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THE STUDY OF TECHNOLOGICAL PROPERTIES OF WAXY WHEAT FLOUR AND ITS INFLUENCE ON REFINED SUGAR-FREE HARDTACK`S DOUGH

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Abstract

There was grounded the choice of ingredients for developing floury confectionary products without sugar and prospects of using amylose-free flour of waxy wheat and sunroot powder for their production. There were determined quality parameters of used flour, conditioned by the state of the protein-proteinase complex.

Based on studying technological properties of flour of waxy wheat, there was demonstrated the expedience of its use in the technology of products of yeasty dough, especially hardtacks, at replacing sugar for sunroot powder. There was offered to introduce sunroot powder at producing hardtacks with the decreased sugar content in equal shares at the stage of kneading liquid fermented dough and ready one.

There was determined the influence of using amylase-free flour of waxy-wheat and inulin-containing raw material on structural-mechanical and surface properties of dough for sugar-free hardtacks. It was demonstrated, that combined introduction of waxy wheat flour and inulin-containing raw material positively influences quality parameters of semi-products of yeasty dough at complete exclusion of sugar from their recipes. The replacement of bakery wheat flour by amylase-free one allows to get dough with sunroot powder for sugar-free hardtacks with less firmness, elasticity and tendency to adhesion.

Keywords: flour force, dough for hardtacks, decreased sugar capacity, sunroot powder, waxy wheat flour.

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1. Introduction

For the last time the urgent direction at developing new types of floury confectionary products is a search and use of recipe components, allowing to decrease a sugar content and energetic value of manufactured products [1]. It is conditioned by the growing demand for food products with healthy effect, dietary properties on the background of raising the level of consumers' awareness of the necessity of observing rational nutrition principles. At the same time the necessity of such studies is connected with the increasing number of people with the disturbed carbohydrate metabolism – diabetes mellitus, obesity and so on [2].

The conducted analysis of literary sources testifies that the special interest is awaken by inulin-containing raw materials, in particular, sunroot powder (SP) as ingredients that may be used for replacing saccharose. Together with the positive influence on the human organism due to its physiological properties, sunroot powder is characterized by a series of technological advantages – easiness in use high hydrophilic capacity; improvement of organoleptic and physical-chemical characteristics of ready products at its optimal dosage and so on [3]. Further studies of characteristics of this raw material may favor its wider use in different branches of food industry, including for bakery.

It must be noted, that producers of floury confectionary products without sugar or with its decreased content often face the problem of worsening the products' quality [4]. This tendency is conditioned by important technological functions of sugar as a recipe ingredient, and its essential influence on the production process and characteristics of ready products [5].

It is probably possible to provide intensification of the fermentation process of yeasty semi-products at excluding sugar from recipes due to the use of waxy wheat flour (WWF) for their production. Flour of such wheat type, found for the first time by Japan selectors, is characterized by the absence of amylase in the composition of its starch and also its high pliability to the effect of amylolytic enzymes [6, 7]. The replacement of bakery wheat flour (BWF) by amylase-free waxy wheat one obviously allows to stabilize the quality of semi-products for hardtacks, prepared with introducing sunroot powder instead of sugar.

The aim of the work is to determine technological properties of waxy wheat flour and structural-mechanical characteristics of sugar-free dough for hardtacks, based on the joint use of WWF and SP. Obtained results allow to estimate a possibility of processing and formation of the studied yeasty semi-products on the existent equipment and to prognosticate the quality of obtained products.

2. Materials and Methods

The experimental part of the work is conducted in the laboratories of the Department of bakery, confectionary, pasta and food concentrates technology, problem scientific-research laboratory of Odesa national academy of food technologies (Ukraine).

The research object – technological properties of WWF, conditioned by the state of the protein-proteinase complex; structural-mechanical and surface properties of dough for sugar-free hardtacks.

The research subject was wheat flour of waxy sort Sofiyka, yeasty dough for hardtacks with the decreased sugar capacity and control samples. Sunroot powder "Interest" (CFN "Malva", Ukraine) (**Fig. 1**) was used as a sugar-replacing ingredient [8].

