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INVESTIGATION OF THE FUNCTIONAL PROPERTIES OF WAXI WHEAT FLOUR

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Abstract. The results of the research on the functional properties of waxy wheat flour, obtained from the spring waxy wheat grain of the Biskvitna variety, adapted for agro-climatic conditions of the Kharkiv region, in comparison with white wheat flour, are presented. It is found that waxy wheat flour contains 16.8% less raw gluten than the reference sample, the gluten is 18.8% less elastic and 21.4% more stretchy, has a light gray color and can be attributed to the II group of quality. Waxy wheat flour has a 1.8 times higher water-holding capacity, its starch begins to gelatinize at a lower temperature, while the maximum viscosity of the waxy wheat flour starch paste is almost 1.6 times higher than that of the reference sample. It is established that falling number of waxy wheat flour is only 68 s that more than 5 times lower than that one of wheat flour. The model dough system prepared from the waxy wheat flour has a 6.9% better lifting power in comparison to the system prepared from the wheat flour. Baking tests for sponge cakes, biscuits, fruitcakes and muffins with the substitution 25.0 to 75.0% of white flour to waxy wheat flour was performed. With an increasing of the dosage of waxy wheat flour a tendency of the increasing of the dough stickiness in all samples tested was observed. The baked goods tested were distinguished by good quality indicators, although in fruitcakes and muffins with a dosage of waxy wheat flour of more than 50.0%, the formation of large gas cells unevenly distributed in the crumb was noticed. Addition of 25.0% of waxy wheat flour causes an increase of the specific volume and porosity of sponge cakes by 11.1 and 9.3% respectively. With a further increase in the dosage of waxy wheat flour, the specific volume and porosity of the samples tested are verging to the reference sample. All samples of fruitcakes and muffins were not differ significantly in terms of specific volume and porosity. According to the results of the research conducted, it is suggested to use waxy wheat flour, obtained from the grain of Biskvitna variety, for the production of sponge cakes and biscuits in an amount of up to 75.0%, for fruitcakes and muffins – in an amount of up to 25.0% instead of wheat flour.

Keywords: waxy wheat flour, sponge cakes, biscuits, fruitcakes, muffins.

Introduction. Formulation of the problem

In recent years, such a unique grain crop as waxy wheat has attracted the attention of scientists around the world. The main feature of waxy wheat is that it has null alleles in three loci that encode granule-bound starch synthetase (EC 2.4.1.21) [1]. The last one is responsible for the synthesis of amylose in the starch composition of the grain endosperm. As a result, waxy wheat starch consists mainly of amylopectin, and waxy wheat itself is often called as amylose-free wheat [1-2]. The typical features of waxy wheat flour include increased water-absorbing capacity, it needs more time

for dough formation, which is usually significantly less stable than traditional baking flour, a low index of falling number, a reduced temperature of gelatinization of starch paste and its higher viscosity [1-4]. It is believed that waxy wheat starch is more easily attacked by amylolytic enzymes, so food products made from waxy wheat flour are better absorbed and can be recommended for inclusion in the diets of children, athletes, solders, people engaged in heavy physical labor, etc. Various researchers have proven the impracticality of independent use of waxy wheat flour for bread and pasta making, although the use of a mixture of waxy wheat flour and baking flour, as a rule, allows to obtain products of increased quality [2,5-8]. In the scientific literature, there are enough publications that confirm the expediency of using waxy wheat flour for makinf flour confectionery products [9-11].

The first studies aimed at the selection of waxy wheat and the study of its technological properties were started by Japanese scientists back in the 90s of the 20th century [12] and continue in various countries of the world even today [13]. In Ukraine, significant impact on the selection of waxy winter wheat was carried out by the Breeding and Genetic Institute of the National Academy of Sciences of Ukraine (Odesa) under the leadership of O.I. Rybalka. The possibility of using flour obtained from the specified variety of waxy wheat for food production was proven by a team of scientists of the Odessa National Academy of Food Technologies [9-11,14]. At the same time, unstable weather conditions and the absence of snow cover during winter in the northern and eastern regions of Ukraine, in particular in the Kharkiv region, create prerequisites for the preferential use of spring varieties of crops in agriculture. Since spring varieties of waxy wheat were not previously presented in Ukraine, the specialists of the Plant Breeding institute named by V. Ya. Yuryev of the National Academy of Sciences of Ukraine (Kharkiv) created a unique line of spring waxy wheat Biskvitna. The new line of spring waxy wheat was created on the base of spring soft wheat of Kharkivska 30 variety and lines of waxy wheat IR 13640 S, IR 13641 S, IR 13642 S by irradiation of grain gamma rays. Thus, research aimed at studying the possibility of using the flour of a new line of spring waxy wheat for pastry making is of scientific and practical interest.

