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QUALITY IMPROVEMENT FOR THE PRODUCT GINGERBREAD, A STUDY REGARDING THE INFLUENCE OF DOUGH MATURATION TIME AND OF THE AERATION FORMULA ON THE PRODUCT'S TEXTURAL CHARACTERISTICS

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Abstract

The processors' disposition to satisfy the customers' requirements is an essential quality management principle in the food industry. In view of offering a high-quality product to the consumer, various aspects related to the maturation time of gingerbread doughs obtained with various proportions of aeration agents (sodium bicarbonate and ammonium bicarbonate) and acidifier (sodium acid pyrophosphate) have been studied. One witness sample and 5 other samples were analysed. They were matured for 30, 60, 120, and respectively 150 minutes before the products thus obtained were processed and analysed. Maturation has a significant effect on the product's resilience, which has led to an analysis of this aspect. Maturation influences the quality of the product but, at the same time, it impacts its price; it is important to allow the space needed to achieve maturation in the flow, to organise the process flow, and to observe the parameters which need to be attained and monitored.

Key words*: *gingerbread, maturation time, aeration agents, textural characteristics, quality indicators.

INTRODUCTION

The product *gingerbread*, a long-established product in Romania, poses some challenges to the manufacturers. The difficulty consists in adapting the classical doughs to the modern technological processing, but, at the same time, in adapting the traditional product to the market's current requirements.

The crumbly, hygroscopic product of former days has been replaced with the moist, soft product, having different fillings (which must be thermostable), covered in various coatings, from the traditional glazing with a supersaturated sugar solution, to various surrogate coatings or even chocolate.

Such adjustments can only be made by studying the influence exerted by the quality of the ingredients, the aeration formula, the kneading time, maturation times and temperatures, in correlation with the textural characteristics.

Gingerbread production is tricky because of its complex recipe and difficult to process dough. For other products, such as biscuits or cookies, extensive research has been conducted related with dough rheology [4],[5],[7],[8],[9],[12].

This study analysed the influence of both the aeration formula and of the maturation time on the texturometric features of the finished product. A witness sample (P0) was prepared, starting from the basic recipe, as well as a set of 5 samples, with various proportions of sodium bicarbonate and ammonium bicarbonate, to the point of fully replacing the ammonium bicarbonate. Neutralisation was achieved using sodium acid pyrophosphate (SAPP). The effect of the aeration agents on both the texture of the finished product and on its resilience was analysed, using the texture meter.

The doughs obtained from a mixture of wheat flour and rye flour have low resilience and high plasticity, as well as high stickiness [1]. Rye flour is a very good alternative to the "dilution of gluten" in wheat flour [11], [3].

The gluten formed by the rye flour proteins is less resilient and more plastic [6].

To obtain a tender texture, a soft product, rye flour needs to be used in the recipe. It confers stickiness to the dough, which becomes less cohesive, but the end product will be of superior quality in terms of texture [2], [10].

In this context, the research aimed to produce a high quality gingerbread for consumers studying various aspects of doughs maturation and using aeration agents (sodium bicarbonate and ammonium bicarbonate) and acidifier (sodium acid pyrophosphate) in various proportions.

MATERIALS AND METHODS

In view of studying the effect of maturation time and of the aeration formula on the textural characteristics, gingerbread was prepared according to the recipes in Table 1.

