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MECHANICAL PROPERTIES OF TEXTURE OF MIXED FLOUR BREAD WITH AN ADMIXTURE OF RYE GRAIN

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Summary. The paper presents a comparison of the mechanical textural properties of mixed flour bread with an admixture of rye grain and without such an admixture (hardness, springiness, cohesiveness and chewiness) and its chemical properties (moisture and acidity). A discussion is given concerning the dough preparation and the baking of the bread. Additionally, based on sensory evaluation, the shelf live of the bread was determined, during which the bread is acceptable to the consumers.

Key words: mixed flour bread, textural properties, shelf life.

INTRODUCTION

Bread is the most important food product and the most frequently consumed by man. Its unique sensory values caused that it is a universal food product, always up to date and irreplaceable [Adalla 1996].

The extensive range of consumers requires that the market is supplied with breads baked to varied recipes, as well as special and dietary breads [Diowksz 2010]. Mixed flour leaven-based bread, due to its sensory and nutritional values, is believed to be one of the best [Ambroziak 1988, Gąsiorowski 2004, Kot 2010, Piesiewicz 2008, Wojcieszak 1956].

The admixture of certain products to flour allows not only to produce bread with enhanced nutritional value, but also to develop a line of bakery products with health-promoting qualities [Bartnikowska 2007, Park Sang Ha and Morita 2004].

Nutrition and consumer studies show that an addition of rye grain to bread has many advantages. The grain is characterised by a high content of ballast substances, which determines its exceptional dietary value. The specific composition of rye has an effect on the intestinal flora and on optimum functioning of the digestive system. The consumption of rye bread, especially wholemeal, leads to the maintenance of optimum level of sugar in the blood [Staszewska 2008].

Next to the dietary values, the sensory traits are an important factor determining the acceptance of a product by consumers. Sensory evaluation plays a highly important role in the control of food quality [Pijanowski et al.]. Texture is a multi-parametric determinant o bakery products [Borowy and Kubiak 2010]. In certain cases it may even have a stronger effect on the consumer

than taste, flavour and colour [Szcześniak 1998]. Texture has also a high importance in transport and processing, as it determines the manner in which products can be handled [Brandt et al. 1963]. Thanks to studies of textural properties we can create better products that will be successful on the market [Pszczoła 2009, Szcześniak 1977].

The texture of bread is the object of increasing interest of researchers from the field of bakery. It allows to obtain the most comprehensive estimation of bread quality [Surówka 2002].

Texture can be described in the physical sense as well as in the sensory one. In the physical sense, texture is the rheological property of products, comprising the relations of stress – strain – time [Biller 2005, Szcześniak 1963, 2002, Sherman 1970, ISO 1981]. In the sensory context, texture can be defined as a series of sensations or impression induced in the course of eating, related with the physical properties of the product [Korzeniowska-Ginter 2006, Marzec 2007].

OBJECTIVE AND SCOPE OF STUDY

The objective of the study was the comparison of the textural properties of mixed flour bread with an admixture of rye grain and without such admixture, and determination of time of storage (shelf life) during which the bread is acceptable to the consumer. The scope of the study comprised the preparation and baking of the bread, determination of its mechanical properties, moisture and acidity, and sensory evaluation.

METHOD

The experimental material was mixed flour bread and mixed flour bread with an admixture of rye grain. To obtain 10 kg of dough we used: 3.20 kg of wheat flour type 550, 1 kg of wholemeal wheat flour type 2000, 0.5 kg of wholemeal rye flour type 2000, 1.35 kg of rye leaven, 1.2 kg of rye grain, 50 g of salt and 8 g of instant yeast carefully dissolved in 3 l of water, and 225 ml of oil. The leaven was prepared earlier using rye flour type 2000 and water.

The rye grain was cooked in water and, after cooling down, kept under cover at temperature of 5^{o}C for 24 hours. Dough was prepared with the two-phase method (intermediate). Flour to be used for bread baking was brought to ambient temperature and screened. Weighed portions were placed on a spiral mixer (model 15S). Next, yeast, salt, water and leaven were added, and mixed for 5 min using mixer speed of 110 min^{-1}, then rye was added, and mixed for 3 min. at the same mixer speed. A control samples was prepared in an analogous manner (but without the addition of rye grain). The produced dough was divided into 1 kg portions and loaves were formed by hand (ten loaves each) in the form of dough balls; the loaves were placed in pans greased with edible oil. The height of dough in the pans was 70±3mm. Dough in the pans was covered with cloth and left for ca. 1 to rise. After that time the dough surface was wet with water and the pans were placed in the oven. The time of baking was 25 minutes at temperature of 180^{o}C, and additionally 10 min. at 210^{o}C. After taking the pans out of the oven, the surface of the loaves was again wet with water, and taken out of the pans. The bread was then left for 24 hours at ambient temperature without covering. Two loaves each (with and without rye grain addition) were subjected to textural and physicochemical tests on the same day. The remaining loaves were sealed in polyethylene bags and stored in a controlled climate chamber at 16^{o}C. The analyses were repeated for the subsequent 4 days.

