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EXPERIMENTAL CHARACTERISTICS OF DOUGH FREEZING AND PRODUCTS OBTAINED FROM FROZEN DOUGHS

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ABSTRACT

Wheat and wheat-rye doughs, including those modified with ingredients, were frozen at -30°C in air recording their temperature with a digital thermometer. After preliminary baking the following were determined: dough and bakery efficiency, crump mass density, bakery volume, baking, total baking loss and crust-crump ratio. The rheological assessment was made after TPA test, while organoleptic evaluation included: bakery appearance, colour, crust thickness, elasticity, crump porosity, taste and flavour.

The dough freezing point depression ranged from -3.00°C to -6.30°C. The ingredients decreased cryoscopic range, improved physical characteristics like the bakery rheological ones; yet modified starch CS exerted the most favourable influence.

Key words: dough freezing, freezing point depression, bakery freezing, rheological characteristics

INTRODUCTION

The fixative effects of freezing applied in food production are obtained as a result of sufficiently deep decrease of a product temperature accompanied by phase change of water into ice, that brings about progressive increase of substance concentration in the solutions inside a product. The processes intensity illustrating a rate of quality changes of frozen food depends on frozen product type and its initial qualities as well as character and parameters of the cooling treatment [2, 5, 9].

A temperature at which the first ice crystals appear in a product is defined as initial freezing point. It depends on cell juice concentration, i.e. tissue structure, product shape and size and heat exchange conditions [3, 8, 9]. The freezing point is considered to be most important characteristics affecting the quality of a frozen product. Knowledge on its development allows to build refrigerating machines and installations best, to plan cooling treatment system in a proper way as well as to optimize production in its economic aspect [4, 7, 12].

Formation of ice crystals over the dough freezing process contributes to impairement of gluten net structure, thus it indirectly affects the rheological and baking characteristics of doughs. It is possible to minimize these effects in the frozen doughs due to modification of material composition and technological process. The added substances can stabilize the material and protect a delicate dough structure against any damage at the freezing through eg. their freezing point depression.

The main objective of the present work was experimental characteristics of freezing point and a range of pure freezing of mixed and wheat dough. The research subject has also included a possibility of supplementation of bakery obtained from frozen dough with some improving substances and examination of their influence on organoleptic and rheological qualities of bakery.

MATERIALS AND METHODS

1. Research material

The research material was made by wheat and wheat-rye dough prepared according to a technological recipe (Table l).

To establish the basic technological parameters, essential to fix flour usability for bakery production there was performed its analysis. Wheat and rye flour moisture, wet gluten content and falling number were determined as well as the assessment of dough qualities. In order to interpret the results the requirements of the American Association of Cereal Chemists (AACC) were used [1, 10, 13, 14, 15].

Table l. Type and share of components used in doughs examined

Materials	Dough	
	wheat	wheat-rye
Wheat flour type 500	100.0%	80.0%
Rye flour type 720	-	20.0%
Baker's compressed yeast	6.0%	6.0%
Salt	2.0%	2.0%
Sugar	2.0%	2.0%
Water	53.6%	53.6%
Dry starter	-	2.0%

The dough was made ac. to a direct method consisting in simultaneous addition of all the ingredients included in a recipe to the flour.

The prepared dough was divided into portions of 30.0 g weight and frozen till it obtained -18.0°C in the thermal center of a sample. The basic recipe was modified with some chosen ingredients specified in Table 2.

Table 2. The ingredients used in the investigations

Ingredient type	Percentage [%]
WHEAT DOUGH	
Guar E-412	0.25÷2.00
Karagen E-407	0.50÷2.00
Glucose	0.50÷2.00
Distarch acetylized adipate E-1422 CS	0.25÷2.00
Distarch acetylized adipate E-1422 HS	0.25÷5.00
Soya milk	3.00÷10.00
Glutamic acid	0.50÷1.50
WHEAT-RYE DOUGH	
Pectin E-440	1.00÷3.00

The mixed and wheat dough for experimental baking was divided into 200.0 g pieces and packed into polyethylene bags. Then the samples were frozen and stored at -18°C temperature for 2 weeks' time.

2. Research stand and methodo logy of freezing assessment

The process of full freezing of samples was conducted at ultra-cryostat N-180 making use of the enthalpy of liquid nitrogen vaporization. That allowed to develop proper conditions of the cooling medium, i.e. -30°C temperature. Temperature measurements were taken with a digital thermometer and attested thermocouples NiCrNi kit of with accuracy ±0.05 K. The freezing point of the doughs was established out of the freezing curves obtained representing the process course. Temperature of water crystallization start in a sample thermal center was considered the freezing point.

3. Experimental baking

The experimental baking was performed in a laboratory oven at temperature 220°C for 30 min. There was determined dough and bakery yield, oven loss, total baking loss according to the presented methodology [8, 10].

