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IMPROVEMENT OF THE TECHNOLOGY OF SHORTCRUST BAKED SEMI-FINISHED PRODUCT ON THE BASIS OF MODEL FUNCTIONAL COMPOSITIONS

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The effect of whey protein concentrate obtained by ultrafiltration (WPC-UV), micronized flour from grain ECO products and amaranth seed fiber (ASF) on the processes of structure formation of shortcrust dough was investigated. The quality indicators of finished flour confectionery products from shortcrust pastry based on model functional compositions (MFC) have been determined.

It has been established that the introduction of ASF and WPC-UV into the model functional compositions leads to an increase in the elasticity of the prototypes and to an increase in the resistance of the dough to mechanical stress. The closest in viscous-plastic characteristics to the control is a sample with a ratio of 96.2:2.0:1.8 of oat flour ECO:ASF:WPC-UV. For shortcrust pastry, the ratio 77.00:1.8:2.2 with wheat germ ECO:ASF:WPC-UV is optimal.

When using the composition in a ratio of 77.00:1.8:2.2 with wheat germ ECO:ASF:WPC-UV, the adhesive stress of the dough masses decreased 2.2 times compared to the control. For the sample using ECO wheat germ, the adhesive stress of the dough masses decreased by 1.7 times compared to the control. The relationship of improved shortcrust pastry with oat flour ECO:ASF:WPC-UV in the ratio 96.2:2.2:1.6 with the surface (steel) is the smallest.

The friability of a shortcrust semi-finished product with the introduction of MFC decreased by 3...5 %. On the contrary, the index of wetness increased with an increase in WPC-UV and ASF, which is explained by the significant content of protein substances and dietary fibers, which have a higher water-clay capacity.

The study of the MFC influence on the processes of structure formation of shortcrust pastry makes it possible to significantly improve the functional and technological properties, nutritional and biological value of confectionery products

Keywords: shortcrust semi-finished product, model functional composition, improved technology, functional and technological properties

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1. Introduction

Butter shortcrust dough is the most unstable semi-finished dough product with a high fat content. This is due to the processes of recrystallization or recrystallization of the fat phase of the dispersion medium of the dough semi-finished product [1]. However, in the structure of consumption (and, accordingly, production) of confectionery products, flour products, in particular, biscuits and waffles, steadily prevail. Most of the production of confectionery products falls on October (in October 2018 – this figure was 120 thousand tons), less – in May-June (in 2018 in June 82 thousand tons), or 35 % less. The demand for confectionery products grows during the New Year holidays and March 8th. It should be noted that the total consumption of flour confectionery products is growing every year. Thus, the crisis events of recent years in the world have made significant changes in the development of the food industry in general and in the confectionery industry in particular. New challenges have been set for the technologists of the confectionery industry.

In order to form and stabilize the structure of shortcrust dough, it is possible to offer WPC-UV, micronized flour with grain of ECO products (from wheat germ, oat flour, and others) and ASF.

WPC-UV has a high energy and chemical composition of biopolymers, in particular, proteins, carbohydrates. Therefore, the addition of WPC-UV, micronized flour with grain of ECO and ASF products can affect the processes of structure formation, as well as the quality indicators of finished flour confectionery products from shortcrust pastry. However, these data are lacking and additional research is needed.

So, studies of the effect of flour compositions of micronized grain ECO products supplemented with amaranth seeds fiber (ASF) and whey protein concentrate obtained by ultrafiltration (WPC-UV) on the processes of structure formation and quality indicators of shortcrust dough and determination of quality indicators of shortcrust semi-finished product based on model functional compositions (MFC).

2. Literature review and problem statement

In the scientific and practical activities of the production of flour confectionery products, considerable experience has been accumulated in the development of technologies that ensure the rational use of raw materials. Wider attraction of local and non-traditional types of raw materials, improving the quality and biological value and reducing the energy value of flour confectionery products [2, 3]. This gives grounds to assert that flour confectionery products have potential favorable development prospects due to the introduction of the latest and improved technologies based on modified functional compositions, despite the negative influence of the external environment. The promotion of new types of flour products made from shortcrust pastry that do not contain traditional types of flour to the market is hampered by an insufficient level of fundamental and applied research. The processes of formation and stabilization of the structure of dough enriched with food additives, which improve the structure of the dough and increase its nutritional value, have not been fully clarified.