Table 1. Recipes for gingerbread sample manufacturing

Raw material	P0	P1	P2	P3	P4	P5
	kg	kg	kg	kg	kg	kg
Wheat flour	1.76	1.76	1.76	1.76	1.76	1.76
Rye flour	0.95	0.95	0.95	0.95	0.95	0.95
Sodium bicarbnate	0.036	0.0334	0.0436	0.054	0.064	0.074
Ammonium bicarbonate	0.018	0.018	0.014	0.009	0.005	0
SAPP 28	0.018	0.044	0.058	0.071	0.084	0.098
Clove	0.01	0.01	0.01	0.01	0.01	0.01
Cinnamon	0.039	0.039	0.039	0.039	0.039	0.039
Salt	0.009	0.009	0.009	0.009	0.009	0.009
Lecithin	0.018	0.018	0.018	0.018	0.018	0.018
Vegetable fat	0.18	0.18	0.18	0.18	0.18	0.18
Caramel	0.29	0.29	0.29	0.29	0.29	0.29
Sorbitol	0.145	0.145	0.145	0.145	0.145	0.145
Glycerin	0.024	0.024	0.024	0.024	0.024	0.024
Inverted syrup	1.55	1.55	1.55	1.55	1.55	1.55

Source: Original.

The witness recipe was changed, considering the following requirements: the gradual replacement of ammonium bicarbonate with sodium bicarbonate and the addition of sodium acid pyrophosphate, so as to achieve a 95% neutralisation of the sodium bicarbonate in the recipe.

To analyse the influence of maturation time on the textural characteristics, after they were kneaded, the samples were left to rest for different time intervals, namely 0, 60, 120, and respectively 150 minutes, at room temperature, before division, moulding and baking.

As it has been found that gingerbread is susceptible to loss of moisture and that its textural characteristics are dependent on the moisture content, before the test, the samples were kept in vessels with H_2SO_4 solutions of various strengths (30, 35, and respectively 40%), ensuring various levels of water activity in the products.

They were kept for 14 days, enough time to balance the moisture between the samples.

To perform the tests, the TexVol TVT-300XP/XPH texture meter, manufactured by Perten, Sweden, was used. It was fitted with a 15 kg load cell. It is a sensitive, modern instrument, but empirical methods are also used in textural analysis, with relevant results for the food products covered by the study [13].

The test device employed was the blade version, a device imitating the bite, the shearing of the product between the incisors. Cutting was achieved at a speed of 1 mm/sec, down to a depth of 10 mm. As the samples kept in the presence of stronger H_2SO_4 solutions suffered more intense dehydration, they were harder, and testing with the ball device was not possible, as the specific hardness values were higher than the measurement range for the device's load cell.

The tool's software provides several parameters as textural characteristics. Such parameters are the maximum resistance force recorded upon testing (ForceA), the hardness stated as the resistance force recorded for the maximum stroke (Hardness), the working energy, as an area of the force graph - pressing distance (Area4), and the product between the force recorded at the end of the stroke and the distance covered (Hard x Dist), similar to the previous parameter - Area4. Figure 1 and Figure 2 show such parameters in relation to one another, to note where any dependencies exist between then and whether the interpretation of each parameter in part is necessary or whether the analysis of a single textural feature is sufficient.

Good correlation was noted (the linear regression coefficient R^2 is 0.9058) between hardness and the maximum force recorded. The correlation is good because, in fact, they both convey the same physical parameter, a force.

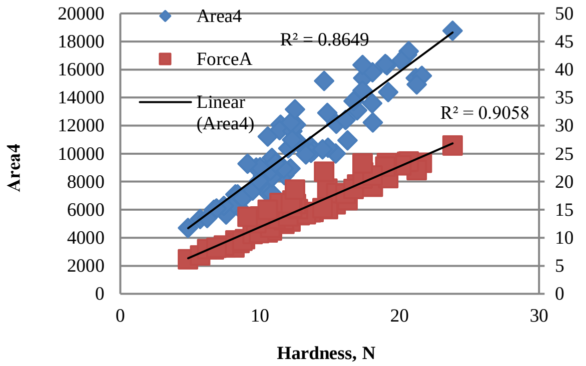

Fig. 1. The relationship between hardness, energy, and maximum force
Source: Own results in the laboratory.

The correlation between hardness and energy is smaller, R^2=0,8649.A very good correlation was also noticed between the curve area and the maximum force, R^2=0.9801. This highlighted the fact that, for the tested samples, irrespective of the recipe or the work parameters, the curves had a similar shape, and the cutting to a 1 cm depth ensured the fact that analysed texture sizes were measured at similar moments, when the analysed samples were not destroyed. This shows that the analysis of how the maximum distortion force varies is sufficient.