Organoleptic analysis and bakery physical qualities establishment were made, so that qualitative changes resulting from storage could be fixed as well as to describe influence of the ingredients used in the tests. Moreover, the following were established: crump mass density, bakery volume, crust and crump ratio. The organoleptic (point) analysis included

evaluation of bakery appearance, colour, crust thickness, elasticity, crump porosity as well as flavour and taste after PN-A-74108:1996.

Assessment of the rheological qualities of ready products was performed with texture profile analysis method (TPA), consisting in interpretation of a measurement curve gained after repeated compression of a product in INSTRON 4302 equipment. Basing on the diagrams obtained there were fixed: hardness, elasticity, cohesion, viscidity, chewiness and compressibility [6, 8, 11, 16].

RESULTS

1. Technological evaluation of flour

Basing on the data obtained it can be stated, that the flour used in the investigations complied with the standards. Samples moisture was equal 13.5%, while a wet gluten content responsible for dough structure shaped out at 29.8% level. The flour under investigation showed a relatively high water absorption (wheat flour 59.6%, rye flour 56%). The results concerning pharinographic assessment indicate, that the flour used can be classified among the flours of good baking qualities.

2. Influence of ingredient quantity on freezing point value

The analysis of freezing point data revealed, that the differences in its value occured not only in dependance on a dough type but chemical composition of wheat and wheat-rye doughs as well.

Table 3. Freezing point values of the doughs examined with regard to ingredient percentage in dough

Ingredient type	Percentage [%]	Freezing point T_{kr} [°C]
WHEAT DOUGH		
Control	0.00	-3.00
Guar	0.25	-3.40
Guar	2.00	-5.00
Karagen	0.50	-3.70
Karagen	2.00	-5.70
Glucose	2.00	-4.70
Distarch acetylized adipate CS E-1422	2.00	-5.30
Soya milk	10.00	-6.30
WHEAT-RYE DOUGH		
Pectin	0.00	-5.00
Pectin	3.00	-6.00

The changes of the fixed value were presented graphically. The examplary values of the freezing point of the wheat and wheat-rye doughs are enclosed in Table 3.

Course of temperature changes of the frozen wheat doughs with karagen additive are illustrated in Figure 1. Freezing point of the wheat doughs examined ranged from -3.00°C (control with no additives) to -5.70°C with 2% karagen supplement. The low karagen contents in dough cause a slight drop of their freezing temperature. However, an increase of karagen added results in considerable decline of freezing point value of wheat dough.