The main problem of creating flour confectionery products from shortcrust pastry with a given set of properties is the complex process of ensuring the most complete balance and structuredness of the product. An important role in solving this problem is played by the correct choice of the raw material base [2]. This directs scientists to search for new affordable and affordable food system improvers that have high nutritional properties and low cost.

In order to create stabilizing complex mixtures for regulating the structure of the dough semi-finished product of the combined butter biscuits, research was carried out on the technological properties of nonionic surfactants produced in Ukraine by NPP Elektrogazokhim. The greatest decrease in the surface tension of the emulsion was observed when adding a mixture of emulsifiers sorbate triastearate, stearic acid triglyceride and glycerol monostearate in an amount of 0.3 % to the emulsion. The decrease in the total amount of emulsifiers during the formation of an emulsion is explained by their synergistic interaction [3].

The study of the influence of oilseed meals on improving the quality of shortcrust biscuits [4] showed the need to add the composition of oilseed meals to shortcrust dough at the level of 20 %. By means of mathematical modeling it has been established that the rational ratio of soybean meal, sunflower meal, milk thistle is 30 %:40 %:30 %. With such a ratio, the chemical composition of the shortcrust semi-finished product is improved in terms of the content of fiber, potassium, calcium, iodine, and vitamins. In the developed confectionery products, the protein content increased by 2.5 times, and the fiber content by 6 times. The content of minerals increased significantly, in particular calcium – by 172.9 mg of selenium – by 13.06 μg of iodine – by 2.76 μg and vitamin E – by 2.4 mg. However, with an increase in the amount of milk thistle meal, the organoleptic characteristics of the shortcrust pastry and products made from it deteriorate significantly.

Numerous works have shown that inexpensive raw materials can be available as a source of functional food ingredients for confectionery products. Such is non-traditional fruit and vegetable raw materials or waste [5, 6], secondary or non-traditional resources of flour-grinding production [7–9], products of extrusion of grain crops [10], traditional and new types of dairy, fatty products [11, 12], medicinal plants [13], which are carriers of essential and valuable substances.

Since the processes of crystallization or recrystallization of the fat phase of the dispersion medium of the shortcrust dough are closely related to the presence of emulsifiers in the food system, it can be considered necessary to study their functional raw material sources. Among the insoluble dietary fiber in food production, cellulose is most widely used – as an emulsifier and as an additive that prevents caking and clumping [14]. Various intense sweeteners and dietary fiber are used in confectionery to reduce the amount of sugar and energy value, and to increase the nutritional and biological value of products [15].

To reduce the proportion of fat in products with an emulsion structure, use the extract of crimson amaranth leaves, which reduces the content of harmful cholesterol. This action of the extract of incarnadine amaranth leaves is very important for patients with atherosclerosis, coronary heart disease and overweight people [16]. Micronized grain ECO products are characterized by an increase in moisture and fat absorption capacity, destruction of starch with the formation of dextrins, a decrease in protein solubility due to their denaturation, and an increased content of minerals and vitamins.

In connection with the above, a variety of plant products should be included in the composition of flour confectionery products from shortcrust pastry. This gives grounds to assert that it is expedient to conduct a study on improving the technology of flour confectionery products from shortcrust pastry based on MFC with WPC-UV, micronized flour ECO and ASF.

3. The aim and objectives of research

The aim of research is to improve the technology of baked shortcrust semi-finished product based on modified functional compositions (WPC-UV, micronized flour ECO and ASF). This will make it possible to reasonably approach the selection of sources of functional food ingredients in confectionery recipes, increase the nutritional and biological value, the efficiency of the manufacturing process and ensure high quality of finished products from shortcrust pastry.

To achieve the aim, the following objectives are set:

– to conduct research on gluten indicators of flour compositions of micronized grain ECO products supplemented with fiber amaranth seeds (ASF) and whey protein concentrate obtained by ultrafiltration (WPC-UV);

– to investigate the viscous-plastic properties of the shortcrust dough and the adhesive stress of the dough masses from various flour compositions (flour ECO, WPC-UV and KNA) and the time of contact with the working body of the technological equipment;

– to improve the general technological scheme of a shortcrust semi-finished product based on modified functional compositions based on the data obtained in the study;

– to determine the indicators of friability and wetness of a shortcrust semi-finished product based on model functional compositions (MFC).