Analysis of recent research and publications

In modern scientific literature, sufficient attention is paid to the study of the properties of waxy wheat flour and the possibility of its use for making food products. Most researchers note that waxy wheat flour in comparison to wheat bread flour, as a rule, has a smaller particle size, contains a slightly smaller amount of protein and a larger amount of arabinoxylan, it is characterized by a higher content of damaged starch granules in the flour [1,3-4] due to lower stability of waxy wheat starch by mechanical damage compared to soft or durum wheat [2,15], as well as slightly higher α-amylase activity [4,14]. Typical features of waxy wheat flour include an abnormally low rate of falling number – according to various researchers, it is 72–75s [3,9,14]. At the same time, scientists note a reduced gelatinization temperature of waxy wheat starch and an increased viscosity of its paste, which are associated with the peculiarities of the structure of amylopectin [1,2,4,14,16]. Iorgachova K. G. and co-authors in a number of works [9-11] proved the increased sugar- and gas-forming capacity of waxy wheat flour in comparison to baking flour. Aaccording to the results of decoding of farinograms, waxy wheat flour shows a 10-15% higher water absorption capacity, a 30-50% increase in the duration of dough formation, almost halved elasticity and stability indicators, and an approximately 30% higher liquefaction index [2-3]. In this regard, the vast majority of researchers do not recommend using waxy wheat flour independently for making bakery products, although in the case of adding waxy wheat flour in the amount of 10–20% of baking flour, it is possible to obtain baked goods of improved quality [2,5-7,9,16,17]. Scientists note that the use of waxy wheat flour allows to obtain an increased specific volume of baked goods with a more developed structure of porosity, and the crumb of the products retains its freshness longer during the storage [2,5,6,7,17]. Takata K. and co-authors note that the use of waxy wheat flour for makin baked goods contributes to the formation of large, unevenly distributed pores in the loaves, which is associated with the increased gas-forming capacity of the flour and the increased viscosity of the dough [2].

Iorgachova K. G. and co-authors in a number of works [9-11] showed the possibility of the use of waxy wheat flour for pastry making, in particular, fruitcakes, galettes and gingerbread. The authors recommend to use up to 60% waxy wheat flour in a mixture with baking wheat flour for fruitcakes of improved quality production, a mixture of waxy wheat flour with baking flour or waxy wheat flour alone for galette making, as well as a mixture of waxy wheat flour and wheat baking flour for gingerbread making, that allows to get goods of improved quality.

The results of pastry test baking with the use of flour obtained from spring wheat of the Biskvitna variety proved the principle possibility and feasibility of the use of this type of flour for making of butter cookies, sponge cake semi-finished products, fruitcakes and muffins [18]. However, since there is still not enough systematic information about the functional properties of the waxy wheat flour obtained from grain of the Biskvitna variety in the scientific literature, it is of scientific and practical interest to study the possibility of the use of this type of flour for pastry making.

The purpose of the research presented in this article is to to substantiate the directions of the use of waxy wheat flour of the Biskvitna variety for pastry making. To achieve this goal, the following **objectives** were formulated:

– to investigate the content and properties of gluten in waxy wheat flour in comparison with wheat baking flour and its water-holding capacity;

– to study the features of the properties of starch of waxy wheat flour, as well as its enzyme complex according to the rates of the falling number and the lifting power indexes;

– to investigate the possibility of the use of waxy wheat flour for pastry making.

Research materials and methods

Waxy wheat flour of 70% extraction ratio, obtained at the Bühler laboratory mill from the spring waxy wheat grain of Biskvitna variety harvested in 2018 and 2021 year s was used in the research.Properties of the investigated waxy wheat flour were compared with properties of commercial patent wheat flour produced by TM "Pokrovchanka" (State Enterprise "Novopokrovsky kombinat hliboproduktiv", Novopokrovka, Kharkiv region). The most often used flour in Kharkiv region for the manufacturing of baked goods and pastry was chosen as a reference sample. The main research was carried out in the laboratories of the Kharkiv Institute of Trade and Economics of the Kyiv National University of Trade and Economics (the Department of Innovative Food and Restaurant Technologies) and on the base of the Laboratory of Grain Quality of the Plant Institute named by V. Yuriev of National Academy of Agriculture Science (Kharkiv).

The content and properties of gluten were determined by well-known methods described in [19]. The water holding capacity of the flour was determined by the following method [20]: 1.0g of the flour was mixed with 30cm^3 of distilled water for 1 min at an electronic stirrer speed of 1000 rpm, stood the mixture for 30 min, then centrifuged for 15 min at 4000 rpm. Non-adsorbed water was drained, the tube was set in an inclined position for 10 min to remove residual water. Water holding capacity was calculated by the formula:

$$X = ((a–b) / c) \cdot 100, \quad (1)$$

where a is the mass of the test tube with the sample and bound water, g;

b is the mass of test tube with dry sample, g;

c is the mass of the sample, g.

The properties of the starch of waxy and wheat flour were studied with the use of Brabender amylograph. The autolytic activity of flour was determined by Falling number method. The lifting power of semi-products was determined by the following method: 0.31g of fresh yeast was diluted in 4.8cm^3 of sodium chloride solution with a concentration of 2.5%, 7.0g of tested flour was added and the dough was kneaded in the form of a ball. The ball was lowered into a glass with warm water and kept in a thermostat until it floated. The lifting power was determined by the time that lasted since the beginning of the experiment till the floating of the dough ball over the surface of the glass. The temperature of the sodium chloride solution, the water in the glass, and the thermostat was 35°C.