Instrumental analysis of the product studied was conducted using the texture tester TA.XT plus, coupled with a computer. The samples were cubes cut out from the bread crumb, with side of 2 cm (10 each from every loaf). The samples were subjected to double compression at tester head

travel speed of 50 mm·min^{-1}. The compression process was conducted at constant deformation of the samples, of 50% of their height, with intervals between compression series being 5 s.

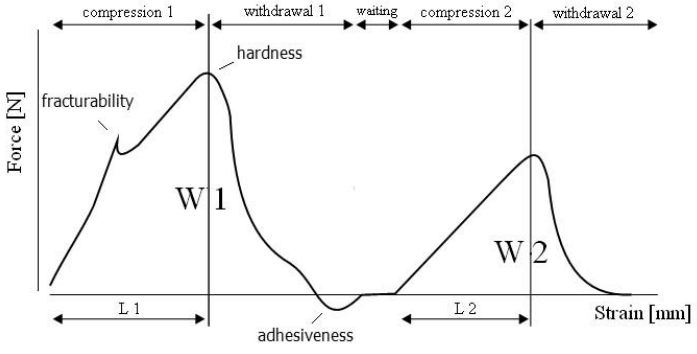

Fig. 1. Example of a graph obtained in the double compression test (TPA)

The TPA graphs (Fig. 1) were used for direct reading or for calculation of the following mechanical properties of the material tested:

- hardness [N], i.e. the maximum force during the first cycle of compression,
- springiness [-], that characterises the degree of recovery of the initial form; it is the quotient of sample deformations during the first and second compression (*Spr=L2/L1*),
- cohesiveness [-], characterising the forces of internal bonds that hold the product in one piece; it is the quotient of the areas beneath the graphs of forces of the forst and second compression of the sample (*Koh=W2/W1*),
- chewiness [N], which is a measure of force required to chew a bite of food to make it ready for swallowing; it is defined as the product of hardness, cohesiveness and springiness.

The breads were also subjected to sensory evaluation in accordance with the standard PN-A-74252 [1998].

Measurements of acidity and moisture of the bread crumb were conducted in conformance with the standard PN-A-74108 [1996].

RESULTS

The effect of rye grain addition on the textural properties of the bread is presented in Fig. 2-5.

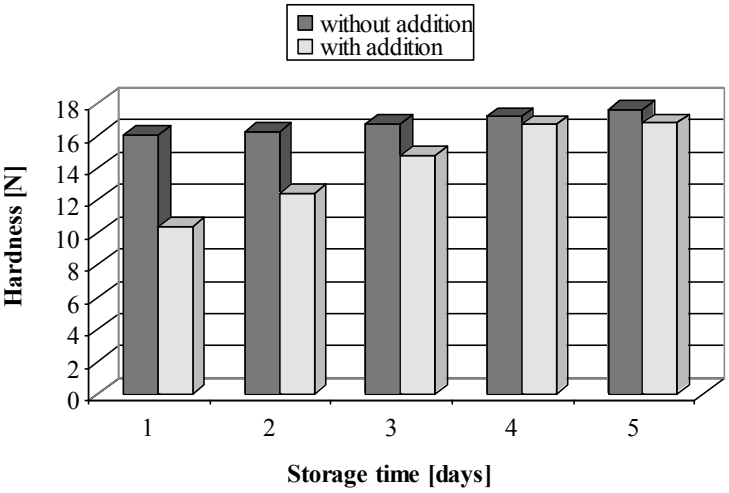

Fig. 2. Hardness of mixed flour bread without [H_1] and with an admixture of rye grain [H_2] versus time of storage

The relations presented in the Figure are described with equations (1) and (2):

$$H_1 = 0.407t + 15.533, \quad (1)$$

$$R^2 = 0.99,$$

$$H_2 = 10.25t^{0.323}, \quad (2)$$

$$R^2 = 0.98.$$

As can be seen from Fig. 2, after 1 day of storage the hardness of the bread without an admixture of rye grain was higher than of that of the bread with rye grain by 58%. Extension of the time of storage caused a reduction of the difference between the hardness levels f both products. The level of hardness of the bread with an admixture of rye grain increased with extension of storage time to 4 days. The value of that trait after 1 day from baking was 10.36 N, and after 5 days - 16.80 N. Whereas, the increase in the hardness of the bread without rye grain was slight, followed a linear function, and the value of that trait varied from 16.02 after 1 day of storage to 17.59 N after 5 days from baking. The equations describing the changes in bread hardness have a very high value of the coefficient of determination.