4. Materials and methods of research

The object of research is the technology of shortcrust baked semi-finished product based on model functional compositions (MFC).

The subjects of research are concentrate of whey proteins obtained by ultrafiltration with a content of 65 % dry matter; shortcrust baked semi-finished product based on MFC [17].

The preparation of prototypes based on model functional compositions (MFC) was carried out according to the traditional technology, control samples according to the classical recipe [18].

The method for determining gluten indicators on the IDK apparatus is standard, described in more detail in DSTU ISO 21415-2:2009 "Wheat and wheat flour. Determination of gluten content. Part 2. Determination of wet gluten content by mechanical method". The Gluten Index is calculated by the formula:

$$\mathrm{GI}=\frac{(M_1)}{M_0}\cdot 100,\ \%, \tag{1}$$

where M_1 – mass of gluten remaining on the sieve of the cassette after centrifugation, g; M_0 – total mass of washed gluten, g.

Drying of the washed gluten is carried out between two Teflon plates of the Glutork 2020 device (Sweden) at a temperature of 150 °C for four minutes. This indicator allows to assess the potential water absorption capacity of flour. A Brookfield viscometer was used to measure the visco-plastic properties of the shortcrust dough under known shear conditions. To determine the adhesion, a control was used – a shortcrust dough according to a traditional recipe on wheat flour, and dough samples of a simulated product with different concentrations of wheat germ fiber. To study the adhesion of narrow-plastic food materials, a device based on the method of uniform separation was used (Fig. 1).

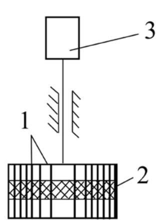

Fig. 1. Diagram of the working body of the adhesiometer: 1— plate, 2 — product, 3 — loading element

With such a separation, the value of adhesion is determined at the time of simultaneous breakdown of contact in all sections of the contact area at the position of the breaking load in the direction perpendicular to the plane of contact of the surfaces according to the formula:

$$P_0=\frac{P}{F}, \tag{2}$$

where P_0 – adhesion value, Pa; P – maximum separation force, N; F – area of the plate, m^2.

Wetness was calculated using the formula:

$$W=\frac{(M_k-M_e)\cdot 100}{(M_C-M_e)}, \tag{3}$$

where W – wetness of products, %; M_e – mass of the empty mesh after immersion in water and wiping off the outer side, g.

5. Results of studies of indicators of improved shortcrust semi-finished product based on model functional compositions

5. 1. Results of studies of indicators of gluten of flour compositions

To predict the possibilities of improving the shortcrust semi-finished product based on MFC in the technologies of flour confectionery products of improved quality and nutritional value, the indicators of gluten of flour compositions were studied. The obtained data on the quality of gluten flour compositions based on ASF, WPC-UV and micronized grain ECO products are given in Table 1.

Table 1

Indicators of the quality of gluten flour compositions

Shortcrust pastry samples	Wet gluten content, %	Gluten quality indicators		
		IDK indicator, units	extensibility over the ruler, mm	hydration capacity, %
With oat flour ECO (control)	14.0±0.2	65±1.5	9.0±0.1	185±2.0
With wheat germ ECO (control)	14.5±0.4	65±2.0	8.5±0.2	175±4.0
With oat flour ECO, WPC-UV and ASF:96.2:2.8:1.2	27.5±0.5	95±3.0	15.0±0.5	210±5.0
With oat flour ECO, WPC-UV and ASF:96.2:2.2:1.6	17.3±0.5	65±2.0	10±0.5	185±5.0
With oat flour ECO, WPC-UV and ASF:96.2:2.0:1.8	13.5±0.2	60±2.0	8.5±0.5	182±2.0
With wheat germ ECO, WPC-UV and ASF:77.00:1.8:2.2	15.5±0.3	75±3.0	10.5±0.2	190±3.0
With wheat germ ECO, WPC-UV and ASF:77.00:1.65:2.30	14.5±0.4	65±2.0	8.5±0.2	175±4.0
With wheat germ ECO, WPC-UV and ASF:77.0:2.0: 1.8	14.0±0.2	65±1.5	9.0±0.1	185±2.0

The presented in Table 1 show that when ASF and WPC-UV are added to the MFC, the elasticity of the prototypes increases, and the resistance of the dough to mechanical stress increases several times.