Figure 1. Freezing curves of model wheat doughs with karagen supplement

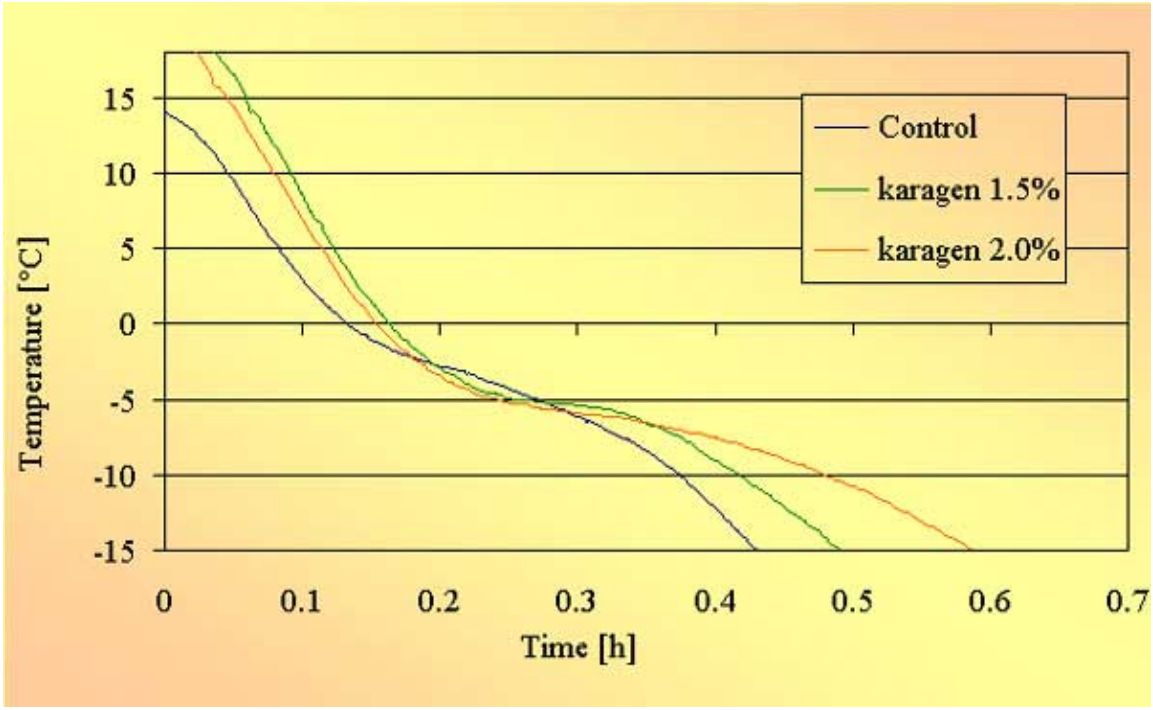
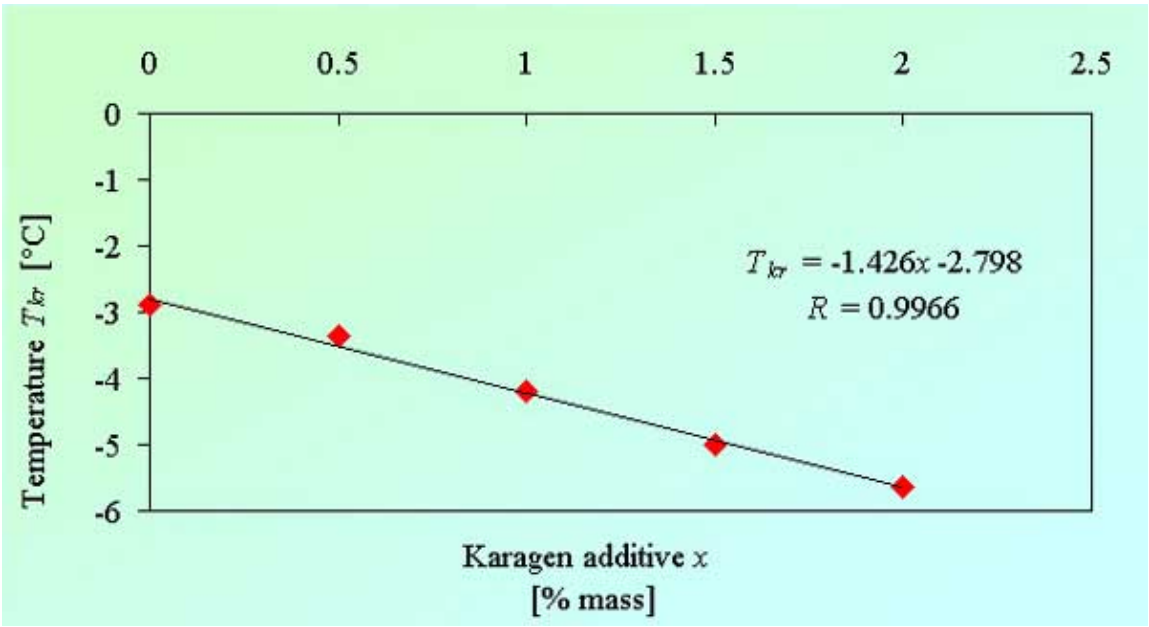


Figure 2. Influence of karagen presence *x* in wheat doughs on their freezing point T_{kr}



Dependance of dough freezing point on added karagen amount (Figure 2) is described by a linear equation. Soya milk content added to wheat dough, relatively high compared to other ingredients, brought about significant drop of freezing point (Figures 3 and 4).