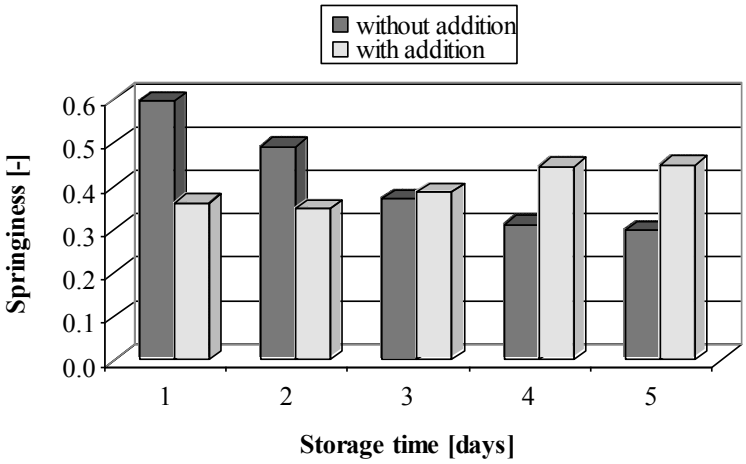

Fig. 3. Springiness of mixed flour bread without [Spr_1] and with an admixture of rye grain [Spr_2] versus time of storage

The relations presented in the Figure are described by equations (3) and (4):

$$Spr_1 = -0.1984\ln(t) + 0.603, \tag{3}$$

$$R^2 = 0.98,$$

$$Spr_1 = 0.0039t^2 + 0.0041t + 0.3428, \tag{4}$$

$$R^2 = 0.86.$$

As follows from Fig. 3, presenting changes of springiness of mixed flour bread, the springiness of the bread without any admixture of rye grain decreased with extension of storage time, while that of the bread with such an admixture increased. The springiness of the bread without rye grain, after 1 day, was higher than that of the bread with an admixture of the grain (by 0.24). The value of that trait after 1 day from the time of baking was 0.57, and after 5 days – 0.29. Whereas, the springiness of the bread with an admixture of rye grain initially stayed at a constant level; an increase in the value of that trait was noted after 3 days from baking. The difference in springiness between breads tested after 2 and 3 days amounted to 0.04. Extension of the time of storage by another day caused further increase of springiness by 0.06, while after additional 24 hours the value of the trait was at the same level.

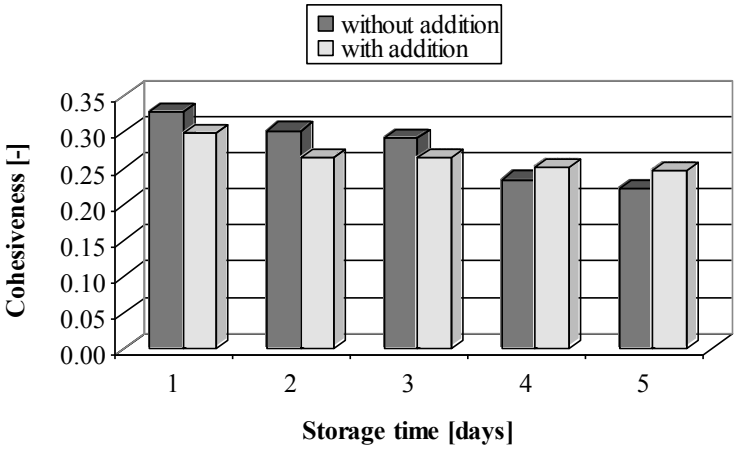

Fig. 4 presents the results of measurements of cohesiveness

Fig. 4. Cohesiveness of mixed flour bread without [Coh_1] and with an admixture of rye grain [Coh_2] versus time of storage

The relations presented in the Figure are described by equations (5) and (6):

$$Coh_1 = -0.0016t^2 - 0.0196t + 0.348, \tag{5}$$

$$R^2 = 0.95,$$

$$Coh_2 = 0.2955t^{-0.1163}, \tag{6}$$

$$R^2 = 0.96.$$

After 1 day of storage the cohesiveness of the bread without an admixture of rye grain was higher by 9% than that of the bread with such an admixture. The values of that trait decreased with the passage of time (from 1 to 5 days) for the bread without an admixture of rye grain, from 0.33 to 0.22. In the case of bread baked with an admixture of rye grain, the decrease in the level of cohesiveness was less pronounced, the difference between the product tested after 1 day from baking and that examined after 5 days of storage being 0.05.

