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INVESTIGATION OF STRUCTURAL-MECHANICAL PROPERTIES OF THE RECIPE COMPOSITION FOR SPECIAL PURPOSE FONDANTS

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Abstract: *In Ukraine, scientists and experts have paid great attention to the development of culinary wellness products and products of special purpose.These products include sweet dishes, in particular fondants, which are popular among population. Therefore, researches have been done to justify the composition and structural-mechanical properties of dough and fondants made from gluten-free rice flour, using innovative ingredients - cocoa butter, condensed milk, chicken eggs, white sugar and citron powder.The main technology characteristics of fondants have been presented. Surfactants were used in order to obtain the desired structure. The necessity of using surfactants in fondants has been proved. This article analyses the advantages and disadvantages of the new recipe composition, in search for solutions to optimize formulations, taking into account the introduction of surfactants. On the basis of theoretical analysis and analyzing the classic ingredients of hot dessert, the authors have chosen the formulation of special purpose fondants. The article also presents the results of experimental studies on parameters such as porosity, adhesion, general deformation of dense part of the fondant. Therefore, it is reasonable to conduct the experimental research and develop the technical documentation for new types of fondant desserts using alternative raw materials. As a result of research on dough viscosity, the porosity of the dense part of fondant optimized the ratio between flour and surfactant. It is shown that the adhesion values of dough and total deformation of dense part of fondants are 1.3 times greater, and by 11% greater respectively in comparison with the control sample.*

Keywords*: hot sweet dishes, surfactant, porosity, adhesion, optimization.*

1. Introduction

In Ukraine, there is a group of diseases, their socially dangerous relevance and importance being determined not only by their high prevalence, but also by lack of a range of special purpose products. One of such diseases is the celiac disease – metabolic intolerance to cereal protein by the body. As a result of the United European Gastroenterology Week in 2002 in Geneva at a plenary meeting it was determined that every hundredth citizen of the country has food intolerance to proteins of wheat, rye, barley and cereal- made products. It is known that the majority of patients suffering from celiac disease are children of different ages.

In connection with the absence of a wide range of gluten-free products on the territory of Ukraine, and considering the widespread popularity of hot sweet dishes among different age groups, recipes of special purpose fondants have been developed on the basis of gluten-free rice flour in order to implement them in public restaurant business units.

Currently, the implementation of traditional technologies of fondants (chocolate fondants fig.1) is at an early stage, though this dessert is becoming more and more popular in the restaurant business establishments of Ukraine. But, unfortunately, there are still no profound researches on diversification and adaptation of assortment for different populations.

These factors lead to further improvement of the technological production process of recipe compositions of special purpose fondants using mathematical modeling.

The classic technology of cooking fondant consists of the following steps: introduction of the stuffing – chocolate cream ganache which is frozen, then addition to form inside the biscuit dough and baking for five minutes. For the preparation of the traditional product the following ingredients are used: dark chocolate (28...30%), cream butter (13...14%), wheat flour (20%), eggs (22...25%), white sugar (13...14%). However, the use of wheat flour in the production of gluten-free products is impossible.

Fig. 1. Chocolate fondant

Given the characteristics of the developed product, the recipe of special purpose fondants is hereby given: rice flour (GOST 27168-86), cocoa butter (DSTU 5004:2008), white sugar (DSTU 4623:2006), and citron powders (GOST 6829-89), eggs (DSTU 5028:2008), condensed milk (DSTU 4274:2003).

During the technological production process, one of the key steps is preparing the recipe mixture for semifinished special purpose fondants and formation of a complex colloidal system.

However, given the selection of these components in terms of their physico-chemical properties, research goals and objectives were established.

The purpose of the article was to study the structural-mechanical properties of a recipe mixture for special purpose fondants to further optimize the recipe.

Tasks:

1. To justify the nomenclature of the list of indicators which form the structural-mechanical properties;
2. to investigate viscosity, shear stress and porosity recipe mixture for special purpose fondants;
3. to establish correlations between porosity and viscosity of the finished product.
4. to investigate adhesion strength and overall deformation of the thick part of fondants.

2. Matherials and methods

The main objective of this survey is to analyze fondants made from wheat flour as control sample and those made from rice flour.Traditional methods of determining viscosity, shear stress were used: viscometer Reotest-2, porosity – by means of the computerized method, adhesion – by means of adhesion tester, total deformation – by penetrometer, optimization – by the method of least squares using software packages.