Fig. 1. Sunroot powder

2. 1. Experimental procedures

Determination of the rough gluten content was realized by the method presented in [9]. For this aim 25 g of flour and 14 cm^3 of drinking water with temperature from 18 to 20 °C were taken from the middle sample. Dough was kneaded on the dough-kneading machine У1-ЕТК («UKRMACHIND», Ukraine), with preliminary pouring of a necessary amount of water in a pan for kneading by a doser. Then the prepared flour batch is transferred there. The pan is set in the body of the kneading machine, and dough is kneaded. After ending of kneading, the pan is taken off and dough is taken from it. Pins and pan are accurately cleaned from dough remains, which are transferred to the total mass. Dough is rolled in a ball, put in a dish, closed by glass for preventing chapping and left for 20 min for swelling of flour ingredients.

After 20 min lying dough is started to be washed under a light water filament with the temperature from 18 to 20 °C above a sieve No. 27. At the beginning it is washed carefully, by wrinkling by fingers for preventing tearing off pieces of dough or gluten together with starch. When the more part of starch and surfaces is eliminated, dough is washed more energetically. Pieces of gluten, torn away, are accurately collected from the sieve and added to the total mass.

Washing is considered as finished, when starch marks are absent in water, squeezed out from the gluten ball. The iodine solution with the concentration near 0,001 mol/dm^3 is used for its determination.

Washed gluten is squeezed from excessive water by pressing. Gluten squeezed in such a way is weighed on technical scales. After the first weighing, gluten is washed under the water filament one more time during 3-5 min, after which squeezed again and weighed. If the difference between two weighing doesn't exceed 0,1 g, washing is considered as finished.

The amount of raw gluten G_{raw}, % is calculated by the formula:

$$G_{raw} = \frac{m_{gl} \cdot 100}{T_f}, \quad (1)$$

where m_{gl} – mass of raw gluten, g, m_f – mass of flour batch, g.

GDM device is designed for determining the gluten quality group, its elasticity, estimated by the value of its deformation under the load effect [10]. For that two batches of 4 g are separated from washed, squeezed and weighed gluten, and balls with the smooth surface without breaks and cracks are formed of it. A gluten ball with mass 4 g is put in a glass with water with temperature 18...20 °C for 15 minutes for lying, eliminating internal stresses. After lying a gluten ball is placed in the center of a support table of the device and a die that compresses gluten during 30 seconds with the force near 1,2 N is let off. The results of measuring the gluten elasticity are expressed in conventional units of the device scale. Depending on the value of measuring results, gluten is related to the correspondent quality group.

The hydration ability of gluten is determined, using the wet value of gluten and calculated by the formula:

$$H = \frac{W_{gl} \cdot 100}{100 - W_{gl}}, \quad (2)$$

where H – hydration ability of gluten, % of the dry gluten mass, W_{gl} – gluten wet.

For determining the gluten elasticity, its pieces are stretched by three fingers of both hands above a ruler approximately by 2 cm and left. After removal of a stress, there are estimated the degree and speed of restoring the initial length or form of gluten.

Determination of the gluten stretchability above the ruler is conducted by the following way. Pieces with mass 4 g are taken from gluten, squeezed, weighed on the technical scales. Balls are formed from these pieces, then they are immersed in the dish with water with the temperature from 18 to 20 °C for 15 min for relaxing a stress, after that the studies are conducted.

For determining the stretchability, a gluten ball, lied in water, is taken by three fingers and evenly stretched above the ruler with millimeter points till breaking. At that the length that gluten is stretched till the braking moment to is noted.

During the work on the farinograph, made by Brabender (ГGermany) **(Fig. 2**) there were studied structural-mechanical properties of dough at kneading.

Fig. 2. Farinograph by Brabender

The studies were conducted according to the method, described in SSU 4111.1-2002/ISO 5530-1:1997 [9].

The extensograph by Brabender (Germany) (**Fig. 3**) is designed for determining physical properties of dough by its resistance to stretching efforts.

Fig. 3. Extensograph by Brabender

The elasticity and energy of wheat flour dough at deformation of the one-axis stretch were determined by the method AACC 54-10 [11].

Determination of the limit shear stress (τ, Pa) for semi-products was conducted on the penetrometer AP-4/1 (VEB Feinmess, Germany) just by the penetration method, using a metallic cone as an indenter. Penetration is a method of determining structural-mechanical properties of semi-products and ready products by determining penetration of an immersion body in them.