Pastries such as sponge cake semi-product number 1, butter cake semi-product number 8, the fruitcake "Stolychnyi" number 82 were made according to the recipes and technologies given in [21]. Test samples of fruitcakes were made according to a modified recipe, namely without adding raisins. The dosage of raw materials for muffins making was the following (g): wheat flour 1000, white sugar 625, margarine 375, sour cream of 20% of fat content 360, eggs 345, baking soda 20, salt 10. At first, a dry mixture (flour, sugar, salt and soda) and a liquid mixture (melted margarine, eggs and sour cream) by the mixing of the ingredients were made. Than by mixing of dry and liquid mixtures the dough of a homogeneous consistency was obtained. Waxy wheat flour was added of the amount of 25.0; 50.0 and 75.0% instead of wheat baking flour. Pastries made of baking wheat flour without adding waxy wheat flour were used as reference samples. Sponge cake semi-products were baked with a weigh of dough blanks of 30g under the temperature of 160°C for 12 minutes; butter cakes semi-products were baked under the temperature of 180°C for 10 minutes; fruitcakes were baked with a weigh of dough blanks of 70g under the temperature of 150°C for 20 minutes; muffins were baked with a weigh of dough blanks of 80g under the temperature of 150°C for 20 minutes. All pastries were baked in an UNOX commercial countertop convection oven with humidity (Italy).

The quality of flour confectionary was assessed by organoleptic parameters in accordance with the requirements for the quality of corresponding pastries described in the State standards of Ukraine as DSTU 4460:2018, DSTU 3781:2014, DSTU 4505:2005, as well as by such physical and chemical parameters as specific volume and porosity (for sponge cake semi products, fruitcakes and muffins). Specific volume and porosity of the baked goods were determined according to the well-known methods given in [19].

The data was statistically processed with the MS Office Excel software.

Results of the research and their discussion

The content and properties of gluten are important parameters that a large extent determine the directions of the use of flour for food products manufacturing. Therefore, at the first stage of the study, it was important to compare these parameters for waxy wheat and wheat baking flour (Table 1).

It was found that waxy wheat flour contains 16.8% less crude gluten, which is generally consistent with the researchers' data on the lower protein content of waxy wheat flour [1-2,4,16]. At the same time, it should be noted that in the case of researching the properties of a significant number of wheat grain varieties, waxy wheat samples containing slightly more protein than the reference samples were found [1]. Therefore, presumably, the reduced content of protein and gluten in waxy wheat should not be considered as a varietal feature of this crop. Interesting data were obtained by Caramanico R. and co-authors [22], who report on the reduced ability of waxy wheat gluten to hydrate due to the low mobility of water molecules in the dough obtained from waxy wheat flour and the strong binding of water by starch. Thus, the reduced yield of raw gluten in waxy wheat flour may be associated not so much with the reduced protein content in this crop, but with unfavorable conditions for the formation of gluten.

Table 1 – Gluten content and properties of waxy wheat and wheat baking flour

Parameter	Waxy wheat flour	Wheat baking flour
Crude gluten,%	26.2±0,4	31.5±0,5
Tenacity of gluten, units	76±1	64±1
Extensibility of gluten, cm	17±1	14±1
Color	light with a gray tint	light
Group of quality	II	I

The analysis of the data in Table 1 allows to notice that the gluten of waxy wheat flour is less elastic by 12 units (or by 18.8%) and 21.4% more extensible than the gluten of wheat baking flour. It has a light color with a gray tint, while the gluten of the reference sample had a light color. According to these indicators, waxy wheat gluten can be attributed to the II group of quality in contrast to wheat one (the I group of quality). The obtained data may indirectly indicate the insufficiently developed baking properties of waxy wheat flour and the feasibility of its use for manufacturing flour confectionaries that do not require the presence of a strong gluten (butter cakes, fruitcakes, muffins, sponge cakes, etc.). At the same time, a number of published scientific works proved the feasibility of the use of waxy wheat flour in a mixture with wheat baking flour for the manufacturing of bread and baked goods of improved quality [2,5-8,16].

At the next stage of research, the water-holding capacity of tested flour samples was determined (Fig. 1).

It is established that waxy wheat flour has 1.8 times higher water-holding capacity compared to wheat baking flour. This is probably due to the significant content of the amylopectin fraction of starch in waxy wheat flour, which has a significant hydrophilicity. In addition, the obtained result may be associated with the formation of an increased number of damaged starch granules during flour milling and smaller particles of waxy wheat flour, as noticed by a number of researchers in their works [1-4,15]. The increased water-holding capacity is probably a typical feature of waxy wheat flour of various varieties, since such results were obtained by various authors during the interpretation of farinograms and micrograms of various flour samples [1-4], as well as according to the results of differential scanning calorimetry [5,22].