Changes in the chewiness of the breads are illustrated in Fig. 5.

The chewiness of the mixed four bread without rye grain, after 1 day, was higher than that of the bread enriched with that component. The difference was high at 2.5 N. In the case of the bread baked without an admixture of the grain the value of chewiness decreased with the time of storage.

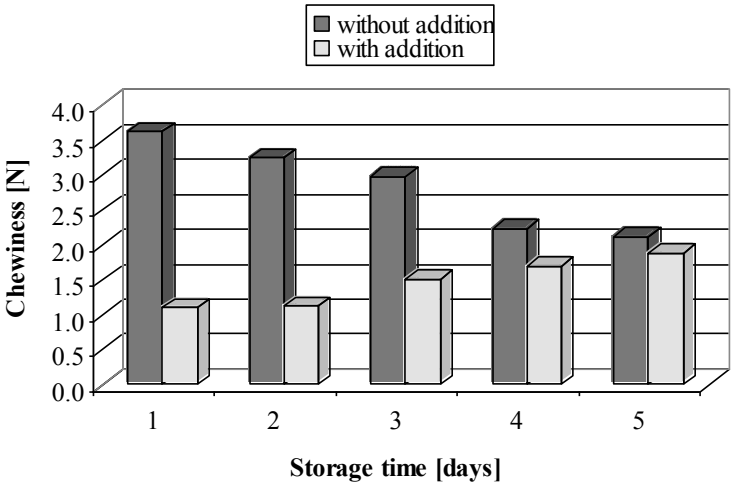

Fig. 5. Chewiness of mixed flour bread without [Ch_1] and with an admixture of rye grain [Ch_2] versus time of storage

The relations presented in the Figure are described by equations (7) and (8):

$$Ch_1 = 0.0043t^2 0.4279t + 4.0766, \tag{7}$$

$$R^2 = 0.96,$$

$$Ch_2 = 0.0088t^2 + 0.1601t + 0.8863, \tag{8}$$

$$R^2 = 0.95.$$

On the first and second day no significant differences were noted between the levels of chewiness of the bread with an admixture of rye grain. Further extension of storage time caused a significant increase in the level of chewiness, up to the value of 1.88 N.

Statistical analysis revealed that the obtained values of all mechanical properties of the breads were significantly related with the time of storage and with the recipe.

The results of assays of the chemical properties are presented in Fig. 6 and 7.

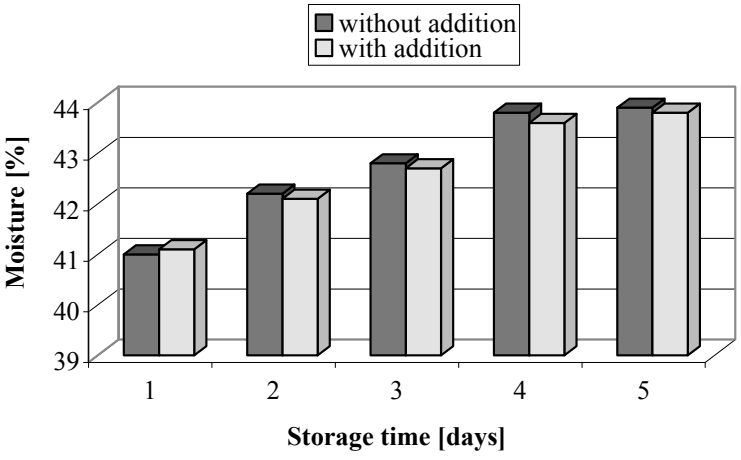

Fig. 6. Moisture content of mixed flour bread without [M_1] and with an admixture of rye grain [M_2] versus time of storage

The relations obtained are described by equations (9) and (10):

$$M_1 = 1.8744\ln 9(t) + 40.945, \tag{9}$$

$$R^2 = 0.98,$$

$$M_2 = 0.69t + 40.59, \tag{10}$$

$$R^2 = 0.97.$$

The moisture content of both breads on particular days was at a similar level, with no significant differences. With the passage of the time of storage there was a slight increase, from about 41 to 43.9%, that being an effect of the tight sealing of the breads and their fermentation.