The results of the penetration studies are objective characteristics that reflect the resistance of the material to compression and shear. The main value, obtained at penetration is a limit shear stress, which index can be determined by Rebinger formula:

$$\tau = C\alpha \cdot P/h^2, \quad (3)$$

where h – depth of cone immersion, m; Cα – cone constant (at α=30° Cα=0,959); P – penetration effort, N, equal to the weight of the cone, bush and immersion system.

AP-4/1 penetrometer (**Fig. 4**) was used at the studies.

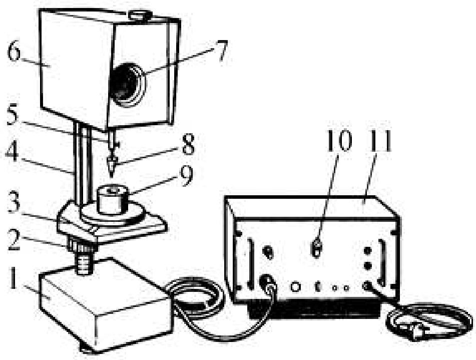

Fig. 4. Penetrometer AP-4/1: 1 – seating, 2 – screw, 3 – measuring table, 4 – upright posture, 5 – sleeve, 6 – measuring head, 7 – microscale for counting determinations, 8 – immersion body – indenter, 9 – glass

On upright posture 4, combining measuring head 6 with seating 1, is measuring **Table 3**, with glass 9, containing dough. The table shifts by screw 2. Measuring head 6 contains the supplying system from sleeve 5 with a replaceable clamping element and microscales for counting immersion of it. Cone 8 is used as an immersion body. A sample for dough is placed on table glass 9, lifted till the surface of a dough sample touches the immersion body. Penetration of the immersion body in dough takes place during some time. After that indications are fixed by the penetrometer.

The specific work of the elastic force of dough was studied on the penetrometer AP-4/1 using a metallic plate-disk (**Fig. 4**) [12]. At determining elastic properties of dough, the cone was replaced by a disk with mass 15 g, diameter 50 mm. A cylindric dough sample is put on the bottom to same overturned glass 9. Glass 9 with the sample is set in device table 3 and lifted till the dough surface touches the disk. A load of 245 g is put on the disk and the device with an immersion body with total mass 300 is switched on. Initial indications are fixed on the device scale. Then the load is removed, and the device is switched on again. At that the value of residual deformation is noted on the scale.

The specific work of elastic forces of dough (A, D/kg) is calculated by the formula:

$$A = \frac{m \cdot g(I - I_b)}{m_{av} \cdot 10^7}, \quad (4)$$

where m – mass of removed load, kg, I_a – initial device indications, I_b – final device indications, m_{av} – average mass of dough samples, g.

Adhesion is understood as sticking of materials, different by structure, with formation of an adhesion connection. An adhesion stress is determined by the method of normal separation of a plate from the structured body (dough for hardtacks) on the setting, developed in ONAFT (**Fig. 5**) [12].

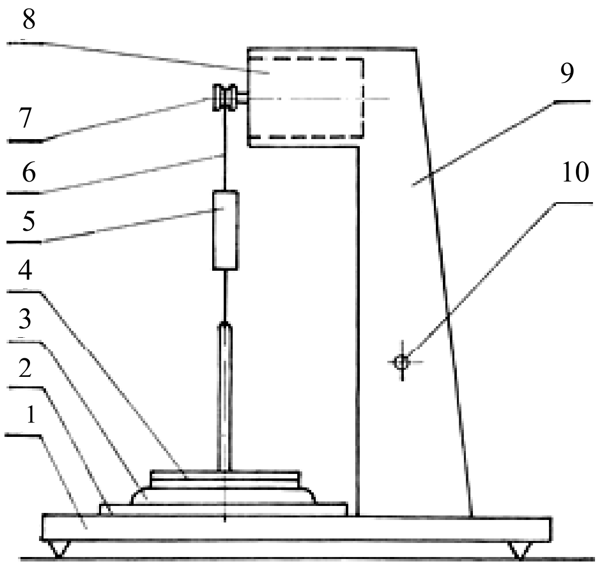

Fig. 5. Device for determining the adhesion stress: 1 – device table; 2 – device chamber; 3 – studied sample; 4 – detachable plate; 5 – dynamometer; 6 – thread; 7 – sheave electric motor; 8 – electric motor; 9 – stand; 10 – tumbler of switching on and reversing of the motor

An adhesion characteristic is the detachment force – P (N), related to the contact area – S (m^2). It is called otherwise an adhesion stress – T (Pa).

