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INFLUENCE OF THE XANTHAN GUM ADDITION ON THE TECHNOLOGICAL AND SENSORY QUALITY OF BAKING PRODUCTS DURING THE FREEZING STORAGE

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ABSTRACT

The influence of the 0.16% xanthan gum addition in the recipe of the bread production and its influence on the baking and sensory quality of products was monitored during the process of our research. Prepared dough was inserted in the freezing box directly (-18°C) and it was stored for one, two, three, four, five and six months. When the baking process was finished, the products with xanthan gum and the products without it were compared and evaluated by both objective and subjective methods. It was found that freezing, cooling and storage of the products without xanthan gum addition influenced the volume, vaulting and general appearance of the products in a negative way and loaves of bread were evaluated as unacceptable after four months of freezing. The quality of experimental loaves of bread with xanthan gum was, even after six months of freezing storage, comparable with freshly baked products. Despite the freezing, the volume of the products had an increased value. After first month of freezing the volume increased by 28.6% and after two months of freezing it increased by 23.8% both compared to the control. The vaulting in products processed by freezing was in the required optimal level during the whole period of freezing. Sensory evaluation results of loaves of bread with xanthan gum were the best after three, four and five months of storage in a freezer, when 98 points were achieved. During the monitored period of freezing, the addition of 0.16% of xanthan gum markedly contributed to the preservation of sensory and baking quality of the frozen wheat dough.

Keywords: xanthan gum; freezing storage; baking quality; sensory quality

INTRODUCTION

The producer's aim is to preserve the product fresh as long as possible, therefore it is feasible to influence the forms of slowing down the bread staling by regulating the room temperature where the bread is stored and by the modification of production process, or recipes **(Cauvain, 1998; Hampl et al., 1981)**. Hydrocolloids are perspective additives with the ability of effective linking of water molecules which become fixed, thus with this mechanism it is possible to eliminate the presence of unfavourable crystals that influence product texture in a negative way **(Gimeno et al., 2004; Khan et al., 2007)**.

Hydrocolloids are high-molecular hydrophilic biopolymers which has many functions in food industry. The most important function could be the ability to control the rheologic attributes and food texture. In baking industry they are mostly added for the purposes of emulsions, suspensions and foams stabilization, to improve the processing attributes, because of their inhibition ability of starch retrogradation, their efficient humidity retaining, improvement of the whole structure, staling inhibition of the products, but also as the replacement of fat and eggs **(Collar et al., 1999; García-Ochoa et al., 2000; Arozarena et al., 2001;Kohajdová et al., 2008; Kohajdová et al., 2009; Magala et al., 2011)**. The most popular hydrocolloid of the microbial origin is a xanthan gum, which is exocellular polysaccharide produced by aerobical sugar fermentation by the *Xanthomonas campestris* bacterium **(Hojerová et al., 2005; Mikuš et al., 2011; Tao et al., 2012)**; the main bond of xanthan consists of β-D-(1.4) glucosic elements and lateral bonds are formed by the D-glucoronic acid leftover and two leftovers of D-mannose **(Velíšek, 2002)**. According to **Hojerová et al. (2005)**, it was discovered that xanthan gum reaches the fastest hydration, the smallest temperature sensibility and its stability in soft acid to neutral pH only.

The xanthan gum is characterized by the ability of creation the reversible gels in conjunction with galactomannans, e.g. carob gum **(Milani et al., 2012)**. It is possible to use xanthan gum as a partial replacement of egg white in cakes **(Miller and Setser, 1983)**. Moreover it was discovered that the xanthan gum addition during the dough kneading, prevented the shrinking of products and markedly improved the volume and height of a bread in comparison with the specimen **(Miller and Hoseney, 1993)**, provided the highest viscosity of dough **(Ashwini et al., 2009)**, firmed the structure of dough **(Ashwini et al., 2009)** and strengthened the bonds between flour proteins **(Collar et al., 1999)**. There are various possibilities of xanthan gum usage: applications in dressings, syrups, or diet, frozen and baking products, but also in other branches of industry and agriculture **(García-Ochoa et al., 2000)**. The xanthan gum has a very important function as an additive in gluten-free bread recipes where, due to the absence of gluten, it is improving technological and sensorial quality of the products for celiatics **(Gambuś et al., 2007)**.