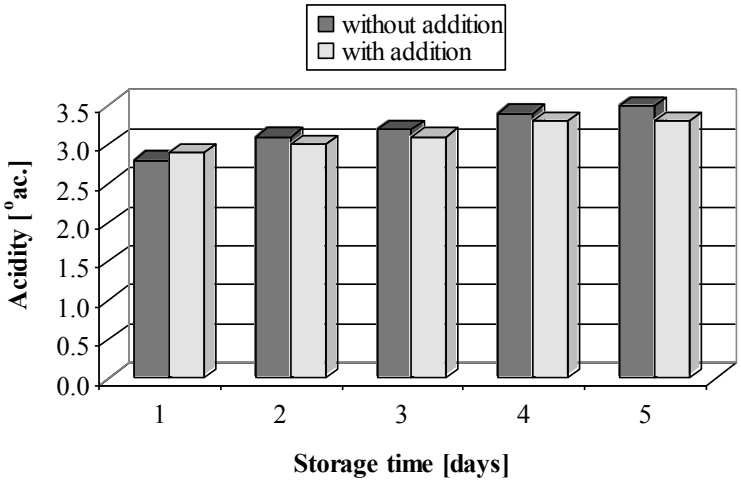

Fig. 7. Acidity of mixed flour bread without [A_1] and with an admixture of rye grain [A_2] versus time of storage

The relations presented in the Figure are described by equations (11) and (12):

$$A_1 = 0.17t + 2{,}69, \tag{11}$$

$$R^2 = 0.96,$$

$$A_1 = -0.0071t^2 + 0.1529t + 2.74, \tag{12}$$

$$R^2 = 0.95.$$

The acidity of both breads on particular days was at a very similar level, with no significant differences. During the storage the value of acidity increased from about 2.8 to 3.5° ac.

The sensory assessment ratings of the quality of the breads showed that the highest – first – level of quality was awarded to the bread without an admixture of rye grain on the first day after baking (33 points). On the second day the quality of that bread dropped to the second level (30 p.). Further storage of the bread resulted in a gradual decrease in its quality to the third level (25 p.). Notably better ratings were awarded t the bread with an admixture of rye grain. Up till the third day it was rated in the first class of quality (33 points), and on the fifth day it was classified in class two (29 p.). That bread can be stored for longer periods of time. It retains its freshness longer.

Using the instrumental analysis one can largely eliminate the sensory evaluation of bread, that being time-consuming and not overly objective. Control of the mechanical parameters of bread allows the estimation of the quality of the product, as it largely correlates with the sensory evaluation.

CONCLUSIONS

1. The recipe of the breads and their storage time had a significant effect on the studied mechanical properties and on their sensory evaluation.

2. The bread with an admixture of rye grain had lower hardness and chewiness, which is a positive feature. The values of those traits increased with the time in storage.

3. In the course of storage, the admixture of rye grain caused a decrease in the springiness and cohesiveness, and an increase in the chewiness of the product. The mean values of those parameters after 1 day of storage were from 0.361, 0.299 and 1.104 N, respectively, for samples of bread with an admixture of rye grain, to 0.596, 0.327 and 3.625 N in the case of bread without that admixture.

4. Storage caused an increase in the moisture content and in the acidity of the breads.

5. Most recommended is the bread with an admixture of rye grain during the first three days of storage, and the bread without such an admixture during the first two days from baking.

6. Using instrumental analysis one can largely eliminate the sensory evaluation of bread, that evaluation being time-consuming and not really objective.

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MECHANICZNE WŁAŚCIWOŚCI TEKSTURY CHLEBA MIESZANEGO Z DODATKIEM ZIARNA ŻYTA

Streszczenie. W pracy porównano mechaniczne właściwości teksturalne pieczywa mieszanego z dodatkiem ziarna żyta i bez jego dodatku (twardość, sprężystość, kohezyjność i żujność) oraz właściwości chemiczne (wilgotność i kwasowość). Omówiono przygotowanie ciasta i wypiek chleba oraz określono na podstawie oceny sensorycznej czas przechowywania, w którym pieczywo jest akceptowane przez konsumenta.

Słowa kluczowe: chleb mieszany, właściwości teksturalne, czas przechowywania.