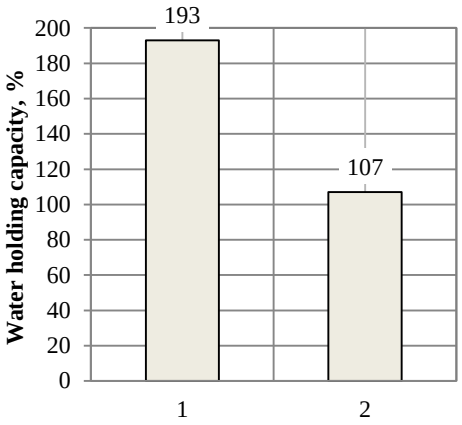

Fig. 1. Water holding capacity of waxy wheat flour (1) and wheat baking flour (2)

At the next stage of research, the parameters of starch pasting with the use of amylograph test were studied (Table 2) as well as falling number according to Harberg-Perten (Fig. 2) and the lifting power of model dough systems (Fig. 3) were defined.

Table 2 – Pasting parameters of the flour starch

Parameters	Waxy wheat flour	Wheat baking flour
Pasting temperature, °C	57±1	60±1
Time till the pasting beginning, min	21±1	23±1
Peak viscosity, cP	920±10	580±10

It was established that waxy wheat flour starch begins to gelatinize a little earlier and at a slightly lower temperature than wheat starch. This may be related to both of the peculiarities of the structure of starch granules and the absence of amylose in waxy wheat flour starch, which is mainly associated with the lipid complexes of flour and leads to an increase in the starch pasting temperature as a result of reduced swelling of these complexes [4,9,16]. At the same time, it should be noted that the data published by other researchers regarding the absolute values of the pasting temperature of waxy wheat starch differ and are within 67 and 71°C [3,14]. The peak viscosity of the starch paste of waxy wheat flour is almost 1.6 times higher than that of reference sample and gains the critical values measured during the observation. High

indicators of the viscosity of the starch paste of waxy wheat flour are probably related to the predominant content of amylopectin in waxy wheat flour, that has a significant molecular weight compared to amylose and a high hydration capacity. This correlates with the results obtained during the determination of the water-holding capacity of the tested samples of flour (Fig. 1), as well as the data of other researchers regarding the conduct of relevant tests on an amylograph and mixograph [1-3,14]. The similar results were obtained when studying the properties of the isolated starch of durum wheat waxy compared to the isolated starch of durum common wheat [4]. It is worth noting, however, that in the case of determination of starch pasting temperatures by the method of differential scanning calorimetry, the measurement result is the opposite – waxy wheat starch samples have higher temperatures of the beginning of gelatinization, as well as temperatures corresponding to the peak viscosity and the beginning of destruction, compared to the wheat starch paste [3,5,22].

The results of deciphering the amylograms, in particular the parameter of the peak viscosity of the starch paste, may indicate the feasibility of the use of waxy wheat flour in a mixture with strong flour for the manufacturing of flour products in order to equalize the properties of both types of flour and obtaine products of better quality.

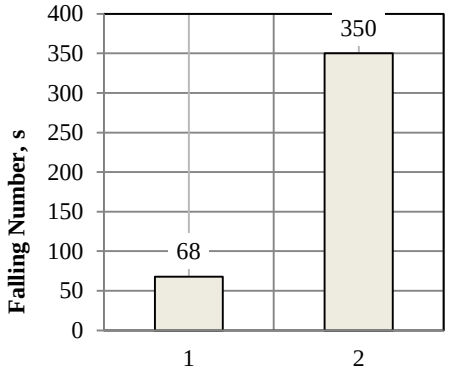

Fig. 2. Falling number of waxy wheat flour (1) and wheat baking flour (2)

According to the results of determining of the falling number of tested samples of flour (Fig. 2), it was established that this parameter for waxy wheat flour is only 68 s that is more than 5 times lower than for wheat baking flour. Usually, such values of the falling number are associated with abnormally high activity of flour amylases. At the same time, the obtained data to some extent do not agree with the result of deciphering the amylograms, in particular, the increased viscosity of the starch paste of waxy wheat flour (Table 2), but they correspond to the data of a number of other researchers [3,9,14]. It should be noted that a number of authors associate the reduced falling number of waxy wheat flour not with the increased activity of amylases, but with the better susceptibility of starch to the action of enzymes due to their significant damage during milling, the absence of bound complexes between amylase and lipids, which cause higher values of this parameter, as well as the reduced temperature of waxy wheat starch pasting [3,9]. At the same time, the data published by Purna Sh.K.G and co-authors [4], as well as Iorgachova K.G. and co-authors [14] testify to the fact that the activity of amlolytic enzymes of waxy wheat flour is 2.2...6.6 times higher than that of wheat baking flour.

In order to study the possible influence of waxy wheat flour on the technological properties of fresh yeast, the lifting power of model dough systems was determined. The results of the research are presented in Figure 3.