MATERIAL AND METHODOLOGY

The first experimental group of loaves of bread were prepared from wheat extra fine flour T 650 (Mlyn Pohronský Ruskov a.s.) in amount of 500 g, sugar (1%), salt (1.6%), yeast (4%) (Trenčianske droždie, OLD HEROLD HEFE, s.r.o.) and water which was added according to farinograph **(ICC - Standard 115/1, 1992, AACC Method 54-21, 1995)** farinograph water absorption of the flour (150 cm^3). The second experimental group of bread loaves was created with the same ingredients in same proportions, but in addition it contained 0.16% of xanthan gum (f. Natural Jihlava) in regard to the flour weight.

The dough was kneaded in a laboratory kneader Diosna SP 12. Then it was designed into loaves of bread, which rose in rise rooms for 20 minutes at 30°C and after that were baked at 240°C for 20 minutes with a steaming in Miwe Condo oven. The control specimen of wheat bread loaves was prepared this way. The rest of the loaves was put without yeasting into the freezer with temperature of -18°C (AFG 070 AP, company: Whirlpool Slovakia spol. s.r.o.,) and stored at this temperature for one, two, three, four, five and six months. The defrosting of the loaves before the yeasting and baking lasted 2 hours at room temperature of 22°C ±2°C.

The flour was quantitatively evaluated and the following attributes were set: *determination of the moisture content, %* **(ICC Standards No. 110/1 (1976))**, *ash on products, %* **(ICC Standard No. 104/1, (1990))**, *determination of the "Falling number", s* **(Falling Number, measurer FN 1800, Perten, according ICC Standard No. 107/1, (1995))**, *the wet gluten rate, %* Glutomatic 22000, Perten, (**ICC Standard No. 155, (1994))**, *determination of the sedimentation value by Zeleny, cm^3* **(ICC Standard No. 116/1, (1994)**), *determination of crude protein* **(ICC Standard No. 105/2 (1994))**.

Baked loaves of bread were evaluated by objective methods for baking quality examination during the storage at -18°C. Within them the following attributes were set by standard procedures and calculations used at the working place: *volume of the products* (cm^3), *specific volume of the products* ($cm^3.100g^{-1}$), *volume recovery* ($cm^3.100g^{-1}$ flour), *yield of products* (%), *baking losses* (%) and *vaulting of the products* (the ratio of the height and width of the loaves). Also, the loaves were evaluated sensorically by using the one hundred points test applied by the retrained evaluators at the Department of Plant Products Storing and Processing. These attributes were evaluated: *general appearance and shape* (the coefficient of the importance 1), *surface and characters of the crust* (the coefficient of the importance 2), *rising and the appearance of the crumb* (the coefficient of the importance 4), *structure and elasticity of the crumb* (the coefficient of the importance 4), *smell and taste* (the coefficient of the importance 9) with the maximum possible reached points of 100. In terms of sensory evaluation, the general profile of experimental controlled loaves (which were stored for six months in a freezer) with xanthan gum, was created and compared. The experiment results are pictured graphically and they were evaluated by the application of non-parametric statistic methods: Wilcoxon test and Kruskal-Wallis test and evaluated in **R Core Team (2014)**.

RESULTS AND DISCUSSION

The year consumption of pastry for one inhabitant of the Slovak Republic is approximately 40 kg of bread and 30 kg of wheat pastry **(ŠÚ SR)**. The quality of bread and pastry as the essential food is a very current topic. It is markedly influenced by the quality of used ingredients, especially flour and additives. In the flour we used (T650) it was detected: moisture content 13.9%, ash on products 0.49%, the Falling Number test 324 s, the wet gluten rate 32.6%, sedimentation value according to Zeleny 40.0 cm^3, crude protein (Nx5.7) 11.5%. Based on the analysis of **Muchová et al. (2001)** the used flour can be characterized as mid-strong with proportional amylases activity and sufficient amount of good quality gluten; so it can be used for risen products.