5. 2. Results of studies of visco-plastic properties and adhesive stress of the improved shortcrust dough

The viscous-plastic properties of shortcrust dough are investigated with wheat germ ECO with the addition of ASF and WPC-UV in the ratio: 1 – 77.00:1.8:2.2; 2 – 77.00:1.65:2.30; 3 – 77.0:2.0:1.8; 4 and shortcrust pastry with oat flour ECO with the addition of ASF and WPC-UV in the ratio: 1 – 96.2:2.8:1.2; 2 – 96.2:2.2:1.6; 3 – 96.2:2.0:1.8 (Table 2).

The closest in viscous-plastic characteristics to the control of wheat dough is a sample with a ratio of oat flour ECO with the addition of ASF and WPC-UV 96.2:2.0:1.8. Whereas shortcrust pastry with wheat germ ECO with the addition of ASF and WPC-UV is closest to the control ratio 77.00:1.8:2.2.

During experimental studies, the dependence of the adhesive stress of the dough masses on the influence of various flour compositions was determined (Fig. 2).

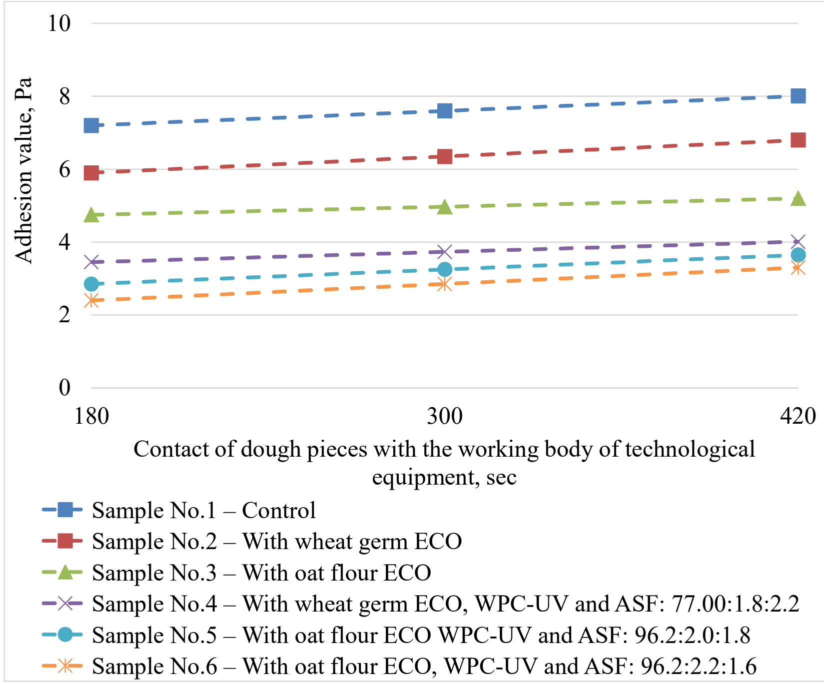

Fig. 2. Adhesive stress of the dough masses depending on the influence of various flour compositions

The dependence of the adhesion stress of the dough masses on various flour compositions (flour ECO, WPC-UV and ASF) and the time of contact with the working body of the technological equipment have been determined. In Fig. 2 it is seen that with an increase in the addition of additives, the value of adhesion decreases. With the introduction of ECO, WPC-UV and ASF into the formulation of oat flour in a ratio of 96.2:2.2:1.6, the connection of the improved shortcrust dough with the surface of the processing equipment (steel) is the smallest.