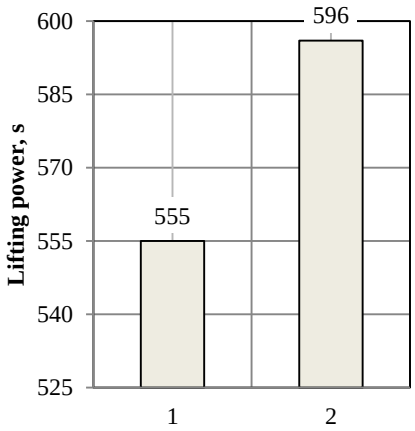

Fig. 3. Lifting power of yeast into model systems made from waxy wheat flour (1) and wheat baking flour (2)

The data obtained indicate that the model system made of waxy wheat flour shows a 6.9% better lifting power parameter compared to the system made of wheat baking flour. In general, such a difference can be considered insignificant, and the differences can be caused by a number of factors: the increased susceptibility of wheat starch to amylolysis, increased α-amylase activity as well as sugar- and gas-generating capacity, which was previously reported by various researchers [1,3-4,8-10,14,15]. At the same time, it is worth noting that the data published by Iorgachova K.G. and co-authors [10], testify to two times better indicators of the lifting power of semi-finished products made of waxy wheat flour, compared to wheat baking flour. The result obtained can be taken into account during the study of the possibility of the use of waxy wheat flour for the manufacturing of baked goods in a mixture with strong baking flour, as well as flour confectionery with the use of baking yeast as a leavening agent, such as crackers, galettes, yeast cakes, etc.

The obtained results became the basis for laboratory testing of pastries recipes with the use of waxy wheat flour. Taking into account the obtained data on the technological properties of waxy wheat

flour of the Biskvitna variety, as well as the results and recommendations of other researchers, it was considered appropriate to investigate the possibility of making sponge cakes and butter cakes semi-products, fruitcakes and muffins with the addition of waxy wheat flour. Test samples of the dough were prepared according to the known recipes with the addition of 25.0, 50.0 and 75.0% waxy wheat flour instead of wheat baking flour. Pastries made of wheat baking flour without adding waxy wheat flour were used as a reference samples. The result was evaluated by organoleptic quality parameters, as well as specific volume and porosity for sponge cakes, fruitcakes, and muffins. The results of the research are presented in Fig. 4-5.

It should be noted that during the kneading of all test samples of the dough (sponge cakes, butter cakes, fruitcakes and muffins), the same tendency was visually observed, which was previously obtained by Takata K. and co-authors [2] during bread dough manufacturing: with an increase in the dosage of waxy wheat flour the dough became thicker (sticky). This may be related to the reduction of free moisture in the system due to its binding by starch, which correlates with the data of Caramanico R. and co-authors, obtained during the study of the properties of waxy wheat flour by the method of differential scanning calorimetry [22]. The effect obtained is also consistent with the result of determining the water-holding capacity of flour (Fig. 1), and the data of other researchers regarding to the increased moisture-absorbing capacity of waxy wheat flour [1-5].

During the assessment of the organoleptic indicators of the quality of sponge cake semi-products, it was established that all samples had the proper shape and a smooth surface without cracks, and the samples with the addition of 50.0 and 75.0% of waxy wheat flour, have slightly more microcracks on their surface than other samples. The color of the crust is light brown, the color of the crumb is light yellow, the smell is typical for sponge cakes, the taste is sweet, without extraneous flavors. The structure of the crumb is loose, the porosity is uniform, small, and the samples with the addition of 50.0 and 75.0% waxy wheat flour were slightly more moist, but not sticky, that can be used in cakes manufacturing thus the stage of soaking of sponge cakes with a syrup can be skipped (or amount of the syrup consumped can be significantly reduced). The effect obtained corresponds to the data of Abdel-Aal E.-S. and co-authors [3] about the content of a significantly higher amount of absorbed moisture in flour products made from waxy wheat flour during storage under positive temperatures, as well as the data of Caramanico R. and co-authors [22] about the strong binding of moisture by waxy wheat starch.

Evaluation of the organoleptic parameters of the quality of buttercakes semi-products showed that all samples of cookies had the proper shape and smooth surface, the color was from light yellow to golden (light brown), the smell was typical for pastries. The most significant changes were observed in the consistency (structure) of cakes: with an increase in the dosage of waxy wheat flour, the fragility (crumbliness) of cakes increased. Presumably, the improvement in the structure of butter cakes made with the addition of waxy wheat flour is due to the complication of gluten formation in the system due to the moisture binding with starch. According to the results of the tasting of cookies, it was established that the best quality parameters cakes with the addition of the maximum (75.0%) amount of waxy wheat flour have, that may indicate the potential of a complete replacement of wheat baking flour with waxy wheat flour in the recipes of butter cakes and requires further research.

During the evaluation of the organoleptic parameters of the quality of the fruitcakes, it was found that all the samples had the right shape, without leaks, there were cracks on the surface, and with an increase in the dosage of waxy wheat flour, the size of the cracks increased. Visually, the volume of all samples was approximately the same. The color of the pastries was light brown. The porosity of the reference sample was fine, uniform, the porosity of the samples with the addition of waxy wheat flour – with the presence of a small number of large pores. The samples tested did not differ in terms of taste and smell.