The adhesion stress was determined by the dependence:

$$T = \frac{P}{S}. \tag{5}$$

For determining the adhesion as a protecting contact surface, there were used plates of steel. The working order of the device is the following: dough with thickness 0,01 m is placed to the chamber of device 2, plate 4 is lowered on the surface of mass 3, where a load with mass 400 g is set. A stopwatch measures the contact duration (120 s), then the load is removed. Tumbler 10 switches electric motor 8. The plate rises vertically up and is torn away from the mass. The detachment effort is determined by indicators of dynamometer 5. The type of detachment must be adhesion. A result of cohesion detachment is not fixed.

3. Results

At the first stage there was grounded the expedience of using sunroot powder instead of sugar in hardtacks recipes. Its introduction increases a share of non-starch polysaccharides, mineral substances and vitamins and doesn't need essential changes of the technological process [13]. Waxy wheat flour (WWF) due to its high gas-creating capacity [14], allows to intensify the process of fermentation and maturing of yeasty semi-products, which deceleration is observed at excluding sugar from hardtacks recipes.

For producing most types of floury confectionary products, as opposite to bakery ones, it was recommended to use flour with gluten of the weak or middle gluten quality. That is why it is important to study technological properties of flour, conditioned by the protein-poteinase complex.

The comparative analysis of waxy wheat flour and bakery wheat flour (BWF) by quantitative and qualitative parameters of gluten testified that WWF is characterized by the lower content of raw gluten. Gluten, washed of waxy wheat flour, differs by the higher (in 1,7 times) hydration ability, more stretchability and less elasticity comparing with bakery flour.

It's more objective to study technological properties of flour by determining structural-mechanical properties of dough, made of it, on the correspondent devices. The study of the dough-forming process on the farinograph demonstrated that dough of amylase-free flour is characterized by less stability and more liquefaction. Stretchability and elasticity of WWF dough, determined on the extensograph after 135 min of its fermentation were 2 and 3 times less comparing with the control, respectively. According to complex parameters of the flour force (**Fig. 6**) – energy and valometric number (VN), amylase-free flour may be considered as one of the weak force.

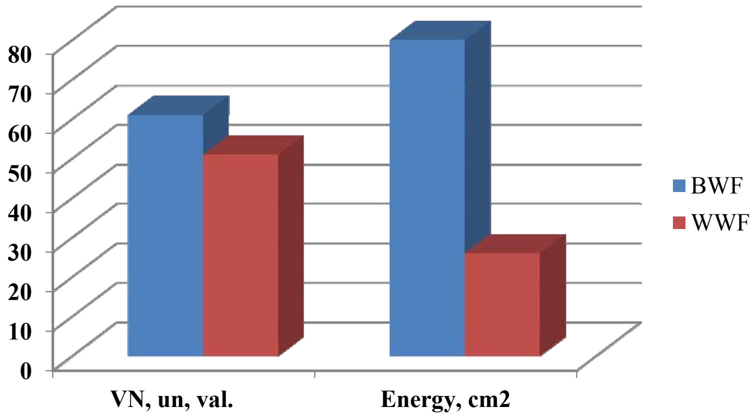

Fig. 6. Results of determination of the flour force by structural-mechanical properties of dough

For substantiating the expedience of using waxy wheat flour at preparing confectionary yeasty dough with replacing sugar by sunroot powder, there were studied structural-mechanical and surface properties of dough for hardtacks. Sunroot powder was introduced in equal shares at kneading fermented liquid dough and ready dough. Characteristics of dough masses were determined on the penetrometer after their lying-keeping and rolling (in 150 min after kneading) before forming workpieces.