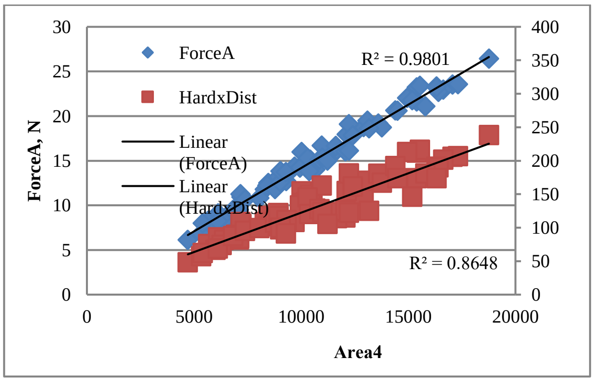

Fig. 2. Statistical ratio between the area of the force variation curve, the maximum distortion force and the result obtained upon multiplying hardness and displacement.
Source: Own results in the laboratory.

Upon analysing the statistical ratio between the area of the recorded force variation curve and the result obtained upon multiplying hardness and displacement, it was found to be significant, although not very solid.

The linear regression rate had a value identical to the linear regression rate upon correlating maximum force and hardness. This is normal, as the distortion distance was always the same, of 10 mm, it was not indicated as a percentage from the height of the sample.

Such data led to the conclusion that, for the textural characterization of gingerbread using this test type, namely cutting to a constant depth, the analysis of hardness and of the maximum distortion force is sufficient.

RESULTS AND DISCUSSIONS

Effect of maturation time on the textural characteristics of gingerbread

Figure 3 presents the variation of hardness and of the distortion energy for the samples maintained at various maturation times, namely from 0 minutes to 150 minutes.

Upon analysing the graphs, we can note that both hardness and distortion energy have a very similar variation model, demonstrated also by the very good correlation of such values.

Another aspect is the increase in hardness as water activity decreases. This mode of variation is specific for all analysed gingerbread assortments and it was also noticed in previous experiments. The lower the water activity, the lower the moisture in the samples. The decrease in the moisture of gingerbread leads to the crystallisation of sugar solutions and to the dehydration of starch and protein gels, which become more rigid and generate higher gingerbread hardness. Surprisingly, an increase in gingerbread hardness is ascertained with the increase in maturation time.

It would have been expected for gingerbread hardness to decrease as maturation time increases.

During maturation, a relaxation of the dough occurs, as well as a hydrolysis of the endogenous proteins and a hydrolysis of the granular starch, which leads to the weakening of the protein and starch gel in the finished product.