5. 3. The results of improving the general technological scheme of a shortcrust baked semi-finished product based on modified functional compositions

Based on the results of the studies, the recipe composition of flour mixtures was substantiated, a rational amount of the constituent flour compositions (flour ECO, WPC-UV and ASF) was proved. And also their influence on functional and technological properties, technological parameters and modes of improved production of shortcrust semi-finished product based on MFC, an improved technological scheme is proposed (Fig. 3).

Table 2

Effective viscosity and shear stress in shortcrust dough samples based on flour mixtures ECO, WPC-UV and ASF

Shortcrust pastry samples	Shear rate, s^{-1}							
	1		2		4		6	
	Effective viscosity, Pa·s	Shear rate, Pa·s	Effective viscosity, Pa·s	Shear rate, Pa·s	Effective viscosity, Pa·s	Shear rate, Pa·s	Effective viscosity, Pa·s	Shear rate, Pa·s
Control (from wheat flour)	80	35	50	45	28	64	20	72
With wheat germ ECO (control)	75	30	45	45	25	50	18	65
With oat flour ECO (control)	140	40	120	60	58	82	30	95
With wheat germ ECO, WPC-UV and ASF: 77.00: 1.8: 2.2	85	40	55	50	33	69	25	77
With wheat germ ECO, WPC-UV and ASF: 77.00: 1.65: 2.30	77	32	47	47	27	52	20	67
With wheat germ ECO, WPC-UV and KNA: 77.0: 2.0: 1.8	88	43	58	53	36	72	28	80
With oat flour ESO, WPC-UV and ASF: 96.2: 2.8: 1.2	155	50	145	55	60	70	45	80
With oat flour ECO, WPC-UV and ASF: 96.2: 2.2: 1.6	160	60	150	65	55	75	50	85
With oat flour ECO WPC-UV and ASF: 96.2: 2.0: 1.8	145	45	125	65	63	87	35	95

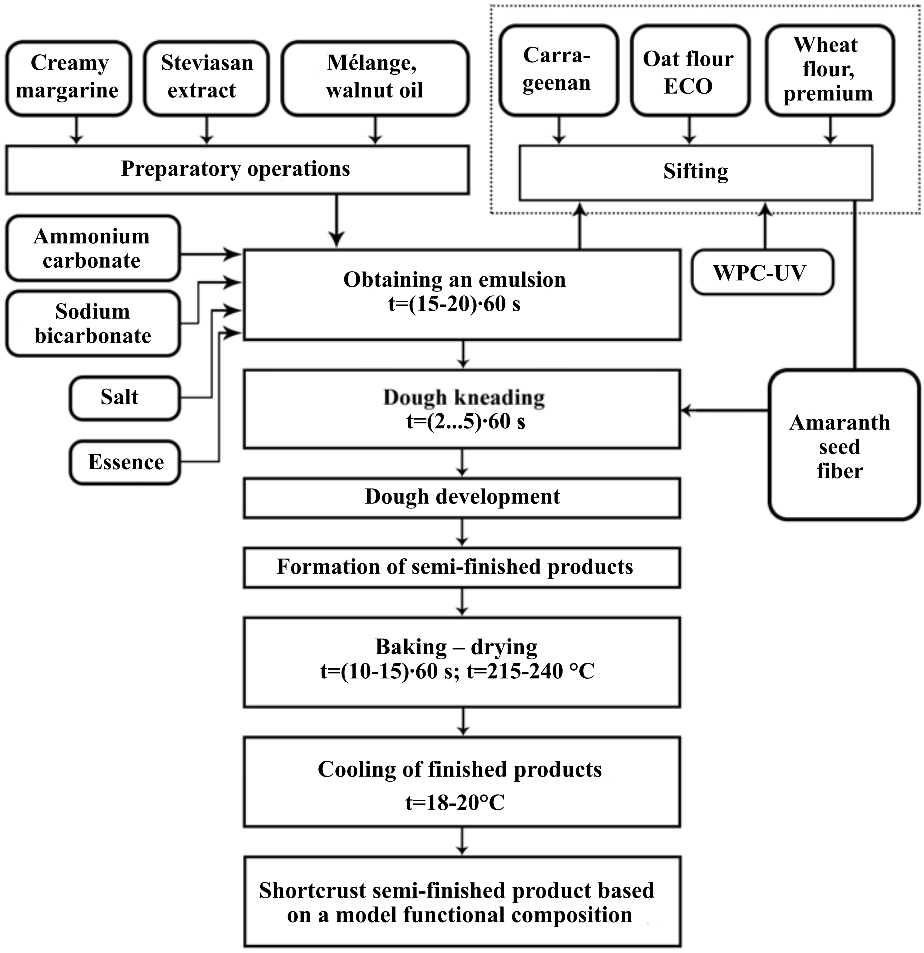

Fig. 3. Improved general technological scheme of baked shortcrust semi-finished product based on model functional compositions (MFC)