Figure 3. Freezing curves of wheat dough with soya milk additive

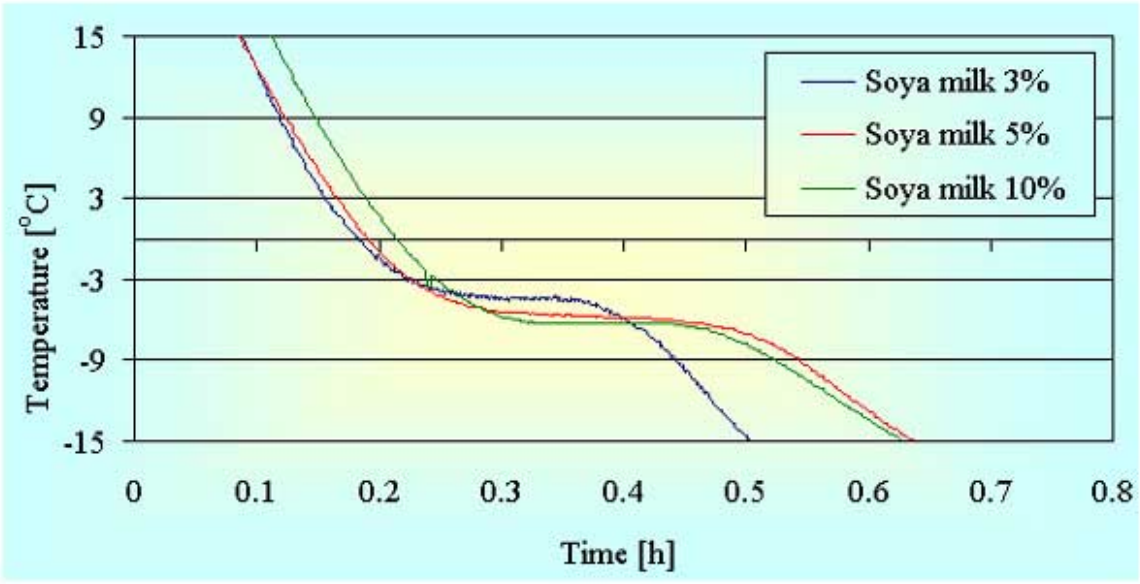
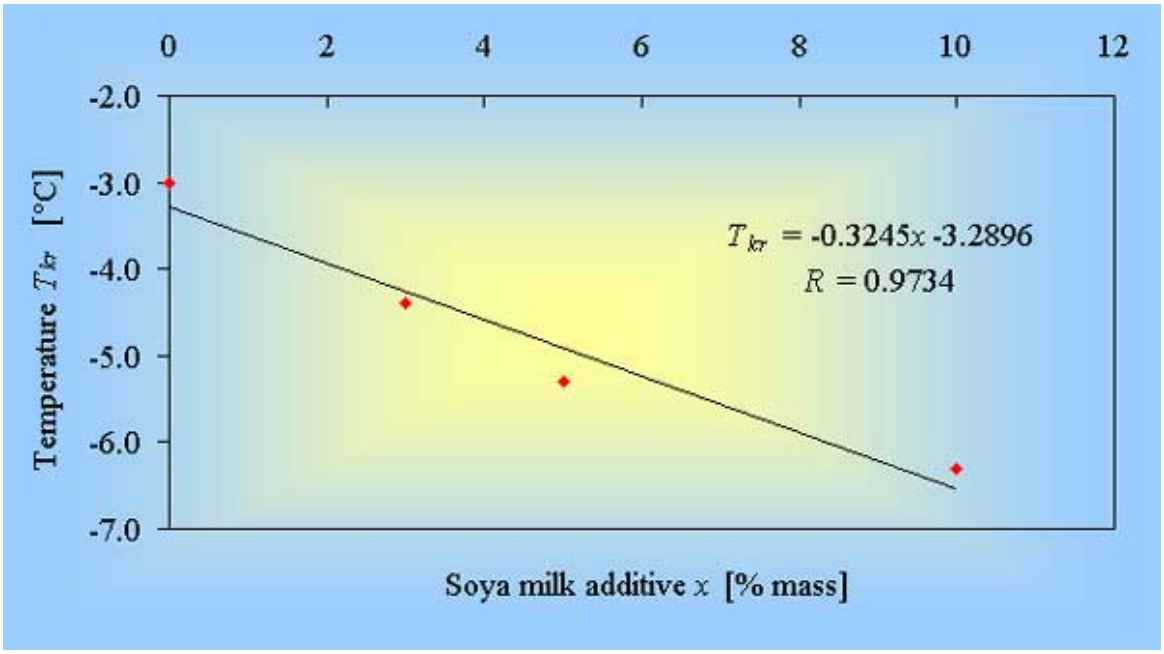


Figure 4. Relationship between freezing point T_{kr} of wheat dough and soya milk concentration x in it



The lowest (3%) additive of soya milk results in freezing point value set at T_{kr} = -4.40°C level. Increase up to 10% in quantity of milk added caused fall of freezing point to T_{kr} = -6.30°C.

A detailed analysis of the results allows to draw conclusion, that increase of pectin content in dough induces serious decline of freezing point of wheat-rye doughs.