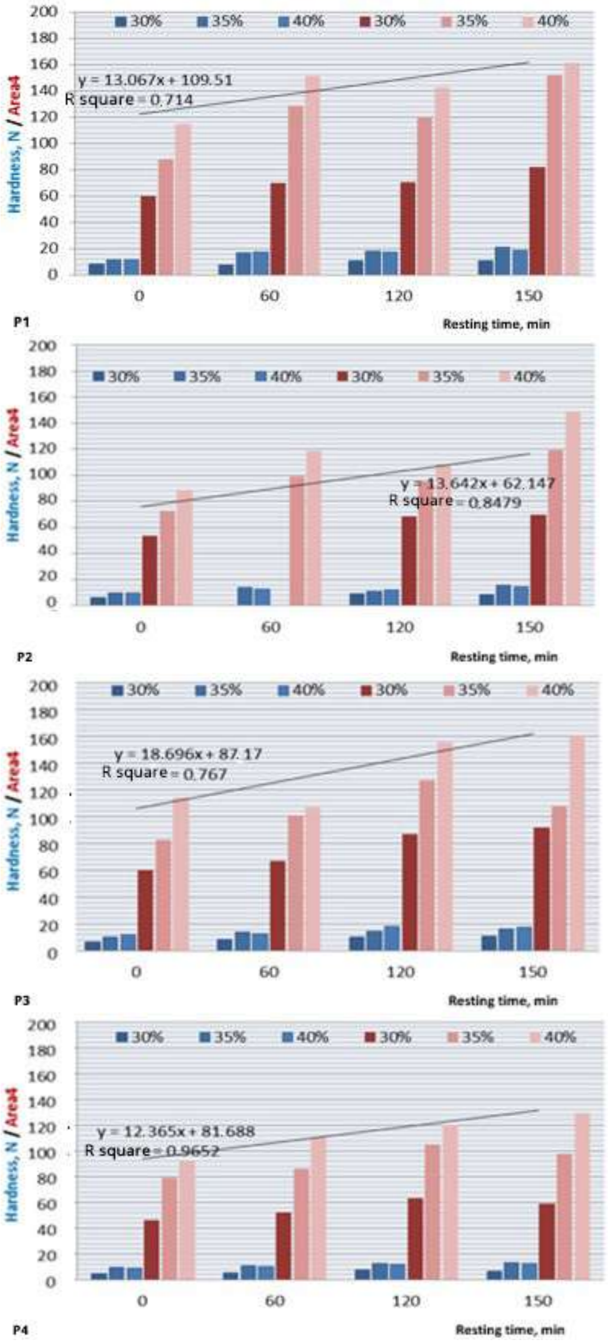

Fig. 3. Variation in hardness and in the distortion energy in conjunction with maturation time for P1, P2, P3, P4
Source: Own results in the laboratory.

This variation in hardness in conjunction with the relaxation time must be correlated with the results obtained in the rheological test. In this trial, the fact was noted that, as dough maturation time increases, its consistency also increases.

We can thus assume that the transformations occurring during dough maturation also affect the hardness of the gingerbread. It is unlikely that the physical processes of gluten or starch hydration during maturation are also the ones that lead to higher hardness.

It was concluded that short maturation times (in the order of 1-2 hours) did not influence the texture of the products in a positive way. The increase in maturation time could lead to texture improvement, but longer maturation times may be needed, of 24-48 hours, as recommended in traditional recipes for obtaining gingerbread.

Upon analysing the series of values for the gingerbread having the same water activity, it was noticed that the differences are higher for the dryer gingerbread, compared to the moister types. In the case of gingerbread with lower water activity, the increase in hardness was more pronounced as maturation time increased. To check this observation, linear trend curves were also marked (not presented in the figure, to avoid overburdening it).

We noted that the slope of hardness variation curves in conjunction with maturation time was smaller for the samples with higher water activity, and that it increased as water activity was reduced.

It was ascertained that product moisture is more important than maturation time.

For instance, the hardness of the witness sample obtained without maturation and with the lowest water activity was higher than the hardness of the sample with the maximum maturation time, but with the highest water activity. It was concluded that the preservation of gingerbread moisture is more effective for maintaining the samples tender.

Predictability in the variation of hardness also improved, as water activity increased. The linear regression rate values are higher for the series of samples with higher water activity.

There is significant-to-good correlation between maturation time and gingerbread hardness. The linear regression rates had values between 0.7000 and 0.9980. The linear regression rate had values smaller than 0.5000 in one case only. However, some reservations should be expressed regarding this observation, as the series of values were reduced to 3 cases only (3 pairs of maturation time - hardness values).

