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Effect of Storage Time On Deformation Characteristics and Water Activity of Wheat Bread with Walnut Flour

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Abstract

The effect of storage time on the deformation characteristics and water activity of wheat bread with different quantities of walnut flour was investigated for period of 72 h. It was found that after 48 hours the processes of bread staling with walnut flour are less intense than those of the control sample. Best results are observed with addition of 1 % walnut flour. From these results, bread with a minimum quantity of walnut flour (A) prolongs the storage time over a sufficiently long period of time – an average of 48 hours, which is completely acceptable in a consumer aspect. The addition of walnut flour increases water activity of the bread.

Keywords: Walnut flour, wheat bread, total deformation, elasticity, plasticity, water activity.

1. Introduction

Walnut flour is characterized by a high content of dietary fiber and polyunsaturated fatty acids, but low content of carbohydrates. It is a rich source of proteins which didn't form a gluten network [5, 6, 8, 11, 15]. The addition of walnut flour leads to the production of a product with high quality with the respective nutritional value and sensory characteristics [4, 8, 10, 11].

According to Ndie et al., walnut flour is used in breadmaking and confectionary due to its rich proteins content and good water absorption properties [7].

In bread storage, a lot of processes occur which affect the quality. In bread storage, it changes the hydrophilic properties in bread crumb, reduces swelling and swallowing water, reduces the total quantity of water-soluble substances [16].

Retrogradation of starch is a process that occurs during storage of starchy foods and is one of the main causes of food spoilage. It represents physical changes in the structure of amylose and amylopectin. In flour and dough, a starch has a crystalline structure. During baking, under high temperature, a starch grains absorb water and swell – the starch goes into an amorphous-crystalline state and this process is called gelatinization. In storage, the starch's solubility in water decreases and it goes back to its initial crystalline form. This process is called retrogradation of starch [7, 12, 13].

Based on the information above and the fact that the carbohydrate content of the walnut flour is lowered, it may conclude that bread storage will be delayed probably by the addition of walnut flour.

According to Sandulachi and Chirita the shelf life of bread samples with added walnut flour is comparatively higher than those of control samples [10]. The data presented proves that an addition of walnut flour to wheat flour preserves freshness and extends the shelf life of bread.
The other authors (9) show that cakes from the supplemented wheat flour tend to stale faster than those from wheat flour (100 %) due to its high rate of weight loss which resulted from higher loss in moisture, soluble starch, amylose, and other volatile compounds from the composite cake.
The aim of the presented study is to determine the effect of different quantities of walnut flour on deformation characteristics and the water activity of wheat bread during storage.

2. Materials and Methods

2.1. Raw materials

Three experimental samples (1 % – A, 3 % – B and 5 % – C) with walnut flour were added to complete the wheat flour to 100 %. The control sample (K) is wheat flour – 100 %.

2.2 Methods

Bread dough is prepared in the University laboratory of bread, breadmaking and confectionery products at the University of Food Technologies – Plovdiv. For dough making it is use a wheat flour (t. 500), yeast (2.0 %), salt (1.5 %) and water according to the water absorption capacity of the flour (determined by farinograph) [3]. The initial temperature of the dough is 29-30 °C. The technology includes also resting (20 min), dividing and shaping the dough pieces, final fermentation (35 °C), and baking (baking temperature – 220-230 °C and baking time – 22 min).
The change of deformation characteristics and water activity are monitored over a period of 72 h (3 days). The samples were stored at a temperature of 20 +/- 1 °C and a relative humidity of 75 % maintained with saturated NaCl solution.
The deformation characteristics of bread crumb (total, elastic and plastic deformation) are determined on an automatic penetrometer according to the methodology, PU [14].
The water activity (aw) is determined by an electronic device type ER – 84 (Novasina, Switzerland) with a RTD – 42 sensor block [1].

3. Results and Discussion

The essence of the bread staling process mainly consists in the changes in the bread crumb – reducing the elasticity and softness. In this sense, the deformation characteristics of the crumb can give an objective idea of bread staling process.

Effect of walnut flour on the deformation characteristics of bread crumb

To establish the change of quality, it is determining the dimensions of the total (TD), plastic (PD) and elastic (ED) deformations of the crumb of wheat bread with addition of walnut flour.

The measurement is made on a piece of bread crumb (from the central part of bread) with a thickness of 40 mm. The principle of determination on the deformation characteristics is: on the flat plate of bread crumb is treated with a body with fixed mass, which is left for a certain time (5 s) to fall freely downwards. In this case, there is a penetration of the immersion body in bread crumb, and the magnitude of its sinking into the medium determines its constriction or total deformation. The immersion system is then unloaded and the baking medium partially restores its height due to its elastic properties and then determines the plastic deformation. The difference between the total and the plastic deformation is the elastic deformation, judging by bread freshness. Depending on the size of the test piece, the definition is made at three (or five) locations.

In figure 1 it is presents the values which characterize the total deformation of wheat bread with different quantities of walnut flour.