The prepared dough in the bowl mixed directly after the rising and the qualitatively evaluated specimen was used for the control. After the process of dough freezing, storage (from one to six months) and defrosting, the next specimens were risen again and baked according to the

Table 1 Results of the experiment with wheat bread loaves without the xanthan gum addition

period of deep-freeze storage	volume of products cm^3	specific volume $cm^3.100g$	volume recovery $cm^3.100$ g flour	yield of products %
immediately baked/ control [a]	262.5	297.1	420.0	141.3
one month [a]	212.5	231.9	340.0	146.5
two months [a]	225.0	258.3	360.0	139.3
three months [a]	240.0	264.6	384.0	145.1
four months [a]	235.0	283.7	380.0	133.9
five months [a]	215.0	239.1	344.0	143.8
six months [a]	200.0	230.9	320.0	138.5

methodology described above. The chosen results of the baking experiment without the xanthan gum are pictured in Table 1. From the Table 1, it is seen that the volume of the baked loaves without the addition of xanthan gum has been gradually decreasing till the third month, then the decrease was stopped and the slight increase of volume was observed compared to the first and the second month of freezing. Based on the results of Kruskal – Wallis test it was discovered that there is no statistic difference between the samples (every month of freezing was compared with the control), because the rate of $p = 0.45$. After five and six months of freezing, the loaves of bread achieved the lowest volume and insufficient vaulting (Figure 1) in comparison to the control and thus these products can be evaluated as unsatisfactory.

Results of the work, which confirm the similar decreasing baking quality during the freezing storage, were also noticed and described after six months of freezing storage by the authors **Berglund et al.** (**1991**).

The disrupted and cracked gluten structure, which was separated from the starch granules, was discovered by them. More authors mention that the most significant changes of frozen dough were related to yeast, because dead ice damaged yeast cells release glutathione, which disables the gluten structure. This consequently leads to the worse retention of gases and extension of the rise time of dough **(Kline et al., 1968; Hsu et al., 1979; Autio et al., 1992; Gelinas et al., 1995; Pepe et al., 2005)**. A decreased ability of the dough to retain emergent gases during the rising process is practically expressed by insufficient and low volume of experimental loaves of bread. So it is possible to state, that freezing storage gradually degrades the baking quality of loaves of bread, which was confirmed also by our experiments.

Table 2 shows experimental loaves of bread staling, which in contrast to products pictured in Table 1 contained

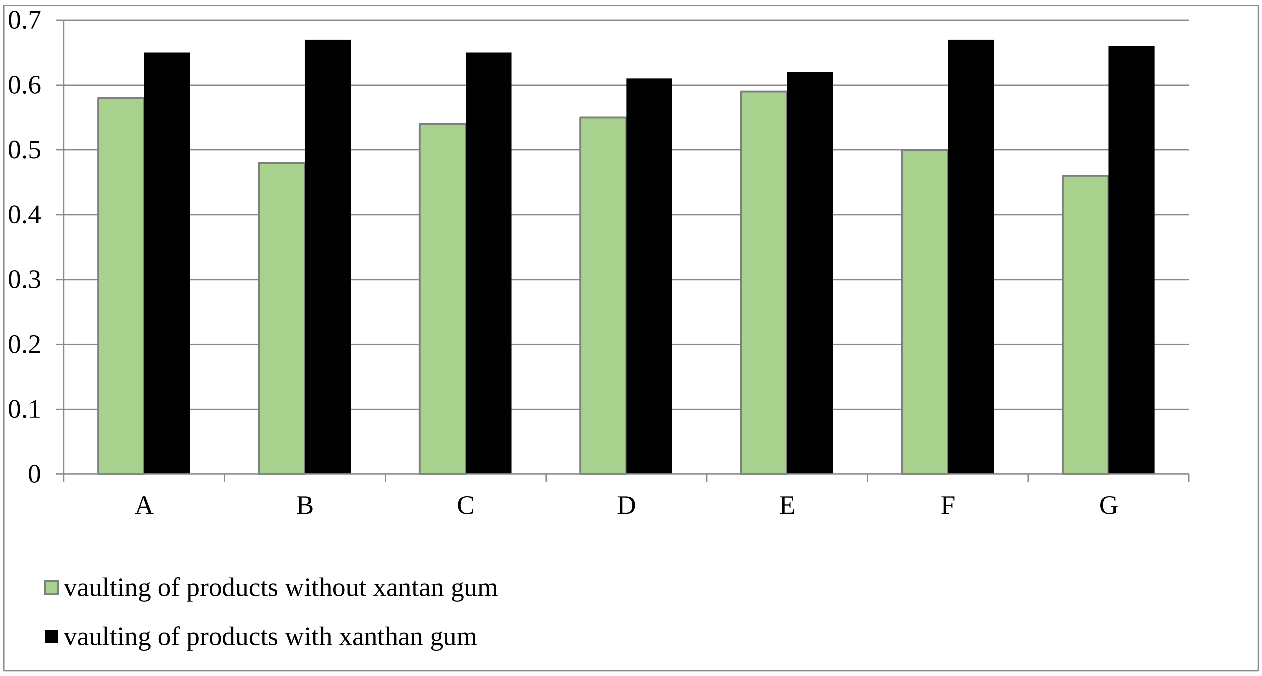

Figure 1 Comparison of the vaulting of the products with and without xanthan gum.