It was established, that at preparing dough of bakery flour, the replacement of sugar for sunroot powder is accompanied by increasing its limit shear stress, adhesion properties of semi-products decrease (**Fig. 7, 8**). So, there is observed denser and harder distended dough. As a result, such increase of the density of hardtack dough gives products with inessentially increased porosity.

The use of waxy wheat flour for kneading dough for hardtacks, prepared with sunroot powder instead of sugar (WWF+SP), is accompanied by decreasing the limit shear stress, elasticity of semi-products (**Fig. 7**).

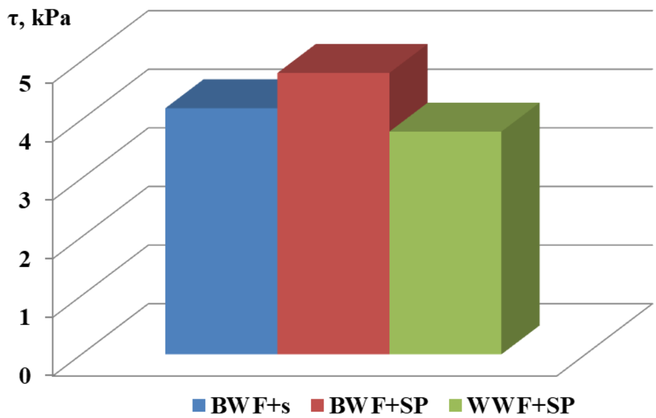

Fig. 7. Strength properties of hardtack dough

At that this tendency is observed comparing with both control sample with sugar (BWF+s) and a sample of bakery wheat flour (BWF+SP) without it. The obtained dependence is probably conditioned by more intensive gas formation at lying -keeping semi-products of WWF. At the same time less resistance of gluten of amylase-free flour as weaker by force allows the protein matrix to stretch more under the effect of carbon dioxide. It helps to get dough with less elasticity and more distended structure (**Fig. 8**).

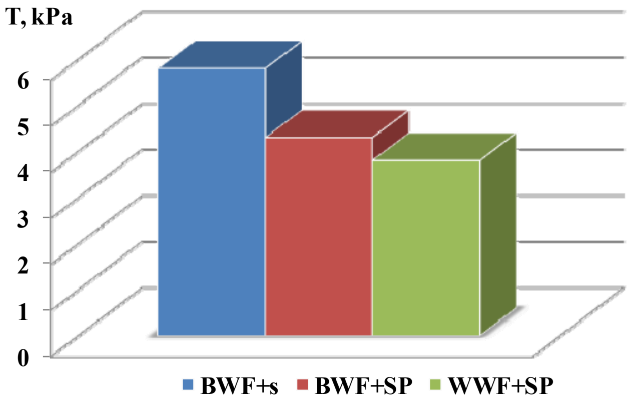

Fig. 8. Adhesion stress of hardtack dough

The decrease of dough adhesion stress at the joint use of BWF and sunroot powder (**Fig. 8**) testifies to the decrease of risk of its sticking to working bodies that favorably influences the currency of the technological process.

4. Conclusions

Based on the analysis of technological properties of waxy wheat flour, there was established the expedience of its use in the technology of yeasty sugar-free confectionary products. It was demonstrated, that this flour differs by the content of less elastic gluten comparing with bakery one and is weak by force. The use of sunroot powder instead of sugar in hardtacks recipe allow to get products with the increased food value and higher content of food fibers, to widen the assortment of floury products with the decreased sugar content.

It was established, that amylose-free flour allows to obtain dough for sugar-free hardtacks with introducing sunroot powder with less adhesion to working surfaces of the equipment. The given samples of dough masses were characterized with less expression of elastic properties and lower firmness that testifies to their better looseness at fermentation-lying. The elasticity decrease of semi-products, based on waxy wheat flour, allows to reduce the duration of lying of sugar-free hardtack dough and to avoid deformation of dough workpieces at forming.

The obtained results give a possibility to state that the joint use of waxy wheat flour and sunroot powder will allow provision of the uninterrupted work of aided and current lines for producing hardtacks, set at enterprises.

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IINFLUENCE OF MAIN TECHNOLOGICAL PARAMETERS OF DRYING ON QUALITY OF BAGASSE FROM CARROT AND BEET

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