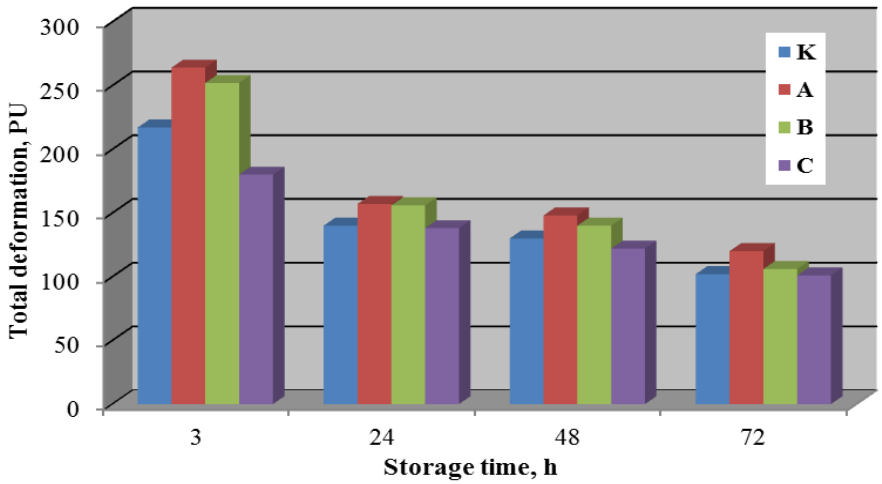

Figure 1. Changes in total deformation of wheat bread with walnut flour

For all samples tested, the total deformation showed a regular decrease in values with an increase of bread storage. However, the values of the test samples are higher than those of the control sample during all period of the study.

The overall deformation of the control sample for the all storage time is 115 PU, which expressed as a percentage is 52.3. The graphical representation of the results shows that, unlike the control sample, in the final phase of the study period, wheat flour bread with a minimum quantity of walnut flour (A) has a higher TD, respectively softness of the crumb. The decrease of the total deformation is 144 PU, which expressed as a percentage is 54.7.

The results of the plastic deformation confirm the results of the variation of total deformation (figure 2).

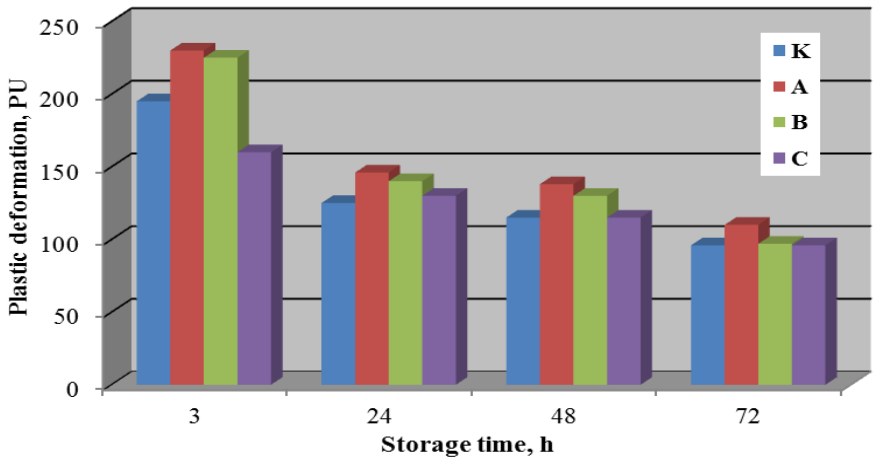

Figure 2. Changes in plastic deformation of wheat bread with walnut flour

The difference between the control sample (195 PU) and the test sample A (230 PU) for plastic deformation is 35 PU, which expressed as a percentage is 15.2. The most significant is the change of samples between 3 and 24 hours. The decrease in the plastic deformation of the control sample at the end of the storage period was 94 PU, which expressed as a percentage is 52.5. Compared with the control sample, in the final phase of the study, the wheat flour bread with a minimum quantity of walnut flour (A) has a higher PD. The decrease of the plastic deformation is 120 PU, which expressed as a percentage is 52.2.
The ED data is illustrated in figure 3. The results obtained for the elastic deformation confirm those for total and plastic deformation of bread with walnut flour.

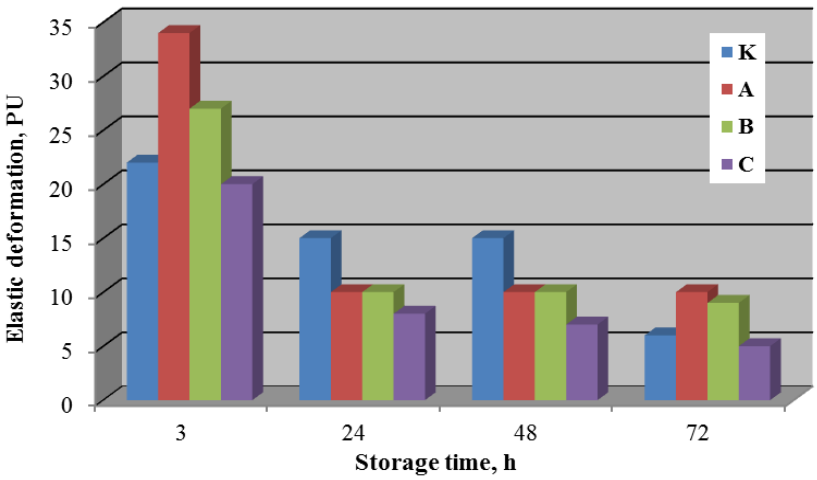

Figure 3. Changes in elastic deformation of wheat bread with walnut flour

The results show a decrease in elastic deformation, both in the control sample and in the tests samples, during the storage period. At the beginning of the study, higher results were obtained from samples A and B, respectively, 34 and 27 PU. Between 24 and 48 h of the study, the results for elastic deformation of the control sample remained approximately constant and highest. At the end of the study, the highest values were obtained by addition of minimum quantity of