Figure 5. Freezing curve course of mixed dough with pectin ingredient

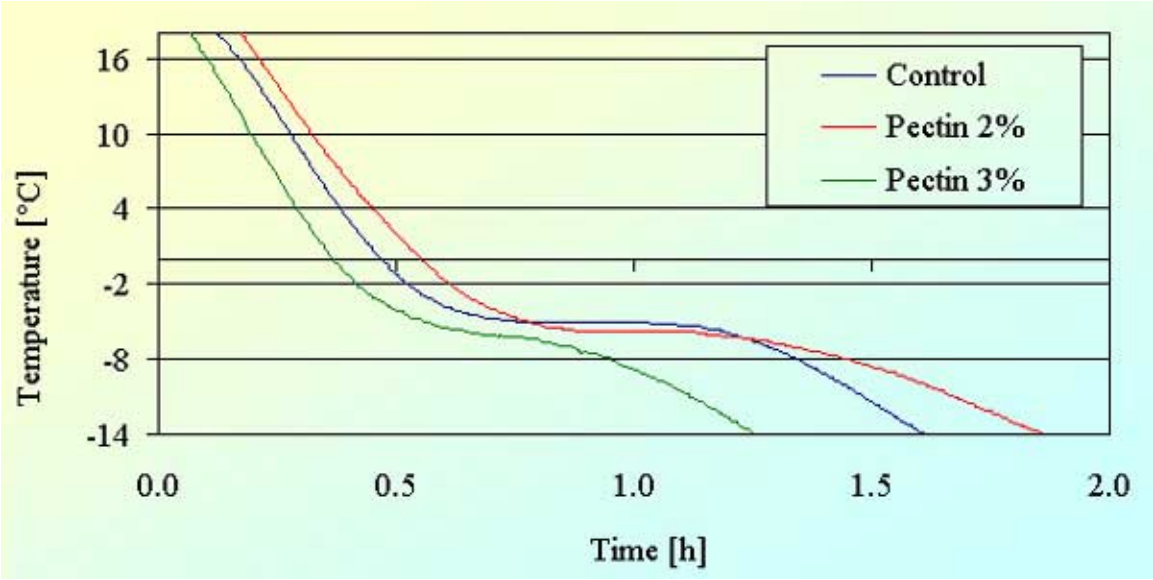
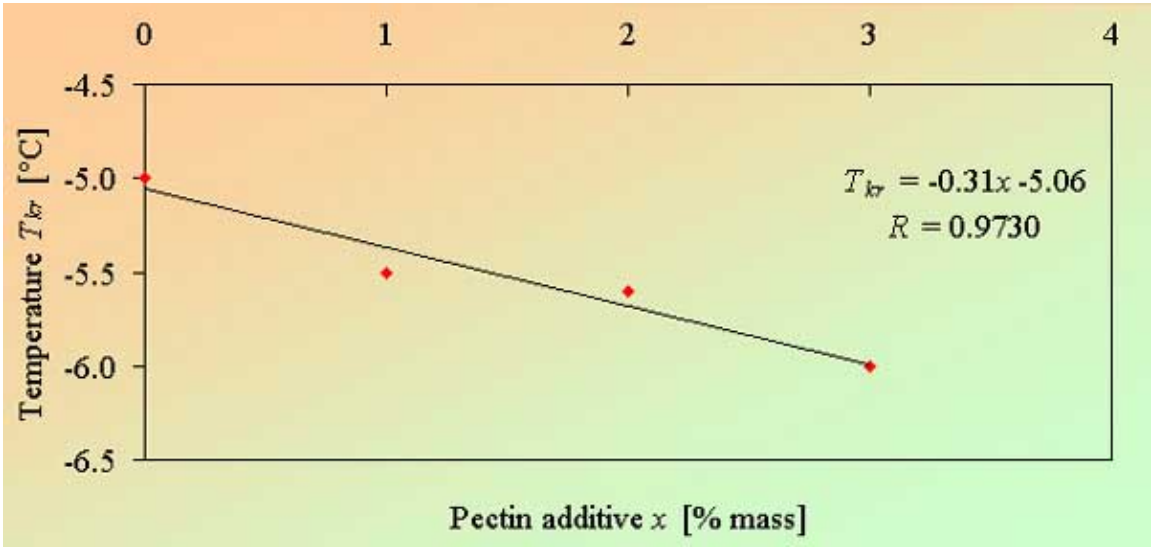


Figure 6. Dependance of freezing point T_{kr} of mixed dough on pectin percentage x in it



At 3% pectin additive freezing point value is reached T_{kr} = -6.00°C. Development of temperature changes over the freezing process of mixed doughs modified with pectin is presented in Figure 5. Relationship between freezing point and pectin content in the mixed dough is described by linear equation with high correlation coefficient (Figure 6).

3. Characteristics of experimental baking

In order to make a technological assessment of flour value, in that baking evaluation of the samples investigated as well as influence of the ingredients studied on the bakery physical properties, there were performed some series of the experimental bakings. The exemplary values of the assessment obtained while examining the bakery are shown in Table 4.

On the basis of the data from Table 4 there can be stated a slight fall of wheat bakery volume obtained from frozen dough as compared to the volume of bakery after traditional technology.

It is likely result from a fact, that freezing process influences the changes occuring in the yeast cells, mainly their survival. Therefore, it is recommended to use increased yeast content to make up for decline of its activity.