All samples of the muffins tested had the right shape, without leaks, there were large cracks on the surface, and with an increase in the dosage of waxy wheat flour, the size of the cracks increased. With an increase in the dosage of waxy wheat flour, a decrease in the roughness on the surface of muffins was also observed, that may be associated with an increase in the density of the dough in the case of the addition of waxy wheat flour. Visually, the volume of samples with the addition of waxy wheat flour was slightly larger than that of the reference sample. The color of muffins was brown. The porosity of the control sample and the sample with the addition of 25.0% waxy wheat flour was fine, uniform, the porosity of the other two samples – with the presence of large pores, that is consistent with the effect previously obtained by Takata K. and co-authors [2] during the manufacturing of baked goods. It is worth noting that the authors associate the formation of large pores in baked goods made with the use of waxy wheat flour with its increased gas-generating capacity, while yeast was not used in the muffin recipe. In our opinion, the formation of large pores in products made on the basis of waxy wheat flour can be related, in addition to the gas-forming ability, to an increase in the viscosity of the dough, in particular, if it has a sufficiently high moisture content. The tested samples did not differ in taste and smell.

1 2 3 4

1 2 3 4

Sponge cakes semi-products

1 2 3 4

Butter cakes

1 2 3 4

1 2 3 4

Fruitcakes

1 2 3 4

1 2 3 4

Muffins

Fig. 4. The appearance of flour confectioneries made with the addition of waxy wheat flour in the amount: 1 – without addition (reference sample); 2 – 25.0%; 3 – 50.0%; 75.0%

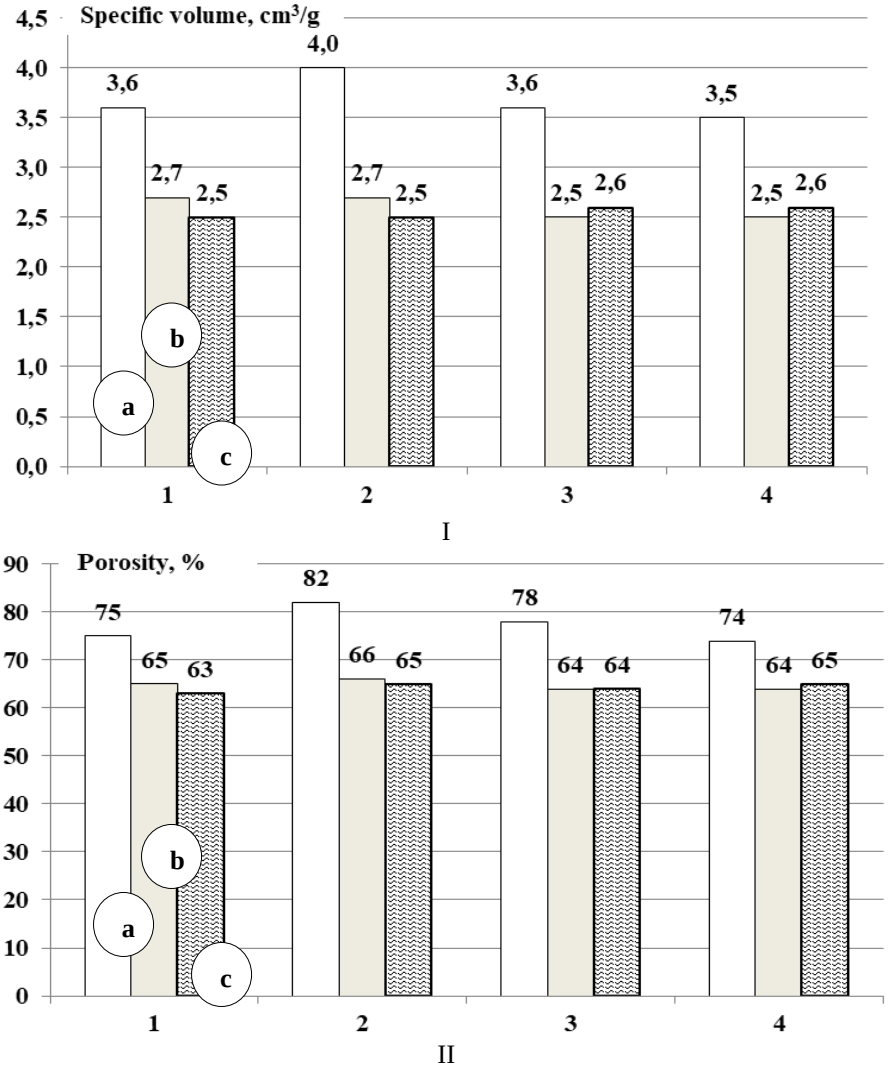

Fig. 5. Specific volume (I) and porosity (II) of:
a – sponge cake semi-products, b – fruitcakes, c – muffins made with the addition of waxy wheat flour in an amount: 1- without addition (reference sample); 2 – 25.0%; 3 – 50.0%; 75.0%

Based on the results of determining the specific volume and porosity of flour confectioneries (Fig. 5), the following was established. In the case of adding 25.0% of waxy wheat flour to the recipe, an increase in the specific volume and porosity of sponge cakes up to 11.1 and 9.3%, respectively, is observed. With a further increase in the dosage of waxy wheat flour, the specific volume and porosity of the products slightly decrease compared to the best result, but do not differ significantly compared to the reference sample. All samples of fruitcakes and muffins tested did not differ significantly in terms of specific volume and porosity, although larger pores were visually observed in the samples with the addition of 50.0 and 75.0% of waxy wheat flour, that was mentioned above.

