекнување, се констатира дека сите варијанти за двете сорти на пченица се со среден квалитет. Според квалитативниот број, сите варијанти од двете сорти припаѓаат на квалитетна група $Б_2$, со исклучок на варијанта 2 за сортата треска и варијанта 5 за сортата радика која припаѓа на квалитетна група C_1.

Од фаринографските анализи може да се заклучи дека биофортификацијата нема значително влијание врз технолошкиот квалитет на брашното. Од резултатите добиени од екстензограмот се констатира дека за сортата радика од варијанти 1, 2 и 7 се добива брашно со поголема растегливост, отпорност и енергија во споредба со сортата треска.

Клучни зборови: *тесто, фаринограф, екстензиограф.*