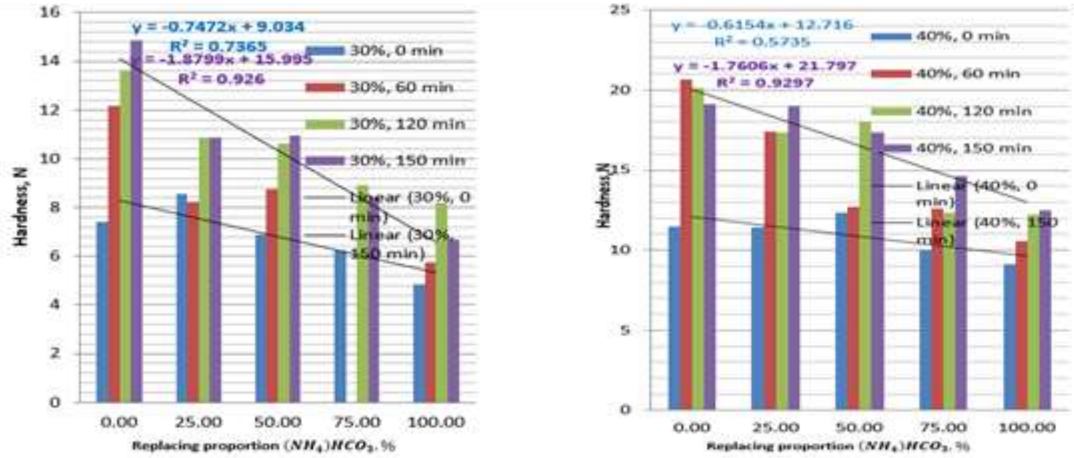

Fig. 4. Variation in gingerbread hardness, depending on the ammonium bicarbonate replacement rate
Source: Own results in the laboratory.

Figure 4 presents the variation in gingerbread hardness, depending on the replacement rate of ammonium bicarbonate.

The figure shows that, as the proportion of ammonium bicarbonate was replaced with sodium bicarbonate, gingerbread hardness decreased.

The effect became stronger as resting time increased, suggesting that the processes occurring upon maturation, which influence the texture of gingerbread imply, in one way or another, transformations of such aerating agents. We must have in view the fact that another variable existed in this system, the dose of acidifier, sodium acid pyrophosphate (SAPP). The SAPP quantity increased so as to achieve a chemical neutralisation of the sodium bicarbonate to a 95% rate.

The actual variable may in fact be the acidifier, rather than the aeration agent.

The fact was noticed that dough maturation time had a greater influence on product texture than the alternative selected for aeration. With small maturation times, the hardness decrease slope in conjunction with the ammonium replacement percentage was smaller. Linear regression rates are also smaller in conjunction with smaller dough maturation times. At 0 minutes maturation time, the decrease in hardness was of 21% and of 31% for the gingerbread cookies kept in 30% and respectively 40% sulphuric acid, and, at 150 maturation minutes, the decrease was of 35% and of 55% for the samples with the highest water activity.

Influence of the aeration formula on gingerbread texture

Hardness curve slope

The effect of ammonium bicarbonate replacement was also analysed in terms of other texturometric parameters. Thus, the effect on the variation curve slope exerted by the distortion force was monitored, depending on the extent of the distortion. The first part of the curve was selected, as distortions are small, and the possibility of product cracking is smaller. The parameter is defined as Degree 1/3.

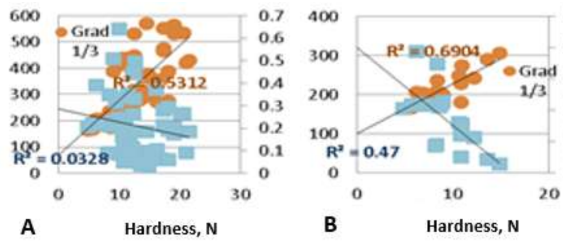

Fig. 5. Correlations between the graph's initial slope, the resilience of the gingerbread cookies and their hardness
Source: Own results in the laboratory.