Thus, confectionery made with the addition of waxy wheat flour have high quality parameters, and the flour tested can be recommended for manufacturing of sponge cakes and butter cakes in the amount of up to 75%, fruitcakes and muffins in the amount of up to 25% instead of wheat baking flour.

Conclusion

As a result of the research, the possibility of the use of waxy wheat flour of the Biskvitna variety for manufacturing of sponge cakes, butter cakes, fruitcakes and muffins has been substantiated. It was found that waxy wheat flour contains 16.8% less crude gluten that is 18.8% less elastic and 21.4% more extensible in comparison to wheat baking flour. Waxy wheat flour has 1.8 times higher water-holding capacity compared to wheat baking flour, which is due to the absence of the amylose fraction of starch, smaller sizes of starch granules and a greater number of damaged starch granules in the flour. It was established that the viscosity of the starch paste of the samples of waxy wheat flour is 1.6 times higher than that of the reference sample, while the falling number is more than 5 times lower than that of wheat baking flour.

This may indicate differences in the structure of starch granules of tested flour samples, as well as about the increased activity of amylases of waxy wheat flour. The model system made on the basis of waxy wheat flour has a 6.9% better lifting power compared to the system made on the basis of wheat baking flour. According to the results of the analysis of the organoleptic, physical and chemical parameters of the quality of flour confectioneries made with the addition of waxy wheat flour in the amount of 25.0 to 75.0% instead of wheat flour, their high quality and compliance with the requirements of the standarts for these types of products. The feasibility of the use of waxy wheat flour for manufacturing of sponge cakes and butter cakes in the amount of up to 75.0%, as well as fruitcakes and muffins in the amount of up to 25.0% instead of wheat bakery flour were confirmed.

References:

1. Graybosch RA, Souza E, Berzonsky W, Baenziger PS, Chung O. Functional properties of waxy wheat flours: genotypic and environmental effects. J of Cereal Sci. 2003;38:69-76. https://doi.org/10.1016/S0733-5210(02)00139-X
2. Takata K, Nishio Z, Iriki N, Tabiki T, Funatsuki W. Comparison of Quality characteristics of waxy wheat using a vear isogenic line. Breeding Sci. 2005; 55: 87-92. https://doi.org/10.1270/JSBBS.55.87
3. Abdel-Aal E-SM, Hucl P, Chibbar RN, Han HL, Demeke T. Physicochemical and structural characteristics of flours and starches from waxy and nonwaxy wheats. Cereal Chem. 2002;79(3):458-464. https://doi.org/10.1094/CCHEM.2002.79.3.458
4. Purna ShKG, Shi Y-Ch, Guan L, Wilson JD, Graybosch RA. Factors governing pasting properties of waxy wheat flours. Cereal Chem. 2015; 92(5):529-535. https://doi.org/10.1094/CCHEM-10-14-0209-R
5. Zhang H, Zhang W, Xu Ch, Zhou X. Studies on the rheological and gelatinization characteristics of waxy wheat flour. Int J Biological Macromolecules. 2014;64:123-129 https://doi.org/10.1016/j.ijbiomac.2013.12.004
6. Qin P, Ma Ch-X, Wu R-L, Zhang B-Q. Effect of waxy wheat flour blends on the quality of fresh and stale bread. Agr Sci in China. 2009;8(4):401-409. https://doi.org/10.1016/S1671-2927(08)60225-4
7. Bhattacharya M, Erazo-Castrejón SV, Doehlert DC, McMullen M. Staling of bread as affected by waxy wheat flour blends. Cereal Chem. 2002; 79(2). https://doi.org/10.1094/CCHEM.2002.79.2.178
8. Lee M-R, Swanson BG, Baik B-K. Influence of amylose content on properties of wheat starch and breadmaking quality of starch and gluten blends. Cereal Chem. 2001;78:701-706. https://doi.org/10.1094/CCHEM.2001.78.6.701
9. Iorgachova YG, Makarova OV, Hvostenko YV. Obosnovaniye vybora muchnykh konditerskikh izdeliy dlia ispolzovaniya muki iz vaksi-pshenitsy. Vostochno-Yevropeyskiy zhurnal peredovykh tekhnologiy. 2016; 2/11(80):12-18. https://doi.org/10.15587/1729-4061.2016.65756
10. Iorgachova YG, Makarova OV, Hvostenko YV. Ispolzovaniye muki iz pshenitsy vaksi v tekhnologii keksov na drozhakh. Kharchova nauka i tekhnologiya. 2015;1(30):54-60.
11. Iorgachova K, Makarova O, Khvostenko K. The influence of the waxy wheat flour on the cake`s staling. Applied Researches in Technics, Technologies and Education. 2018; 6:242-245. https://doi.org/10.15547/artte.2018.04.012
12. Nakamura T, Yamamori M, Hirano H, Hidaka S, Nagamine T. Production of waxy (amylose-free) wheats. Molecular and General Genetics. 1995;248:253-259. https://doi.org/10.1007/BF02191591
13. Kowalski RJ, Dangi A, Gu B-J, Ganjyal G. Twin-screw extrusion characterization of two varieties of soft white waxy wheat flours. J Agriculture and Food Research. 2021; 5(6): 100178. https://doi.org/10.1016/j.jafr.2021.100178
1. 14 Iorgachova KG, Makarova OV. Khvostenko KV, Rybalka OI. Vyznachennia tekhnologichnykh vlastyvostey boroshna z bezamiloznoyi pshenytsi za stanom vuglevodno-amilaznogo kompleksu. Kharchova nauka i tekhnologiyi. 2012;1(18):37-40
14. Bettge AD, Giroux MG, Morris CF. Susceptibility of waxy starch granules to mechanical damage. Cereal Chem. 2000; 750-753. https://doi.org/10.1094/CCHEM.2000.77.6.750
15. Hung PhV, Maeda T, Fujita M, Morita N. Dough properties and breadmaking qualities of whole waxy wheat flour and effects of additional enzymes. J Sci Food and Agriculture. 2007; 87(13): 2538-2543. https://doi.org/10.1002/jsfa.3025
16. Morita N, Maeda T, Miyazaki M, Yamamori M, Miura H. Dough and baking properties of high-amilose and waxy wheat flours. Cereal Chem. 2002; 79:491-495. https://doi.org/10.1094/CCHEM.2002.79.4.491
17. Zaparenko AV, Didenko SY, Borysova AO. Outlook of the application of the waxy wheat flour in pastry technologies. Aktualni problem rozvytku restorannogo, hotelnogo ta turystychnogo biznesu v umovakh svitovoyi integratsiyi. 2019 Sep;118-120
18. Drobot VI. Laboratornyi praktykum z tekhnologii khlibopekarskoho ta makaronnoho vyrobnytstv. Kyiv: Tsentr navchalnoyi literatury; 2006.
19. Zaparenko A, Didenko S, Holyk O, Goloventsov Y. Investigation of the technological properties of emmer flour. Food Science and Technology. 2020;14(2):119-127. https://doi.org/10.15673/fst.v14i2.1717
20. Pavlov OV. Zbirnyk retseptur boroshnyinykh kondyterskykh i zdobnykh bulochnykh vyrobiv. Kyiv: ProfKnyga; 2019.
21. Caramanico R, Barbiroli A, Marengo M, Marti A. Interplay between starch and proteins in waxy wheat. J Cereal Sci. 2017;75:198-204. https://doi.org/10.1016/j.jcs.2017.04.008.