The presented research data allow to state that the addition of ECO, WPC-UV and ASF to a flour composition with flour in the production of products from shortcrust pastry has a positive effect on their organoleptic and structural-mechanical properties. In addition, the introduction of raw sources of essential proteins (WPC-UV), dietary fiber, vitamins and minerals (ASF, ECO oat flour) into the technological scheme allows increasing the nutritional and biological value of finished products.

Table 3

Study of quality indicators of shortcrust cookies using flour compositions (flour ESP, WPC-UV and ASF)

Level of quality	Control (with wheat germ ECO)	Samples		
		With wheat germ ECO, WPC-UV and ASF:77.0:2.0:1.8	With wheat germ ECO, WPC-UV and ASF:77,00:1,65:2,30	With wheat germ ECO, WPC-UV and ASF:77,00:1,8:2,2
Friability, %	48.70	47.10	46.50	46.20
Wetness, %	150.10	152.50	165.00	175.00

5. 4. Results of studies of friability and wetness indicators of shortcrust semi-finished product based on model functional compositions

The results of determining the indicators of friability and wetness of shortcrust cookies are given in Table 3. The studies carried out show a decrease in the friability index with an increase in the percentage of amaranth seeds added to the composition with WPC-UV.

On the contrary, the index of wetness increased with an increase in the percentage of addition of WPC-UV and ASF additives.

Thus, the addition of ESO, WPC-UV and ASF to the flour composition with micronized flour in the production of products from shortcrust pastry has a positive effect on their organoleptic and structural-mechanical properties. In addition, it allows to increase the nutritional value of ready-made shortcrust pastry products.

6. Discussion of the results of the study of indicators of the improved shortcrust semi-finished product based on modified functional compositions

Data presented in Table 1 show that when ASF and WPC-UV are added to the MFC, the elasticity of the prototypes increases, and the resistance of the test to mechanical stress increases several times. The maximum value of the dough stability index – 5.4×60 s, corresponds to research samples with a concentration of ASF – 1, 8 % and WPC-UV – 2.0 %; further on, the dough stability indicator will stabilize. ASF and WPC-UV helps to reduce the extensibility of the gluten samples. In model compositions, the elongation decreases from 135 mm to 95 mm.

According to the results of experimental studies, the maximum value of the effective viscosity at the minimum values of the shear rate of 1..6 s^{-1} was noted in the sample with oat flour ECO, ASF and WPC-UV in the ratio 96.2:2.2:1.6. Whereas the sample with the ratio of oat flour ECO with the addition of ASF and WPC-UV 96.2:2.0:1.8 is the closest in viscous-plastic characteristics to the control of wheat dough.

For shortcrust pastry with wheat germ ECO with the addition of ASF and WPC-UV, the ratio 77.00:1.8:2.2 is closest to the control. The data obtained are confirmed by the studies of Indian scientists [19], who studied flour compositions from millet flour, soybean sprouts and amaranth. Their research data indicate that there are no significant differences in terms of textural properties, dough flow index and mixture index for the control and test samples.

Experimental studies of the adhesive stress of dough masses, depending on the influence of various flour compositions, prove that:

– in comparison with the control (wheat flour dough), adhesion decreased 2.9 times;

– when a flour composition with wheat germ ECO, WPC-UV and ASF was introduced in a ratio of 77.00:1.8:2.2, adhesion decreased 2.2 times compared to the control. For the sample using ECO wheat germ, the adhesive stress of the dough masses decreased 1.7 times compared to the control;

– connection with the surface of technological equipment (steel) for a flour composition with oat flour ESO, WPC-UV and ASF in a ratio of 96.2:2.0:1.8 was fixed by 20 % more.