A very similar variation was noted in correlation with the variation in product hardness (the data is not presented in the figure). To confirm the hypothesis, the relation between hardness and the slope of the hardness variation graph was monitored. The results are presented in Figure 5 A and B. In

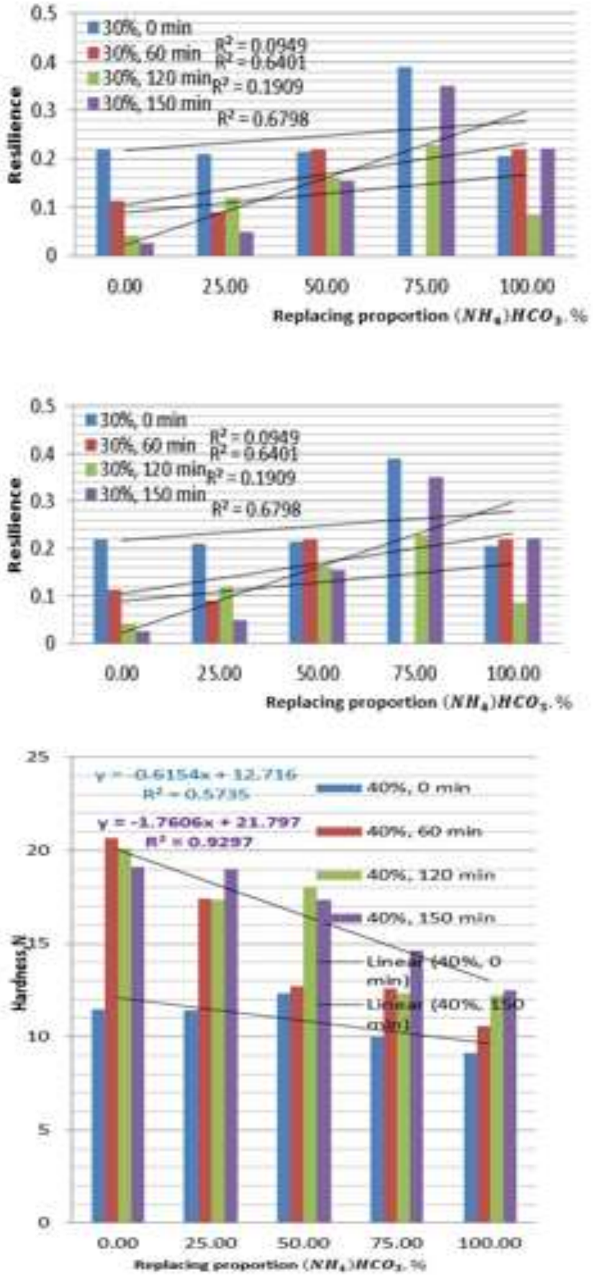

Fig. 6. Variation in gingerbread resilience in conjunction with the replaced proportion of ammonium bicarbonate
Source: Own results in the laboratory.

Figure 5A, all cases covered by the analysis are considered, and very weak correlation of parameters is noted. Upon separating the data into categories, depending on water activity, we note an improvement of such correlation. This suggests that certain particularities occur in the behaviour of the products, depending on the products' characteristics, at least depending on water activity.

Effect of the aeration formula on resilience

Resilience is the ratio between the area below the graph upon withdrawing the testing device and the area below the graph of the pressing force exerted when the device advances, if we use the single-compression test. Using this graphical representation, we can define resilience as the ratio between the energy used by the product to push the knife and the energy needed to push the knife into the product.

In Figure 5A, we note that there is no correlation between product hardness and its resilience. If the cases are selected according to the water activity criterion (Figure 5B), we note an improvement in the linear regression rate; however, its value is less than 0.5.

In Figure 6 we note that no statistical correlations can be established between such parameters.

There were only in several cases, and without following a certain model, that the linear regression rates were higher than 0.5000.

No statistical correlations can be established between resilience and dough maturation time, either.

The graphs lead to the conclusion that resilience is not a textural measure that can be used in cutting tests for gingerbread.

Moslikely, the cutting test induces permanent distortions, leading to the destruction of sample integrity.

COCLUSIONS

The study led to useful conclusions for the processors obtaining the product gingerbread with regard to maturation time, moisture, resilience, aeration formula, product hardness, in view of improving it. It was found that product moisture is more important than maturation time.

Short maturation times (in the order of 1-2 hours) do not influence the texture of the products in a positive way. The increase in maturation time can lead to texture improvement, but longer maturation times may be needed, of 24-48 hours, as recommended in traditional gingerbread recipes.