Note: A – products baked at the beginning - the control, B – products stored in freezer for one month, C – two months, D – three months, E – four months, F – five months, G – six months. The 0.65 value is optimal for vaulting of the loaves of bread. The values under 0.6 and over 0.7 are insufficient for vaulting of the products.

Table 2 Baking experiment results with the wheat loaves of bread containing 0.16% of xanthan gum.

period of deep-freeze storage	volume of products cm^3	specific volume $cm^3.100g$	volume recovery $cm^3.100$ g flour	yield of products %
immediately baked/ control [a]	262.5	286.4	420.0	146.6
one month [a]	337.5	362.5	540.0	148.9
two months [a]	325.0	351.5	520.0	147.9
three months [a]	262.5	241.8	420.0	153.4
four months [a]	312.5	338.2	500.0	147.8
five months [a]	275.0	301.2	440.0	146.0
six months [a]	262.5	280.9	420.0	149.5

0.16% of xanthan gum. The dough prepared in kneader was risen and baked. The qualitatively evaluated sample was used as the control. The other samples (experimental loaves of dough) were put in a freezing storage (from one to six months) and then defrosted, risen, baked and evaluated. Consequently, their baking quality was compared to the products without the addition of xanthan gum.

The Table 2, where results of baking experiment with frozen and baked loaves of bread with 0.16% of xanthan gum are introduced, shows that freezing storage does not affect the quality of products negatively. After the first month the volume of later baked loaves of bread increased by 28.6% compared to the control, after two months of freezing storage it increased by 23.8% also compared to the control and the vaulting rates (Figure 1) were on the required optimal level constantly. After three and six months of freezing storage the same volume as in the control was discovered and after four and five months of storage the increase of volume was observed, while the vaulting was constantly good (0.65). Statistic results reached by Kruskal – Wallis test (every month of freezing storage is compared to the control again) indicated the value of $p = 0.7$ which means that no statistical difference was found between compared samples and the control. By the Wilcoxon test, the results of particular months of freezing storage without xanthan gum were statistically compared to the results of products, which were frozen for the same time span, but they contained xanthan gum. It is possible to claim again that there was no statistically significant difference between compared samples.

In the past, many scientific groups were engaged in removing and eliminating negative impacts on baking products by the addition of xanthan gum, e.g. **Collar et al. (1999)**, who published that xanthan gum in recipes improves the retention of gases which is visible by bigger volume, **Rosell et al. (2001)** discovered the positive effect of increased water activity in a crumb, **Dodić et al. (2007)** measured out the higher specific volume in comparison with frozen products without the addition of hydrocolloids and **Mandala (2005)** discovered that the xanthan gum addition higher than 0.16% causes a decrease of specific volume of breads, so it recommended not to exceed this level. The results of works of the authors who were engaged in this issue were also confirmed by our experiments. It is possible to claim that the baking quality of the products with 0.16% xanthan gum addition was perfect even after six months of freezing storage and it was comparable to freshly baked products. After the evaluation of baking experiment, the loaves of bread were subjectively rated by 100 points questionnaires for the comparison of the xanthan gum influence on sensory quality of the products. Figure 2 shows the results of sensory evaluation.

As it results from Figure 2, the sensory quality of experimental loaves of bread without the addition of xanthan gum has been proportionally declining as the time of freezing storage has been prolonging. The most expressive decline of sensory quality was observed after four months of storage (Letter E). The experimental loaves of bread which contained xanthan gum reached almost the same sensory quality during the whole period of freezing. That proves the positive influence of the additive.