Table 4. The exemplary values of the baking evaluation

Ingredient type [%]	Dough yield [%]	Baking [%]	Total baking loss [%]	Bakery yield [%]
WHEAT BAKERY				
Frozen control	161.54	13.55	15.45	136.56
Guar 1.5%	163.04	13.68	15.32	138.06
Karagen 1.5%	163.04	8.25	9.72	147.19
Glutamic acid 1.0%	162.54	9.10	10.72	145.12
Glucose 3%	164.54	6.90	8.02	151.35
Unfrozen control	161.54	6.73	7.94	148.72
WHEAT-RYE BAKERY				
Frozen control	161.54	13.50	14.95	137.39
Soya milk 10%	171.54	7.35	7.95	157.90
Pectin 3%	164.54	9.30	9.72	148.55
Unfrozen control	161.54	6.08	7.94	148.70

The freezing process has also unfavourable effect on baking increase and total baking loss as well as lower bakery yield. The bakery obtained from the frozen dough showed higher crust percentage compared to crump, probably due to a lower baking temperature (Table 5).

The ingredients examined exerted a slight influence on dough yield increase. At average, dough yield reached 162.54%, whereas the highest one 171.54% was gained for a sample with 10% supplement of soya milk.

Table 5. The exemplary values of bakery physical properties evaluation

Ingredient type [%]	Bakery volume [cm^3]	Crust-crumb ratio	1 cm^3 crump mass [g]
WHEAT BAKERY			
Frozen control	388	0.460	0.400
Guar 1.5%	418	0.500	0.337
Karagen 1.5%	352	0.259	0.500
Glutamic acid 1.0%	413	0.220	0.550
Glucose 3%	422	0.296	0.400
WHEAT-RYE BAKERY			
Frozen control	387	0.452	0.400
Soya milk 10%	434	0.298	0.425

Pectin 3%	367	0.347	0.400
Unfrozen control	448	0.274	0.450

The highest volume and such sensory evaluation was shown by wheat bakery supplemented with mixture of 0.5% guar, 0.5% karagen and glucose 2% amount as well as mixed bakery with 2% pectin additive. In the case of soya milk supplement in dose 5% and 10% the dough and bakery yield obtained was higher by over 5.5% as against the bakery obtained traditionally. There were also the lowest values of oven loss and the total one. However, the total loss amounted to 6.7%.

The organoleptic evaluation of bakery proved, that all the samples obtained had appropriate quality. Bakery size was regular and well-proportioned. The crump manifested good elasticity, even thin-walled porosity of various viscosity degree (depending on ingredient type and percentage). The bakery with glucose additive scoreded the highest amount of points classifying it among the 1st class quality products.

4. Characteristics of bakery crump texture

The results of the profile analysis of texture indicate, that the ingredients used affected the changes of the rheologic properties of the bakery obtained. The bakery from the dough supplemented with guar manifested gain in crump hardness as compared to control bakery from frozen dough (Figure 7).

At 1% guar supplement the bakery showed 21.2 N hardness and compressibility 1413.33 N/m. Growth of guar share in the recipe composition of bakery manifested itself in favourable fall of the parameters: viscidity, cohesion and chewiness. With the ingredient increase there was recorded improvement of these qualities [8].

Moreover, the results also showed that a glucose additive had a good influence on crump hardness and compressibility, lowering the values as compared to frozen control (Figure 8).

Figure 7. Effect of guar additive (% mass) on the hardness of wheat bakery from frozen dough