According to the results of experimental studies, the friability of a shortcrust semi-finished product when making a flour composition with wheat germ ECO, WPC-UV and ASF in a ratio of 77.0:2.0:1.8, the indicator decreased by 3 %. When the flour composition is introduced in a ratio of 77.00:1.65:2.30 – by 4.5 %, and in a ratio of 77.00:1.8:2.2 – by 5 %.

On the contrary, the index of wetness increased with an increase in the percentage of addition of WPC-UV and ASF additives. This can be explained by the significant amount of protein substances and dietary fiber in the flour composition with ECO wheat germ, which has a higher water-clay capacity. In [20], it is also indicated that the mass of muffins and brownies with the addition of pumpkin seed flour changes due to an increase in the water absorption capacity of the flour composition. Pumpkin seed flour was added at a concentration of 10 and 20 % of the total weight of the flour composition. In the process of studying the effect of protein isolates from rapeseed meal, an increase in the volume of baked semi-finished product by 140..155 % and a change in the microstructure of the dough were also observed [21].

Improvement of the technology of shortcrust semi-finished product based on MFC made it possible to stabilize the structure of shortcrust pastry enriched with food additives, and also increase its nutritional value. Thus, the problem of creating flour confectionery products from shortcrust pastry with a given set of properties has been solved, in which the most complete balance and structuredness of the product is ensured.

In a further study, it is necessary to identify the influence of undesirable possible hazard factors of the improved recipe composition of shortcrust semi-finished product based on MFC in the course of production processes. It is also necessary to analyze and identify all potentially dangerous factors associated with each technological operation of its production.

7. Conclusions

1. The conducted studies of gluten flour compositions of micronized grain products ECO, ASF and WPC-UV prove that their use increases the elasticity of prototypes, increases several times the resistance of the dough to mechanical stress. The maximum value of the dough stability indicator – 5.4×60 s, corresponds to research samples with a concentration of ASF – 1.8 % and WPC-UV – 2.0 %; in the future, the indicator will stabilize. ASF and WPC-UV helps to reduce the extensibility of the gluten samples. In model compositions, the elongation decreases from 135 mm to 95 mm (almost as in the control sample).

2. Investigation of the visco-plastic properties of the improved shortcrust dough found that the sample with the ratio of ECO oat flour with the addition of ASF and KSB-UF 96.2:2.0:1.8 is the closest to the control. For shortcrust pastry with wheat germ ECO with the addition of ASF and WPC-UV, the ratio 77.00:1.8:2.2 is closest to the control.

The study of the adhesion stress of the shortcrust dough from various flour compositions (flour ECO, WPC-UV and ASF) and the time of contact with the working body of the technological equipment show a 2.9-fold decrease in adhesion. With the introduction of a flour composition with wheat germ ECO, WPC-UV and ASF in a ratio of 77.00:1.8:2.2, adhesion decreased 2.2 times compared with the control and 1.7 times compared with the shortcrust dough with using wheat germ ECO. The connection with the surface of technological equipment (steel) for a flour composition with oat flour ESO, WPC-UV and ASF in a ratio of 96.2:2.0:1.8 was recorded by 20 % more.

3. Based on the results of the studies, an improved technological scheme for the production of shortcrust semi-finished product based on MFC was proposed, and the recipe composition of flour mixtures was substantiated. A rational amount of the constituent flour compositions (flour ECO, WPC-UV and ASF) has been proven. And also their influence on functional and technological properties, technological parameters and modes of improved production.

4. The friability of a shortcrust semi-finished product when making a flour composition with wheat germ ECO, WPC-UV and ASF in a ratio of 77.0:2.0:1.8 to the recipe for shortcrust dough decreased by 3 %. When making a flour composition with wheat germ ECO, WPC-UV and ASF in a ratio of 77.00:1.65:2.30 – by 4.5 %, and in a ratio of 77.00:1.8:2.2 – by five %. On the contrary, the indicator of wetness increased with an increase in the percentage of addition of WPC-UV and ASF additives. This can be explained by the significant amount of protein substances and dietary fiber in the flour composition with ECO wheat germ, which has a higher water-clay capacity.

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