For better comparison of xanthan gum influence on a general appearance, an appearance of crust and crumb, elasticity, smell and taste; the sensory profile of bread loaves without xanthan gum (Figure 3) and sensory profile of measured index of bread loaves with xanthan gum (Figure 4) was created. By comparison of the Figure 3 and the Figure 4, it is possible to claim that the addition of 0.16% of xanthan gum had a positive effect on surface of loaves of bread, quality of crust and crumb and elasticity

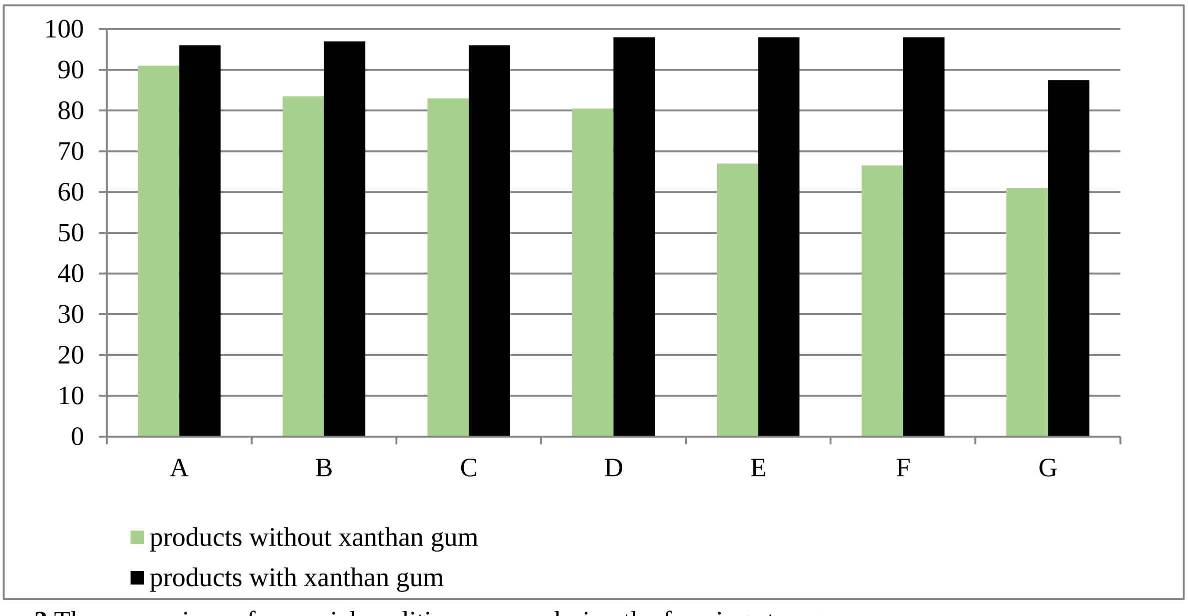

Figure 2 The comparison of sensorial qualities process during the freezing storage.

Note: A – products baked at the beginning - the control, B – products stored in freezer for one month, C – two months, D – three months, E – four months, F – five months, G – six months.

of crumb. The evaluators claimed that even after six months of freezing storage, the crust was softer, crispier and easier to chew in the products with xanthan gum, compared to the products without it.

Moreover, the positive influence of the xanthan gum addition was discovered in the quality of crumb, especially its structure, elasticity and uniform porosity of the products.

The sensory and technological baking quality of baked bread loaves without the addition of xanthan gum were after six months of freezing storage evaluated by **Bojňanská et al.** (**2013**), as decreased in comparison to the control was. Our experiments confirm the results for example of **Gimeno et al.** (**2004**). The sensory quality of experimental loaves of bread with xanthan gum was in balance for almost the whole period of the storage. A mild decline was observed after six months of freezing (85.5 points), but the point score can still be considered as convenient. The addition of xanthan gum had clearly positive effect on the sensory quality of the products during the whole period of freezing storage.

By comparison of the Figure 3 and the Figure 4, it is possible to claim that the addition of 0.16% of xanthan gum had a positive effect on surface of loaves of bread, quality of crust and crumb and elasticity of crumb. The evaluators claimed that even after six months of freezing storage, the crust was softer, crispier and easier to chew in the products with xanthan gum, compared to the products without it. Moreover, the positive influence of the xanthan gum addition was discovered in the quality of crumb, especially its structure, elasticity and uniform porosity of the products.