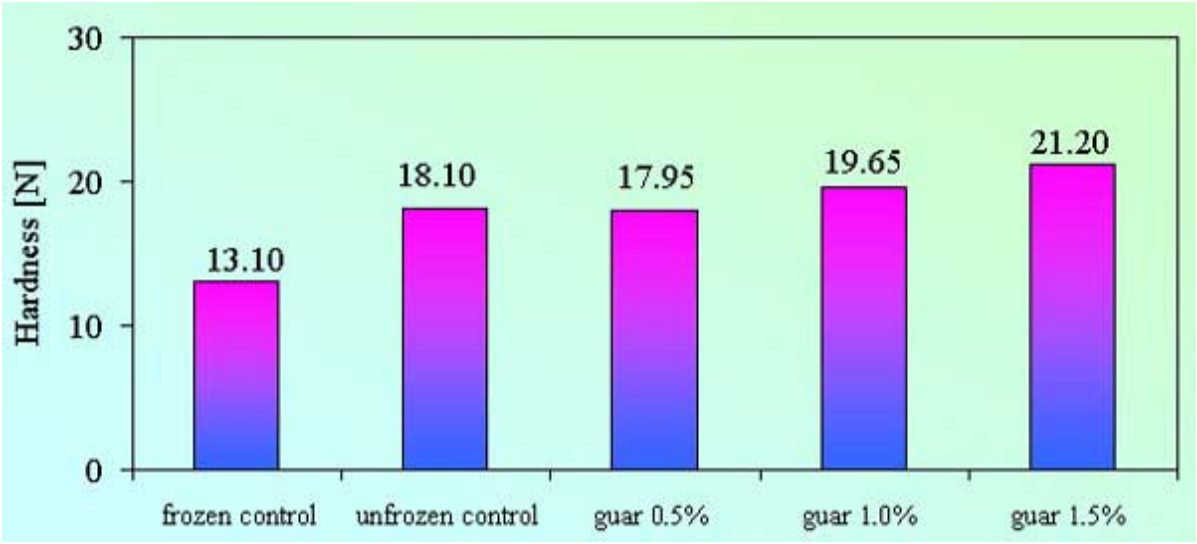
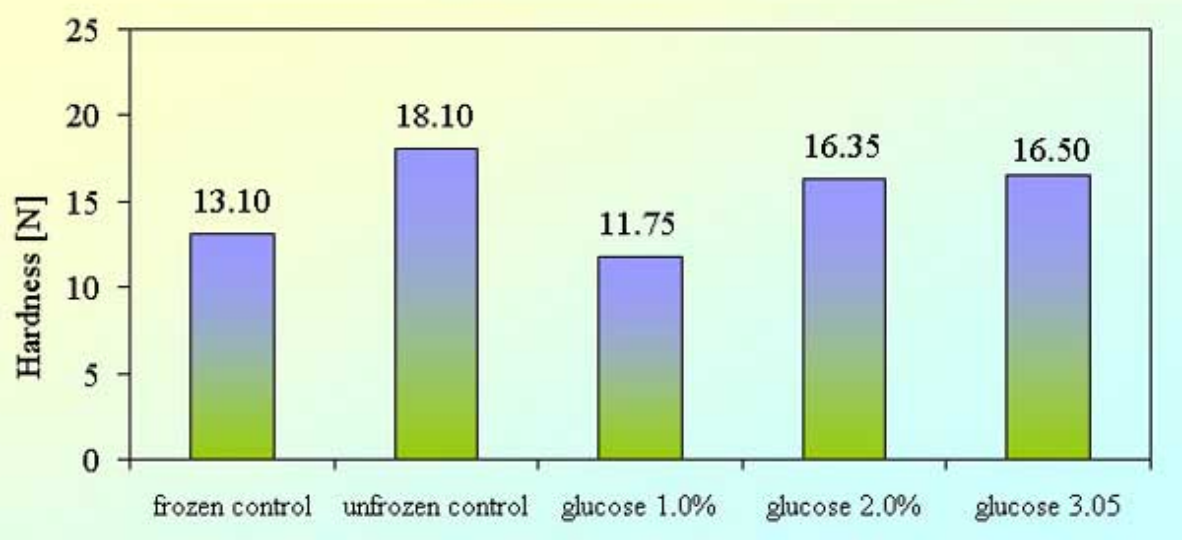


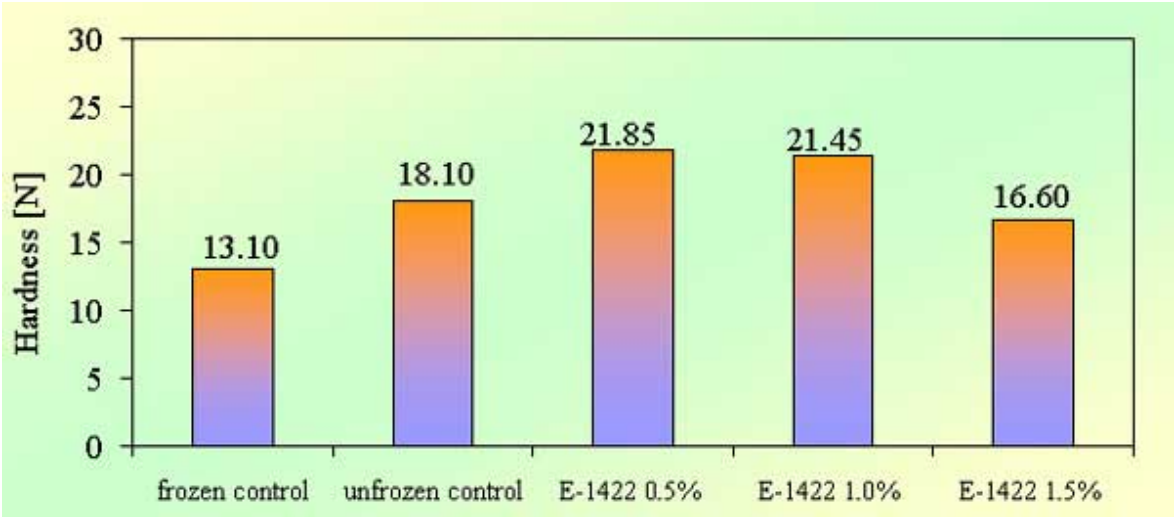
Figure 8. Effect of glucose supplement (% mass) on crump hardness fixed



At 1% glucose additive use there occured a desirable fall of hardness under 13.10 N (control) i.e. to 11.75 N. Further growth of the ingredient caused rise of the quality tested up to 16.5%. Glucose supplement at quantity of 1% has also affected improvement of the other texture parameters compared to both frozen control and the bakery obtained traditionally.