walnut flour (A). There is a minimum difference for ED between the control sample and test sample A – 4 PU (36.4 %).
It can be concluded that after 48 hours of staling in bread with walnut flour the process are less intense than those of the control sample. Best results are obtained for sample A (with 1 % walnut flour). From these data it follows that bread with a minimum quantity of walnut flour (A), extends the shelf life over a sufficiently long period of time – an average of 48 hours that is completely acceptable in a consumer aspect.

Effect of walnut flour on water activity of wheat bread crumb

Water activity is an indicator characterizing the presence of water capable of entering into a chemical reactions and showing the susceptibility of food products to development of microbial spoilage.
Figure 4 graphically compares the water activity results for a control sample (K) and tests samples wheat bread with walnut flour (A, B and C).

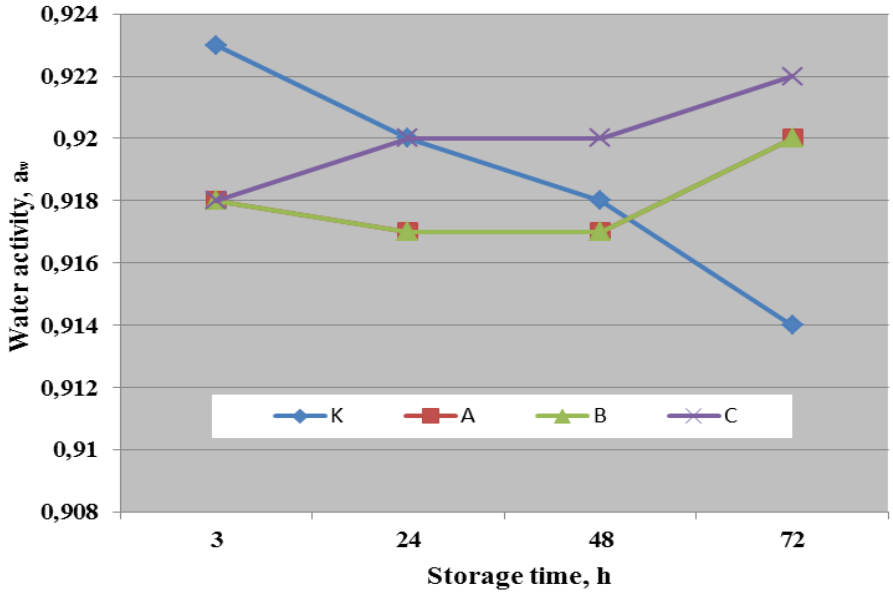

Figure 4. Changes in water activity of wheat bread with walnut flour

The water activity of baking crumb of the control sample is relatively high – 0.923 aw, which is a prerequisite for microbiological deterioration in the storage of bread. In the test samples, a decrease in water activity was observed at the 3rd hour of the study compared to the control sample. The total decrease in sample K was 0.9 %. On its part, the experiments with walnut flour showed an increase in water activity during bread crumb staling. For the first 3 hours samples A, B and C have equal values (0.918 aw). In sample C with the highest quantity of walnut flour (5 %), there was a significant increase in water activity compared to the other tests samples. At 72 hours, sample C had higher values for the test parameter than those of the control sample.
The results may be due to a higher moisture content of walnut flour compared to wheat flour. Lower values of the water activity of the test samples compared to the control may be due to the fact that walnut flour reduces the water absorption properties of flour.
These results didn't correspond to those obtained by Dimitrov et al., which determine the water activity of wheat bread flour type 1150 with the addition of 4, 5, 6, 7 and 8 % flour from

topinambur. They find that water activity decreases during the first days of storage. This decrease being 24 hours slower with flour from topinambur bread compared to the control sample. The same results are obtained by Lee Hoon Ho et al. They find the samples with banana flour were significantly ($p < 0.05$) lower.
The results obtained in the experimental research clearly show that addition of walnut flour by the incorporation of wheat flour increases the water activity of wheat bread.

4. Conclusion

From the results of this study it was found that after 48 hours the processes of bread staling with walnut flour are less intense than those of the control sample. Best results are observed with addition of 1 % walnut flour. From these results, bread with a minimum quantity of walnut flour (A) prolongs the storage time over a sufficiently long period of time – an average of 48 hours, which is completely acceptable in a consumer aspect. The addition of walnut flour increases the water activity of the bread.

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