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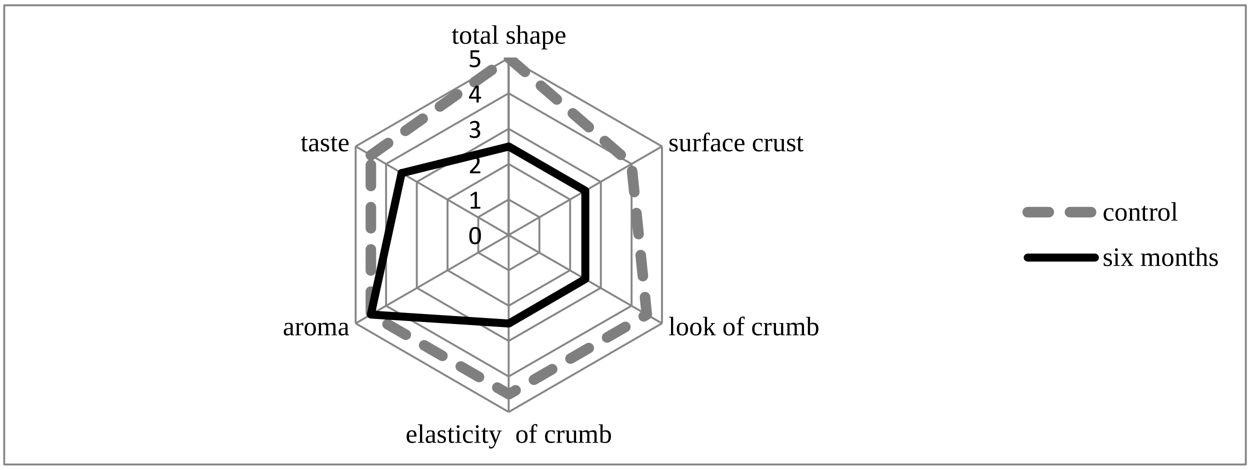

Figure 3 Sensory profile of the products without xanthan gum.

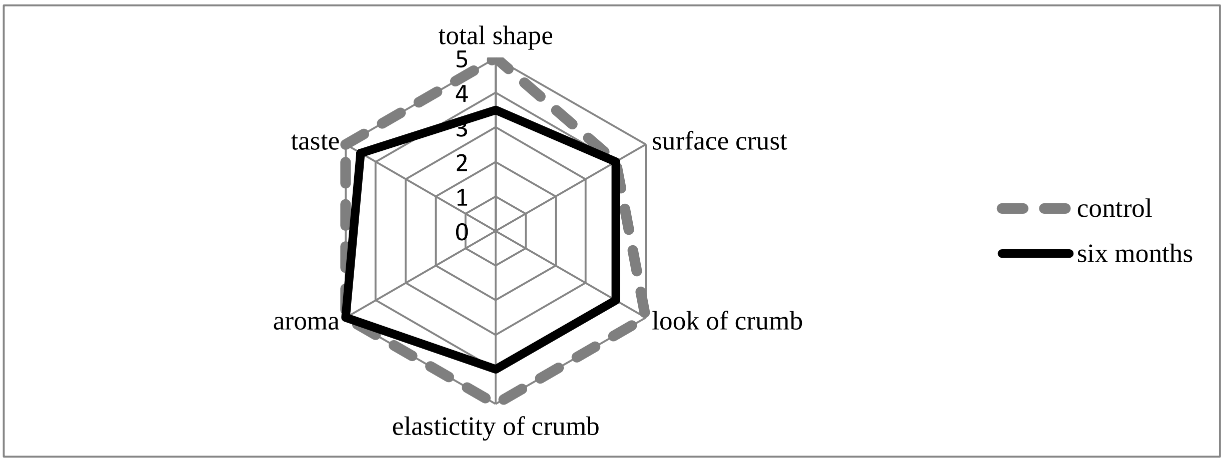

Figure 4 Sensory profile of the products with xanthan gum.

CONCLUSION

Based on the comparison of the baking experiment results and the sensory evaluation of baked wheat bread loaves and bread loaves with xanthan gum addition, it is possible to claim that this additive in recipe has markedly contributed to the elimination of undesirable effects of freezing storage and the products achieved perfect quality also after six months of storage. Technological and sensory quality of the products without xanthan gum can be, after four months of the storage in a freezing box, evaluated as unsatisfactory. This was in contrast to the loaves of bread with 0.16% xanthan gum addition which volume, specific volume, vaulting and sensorial indicators were, even after six months of freezing storage, still excellent and comparable with freshly baked products (the control).

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