ДОСЛІДЖЕННЯ ФУНКЦІОНАЛЬНИХ ВЛАСТИВОСТЕЙ БОРОШНА ПШЕНИЦІ ВАКСІ

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Анотація. Подано результати досліджень функціональних властивостей борошна пшениці ваксі, отриманого із зерна пшениці ваксі ярого сорту Бісквітна, районованого в Харківській області, в порівнянні з борошном пшеничним хлібопекарським вищого ґатунку. Виявлено, що вміст сирої клейковини в борошні пшениці ваксі на 16.8% менший, ніж в зразку порівняння, вона на 18.8% є менш пружною та на 21.4% більш розтяжною, має світлий із сірим відтінком колір та може бути віднесена до другої групи якості. Борошну пшениці ваксі властива в 1.8 рази вища водоутримуюча здатність, її крохмаль починає клейстеризуватися за нижчої температури, при цьому максимальна в'язкість крохмального клейстеру борошна пшениці ваксі майже в 1.6 разів вища, ніж зразка порівняння. Показник «число падіння» для борошна пшениці ваксі в понад 5 разів менший, ніж для борошна пшеничного хлібопекарського, і становить лише 68 с. Модельна тістова система, приготовлена на основі борошна пшениці ваксі, має на 6.9% кращий показник підіймальної сили порівняно із системою, приготовленою на основі борошна пшеничного хлібопекарського. За результатами пробних випікань бісквітних і пісочних напівфабрикатів, а також кексів і мафінів з додаванням від 25.0 до 75.0% борошна пшениці ваксі замість борошна пшеничного хлібопекарського встановлено, що під час замішування всіх дослідних зразків тіста спостерігалась тенденція підвищення його густини зі збільшенням дозування борошна пшениці ваксі. Дослідні вироби відрізнялися гарними показниками якості, хоча в кексах і мафінах з дозуванням борошна пшениці ваксі понад 50.0% було відзначено утворення крупних нерівномірно розподілених у м'якушці пор. В разі додавання 25.0% борошна пшениці ваксі спостерігається збільшення питомого об'єму та пористості бісквітних виробів на 11.1 і 9.3% відповідно, а з подальшим збільшенням дозування борошна пшениці ваксі питомий об'єм і пористість виробів наближалися до відповідних значень цих показників у зразка порівняння. Всі дослідні зразки кексів і мафінів за показниками питомого об'єму та пористості істотно не відрізнялися. За результатами проведених досліджень рекомендовано використовувати борошно пшениці ваксі, отримане із сорту пшениці ваксі Бісквітна, під час виготовлення бісквітних і пісочних виробів в кількості до 75.0%, кексів і мафінів – у кількості до 25.0% замість борошна пшеничного хлібопекарського.

Ключові слова: борошно пшениці ваксі, бісквітні вироби, здобне печиво, кекси, мафіни.