There is significant-to-good correlation between maturation time and gingerbread hardness.

Dough maturation time has a greater influence on product texture than the alternative selected for aeration.

As the proportion of ammonium bicarbonate is replaced with sodium bicarbonate, the hardness of gingerbread decreases. The effect becomes stronger as resting time increases, suggesting that the processes occurring upon maturation, which influence the texture of gingerbread imply, in one way or another, transformations of such aerating agents. We must have in view the fact that another variable existed in this system, the dose of acidifier, sodium acid pyrophosphate. The SAPP quantity increased so as to achieve a chemical neutralisation of the sodium bicarbonate. to a 95% rate. The actual variable may in fact be the acidifier, rather than the aeration agent.

For the textural characterization of gingerbread using this test type, cutting to a constant depth, the analysis of hardness and of the maximum distortion force is sufficient.

Resilience is not a textural measure that can be used in cutting tests for gingerbread. Most likely, the cutting test induces permanent distortions, leading to the destruction of sample integrity. The use of other devices and work protocols, such as compression with two or more cycles, is needed for a characterization in terms of resilience.

REFERENCES

[1]Banu, I., Vasilean, I., Aprodu, I., 2010, Evaluation of rheological behaviour of whole rye and buckwheat blends with whole wheat flour using Mixolab, Italian Journal of Food Science 22(1): 83-89.

[2]Blanchard, C., Labouré, H., Verel, A., Champion, D. 2012, Study of the impact of wheat flour type, flour particle size and protein content in a cake-like dough: Proton mobility and rheological properties assessment, Journal of Cereal Science 56: 691-698.

[3]Bloksma, A. H., Bushuk, W., 1988, Rheology and chemistry of doughs, In Wheat: Chemistry and Technology. St. Paul: 131-218.

[4]Manley, D., 2000, Technology of Biscuits, Crackers and Cookies, Cambridge, UK: Woodhead Publishing.

[5]Fustier, P., Castaigne, F., Turgeon, S.L., Biliaderis, C.G, 2009, Impact of commercial soft wheat flour streams on dough rheology and quality attributes of cookies, Journal of Food Engineering 90: 228–237.

[6]Fustier, P., Castaigne, F., Turgeon, S.L., Biliaderis, C.G., 2009, Impact of endogenous constituents from different flour milling streams on dough rheology and semi-sweet biscuit making potential by partial substitution of a commercial soft wheat flour, LWT - Food Science and Technology 42 : 363-371.

[7]Pedersena, L., Jørgensenb, J. R., 2007, Variation in rheological properties of gluten from three biscuit wheat cultivars in relation to nitrogen fertilisation. Journal of Cereal Science. 46:132–138.

[8]Sudha, M.L., Vetrimani, R., Leelavathi, K., 2007, Influence of fibre from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. Food Chemistry. 100:1365–1370.

[9]Sudha, M.L., Srivastava, A.K., Vetrimani R., Leelavathi, K., 2007, Fat replacement in soft dough biscuits: Its implications on dough rheology and biscuit quality. Journal of Food Engineering. 80: 922–930.

[10]Tulbure, A., 2022, Quality improvement for the product gingerbread, a study regarding the influence of rye four on the product's textural characteristics, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 22(4), 767-772.

[11]Tulbure, A., Danciu, C.A., 2022, Quality improvement for the product gingerbread, corelations between the product's physical and chemical properties and the rheological characteristics of doughs, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 22(4), 761-766.

[12]Van Bockstaele, F., De Leyn I., Eeckhout M., Dewettinck K., 2011, Non-linear creeprecovery measurements as a tool for evaluating the viscoelastic properties of wheat flour dough, Journal of Food Engineering 107: 50–59.

[13]Weipert, D., 2006, Fundamentals of Rheology and Spectrometry. Rheology. in Future of Flour: A Compendium of Flour Improvement. Editor Lutz Popper. Publisher AgriMedia.