Use of modified starch CS influenced development of the rheologic properties of the bakery investigated.

Figure 9. Effect of modified starch on crump hardness

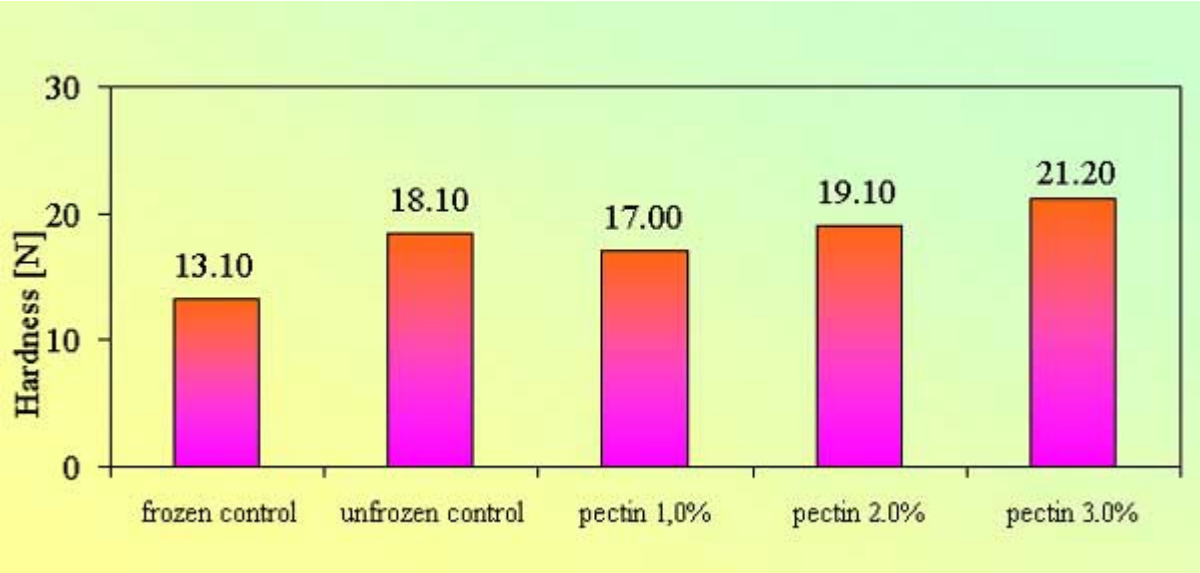


Modified starch additive in amount of 0.5% affected crump hardness growth (21.85) compared to control bakery (13.3 N) (Figure 9). Together with the ingredient increase there appeared favourable decline of the texture parameter studied to 16.60 N at 1.5% supplement share. Whatsmore, there has been observed starch content growth that improved crump texture. A desirable fall of viscidity and compressibility appeared.

A growing level of pectin additive in the mixed dough samples brought about significant increase of crump hardness (Figure 10) of the bakery obtained. The highest growth of the examined characteristics of the texture evaluation followed pectin addition in quantity of 3%.

The other texture qualities assessed like cohesion, chewiness, viscidity proved to be clearly worse for the bakery supplemented with pectin as against the control bakery.

Figure 10. Influence of pectin additive (% mass) on control mixed bakery



On the basis of the researches made on laboratory bakery it can be stated, that technology of delayed baking has really good prospects and that means a necessity of the research work continuation on the freezing process optimization and modification of technological recipes used for frozen dough.

CONCLUSIONS

1. The freezing point of the examined wheat and rye doughs was equal: T_{kr} = -3.00°C and T_{kr} = -5.00°C respectively. The values of this property of the examined mixed doughs ranged from T_{kr} = -3.40 to -6.30°C.
2. A freezing point value of the modified wheat doughs and mixed ones proved to be influenced by an additive kind. A rise in supplement content brings about a significant fall of the freezing point in each case. The more quantity share of additive to dough, the lower freezing point value is. The magnitude examined in dependance on supplement share in all the cases is described by linear equations with high correlation coefficients.
3. On the basis of the results obtained there was stated a fall in bakery volume from frozen dough, compared to the volume of bakery after traditional method. The ingredients applied affected the baking favourably as well as total baking loss, bakery yield and its volume.
4. Bakery coming from frozen doughs demonstrated even and porous crump, good elasticity, savouriness and pleasant, aromatic flavour.
5. The additives influenced the rheological properties development causing increase of crump compressibility and hardness and exerting a differentiated impact on its elasticity, porosity and cohesion.

6. Among the supplements enclosed in a recipe composition, modified starch CS has affected physical, sensory and rheologic properties the most favourably.

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