3. Results and discussion

Despite the exceptional variety of foods that are used in the food industry and establishments of restaurant business, in most cases at different technology stages

of their processing, they are non-homogeneous systems. By homogeneous system we understand that system which consists of two or more phases, each one having its own phase contact area and being mechanically separated from the other phase. Any non homogeneous binary system consists of an internal or disperse system and the external or dispersion medium in which dispersed phase particles are located. A system in which the external phase is a liquid is called the liquid non homogeneous system. Depending on the dispersive and the dispersed phase the following liquid heterogeneous systems are distinguished: Suspension – a liquid which contains therein solid suspended particles; Emulsion – a system in which the liquid dispersion medium contains therein particles of one or more other liquids, wherein all the components of the system must be mutually insoluble; Foam – systems which consist of a liquid dispersion medium and therein particles gas.

In food industry and restaurant business units, homogeneous solutions, suspensions, emulsions were prepared by mixing the dispersion process inseparably.

Dispersing is a grinding process of solid and gaseous substances in the liquid. Among these processes, there are three main ones: emulsification, homogenization and atomization of liquids.

The above-mentioned systems are used to obtain dough for special purpose fondants formed during heat treatment (baking) homogeneous internal component, similar to cream ganache in traditional fondants.

As main type of gluten-free raw materials for special purpose fondants we selected rice flour, which is taken in parts by weight of 20, 25 and 30%. The resulting system is a polidispersoid which is a combination of emulsion and dispersion of particular matter in the fatty phase, and does not provide the organoleptic quality of the finished product at control level.

To improve the data quality and functional properties in food processing industries surfactants are used to stabilize the emulsion and foam structure, modifying the crystalline form of fat compositions, regulating the structural-mechanical properties of semi-finished and hot sweet dishes.

Over the last years, esters of various fatty acids (including citric acid ester) have been increasingly used as emulsifiers both in our country and abroad during the production of food products.

Hydrolysed and standardised lecithin is the most common one in multicomponent food systems.

Standardised lecithin has a more pronounced effect on the process and quality of finished products due to the differences of its hydrophilic-lipophilic balance. The recommended dosage of lecithin is 0.7% in the mass of the composition recipe.

Hydrolysed lecithin has also a number of advantages. It is the most hydrophilic, as determined by the degree of hydrolysis, thus allowing the use of such emulsions in cream lecithins. Its structure is similar to that of monoglycerides, having only one fatty acid which is more effective in baking and provides a delicate product, stable to storage. The best result is achieved by a lecithin content of 0.7% in the weight of the composition recipe.

Among the wide range of emulsifiers, citric acid ester of the company «GRINDSTED®CITREMSP 70» was chosen, which complies with the Regulation № 1829/2003 and 1830/2003 and meets the requirements of the European Union (E 472 c) and is completely safe for use in the food industry. Citric acid ester of mono-, diglycerides made from edible refined sunflower oil and palm oil. It reduces the

tension between lipid and aqueous phase to stabilize the liquid emulsion, ensures the purity and stability of the aqueous dispersion medium with a high fat content, also has a high water binding capacity, and prevents the cracking of the product during baking and sticking to the surface of the molds. The recommended dosage is of 1.0% by weight of the composition recipe.

Based on the experimental data defining the viscosity of the product of the number of rice flour x_1 (v%) and surfactant x_2 (y%), the quadratic regression equation found, is approximately given this dependence.

$$Y = 172.39 + 1.43\ x_1 + 2085.83\ x_2 + 0.31\ x_1^2 - 2683.33\ x_2^2 + 2.50\ x_1\ x_2. \quad (1)$$

Multiple determination coefficient R2 = 0.9877, that is accuracy is quite high. The corresponding surface is as follows (Figure 2).

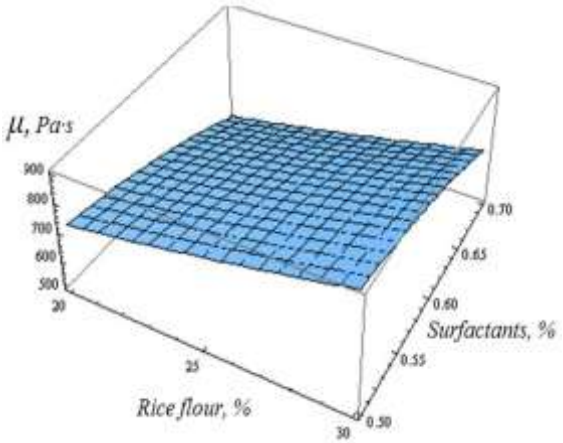

Fig. 2. Response surface of dosing rice flour and surfactant on viscosity of dough for special purpose fondants

Obviously (Figure 2), that in the area of changes factors x_1 and x_2, the viscosity of the product has no extrema. From a practical point of view, acceptable value of viscosity of the product is the value of Y = 800 Pa · s, similar to the viscosity of the test of control. Therefore, we can write the equation of the corresponding line level:

$$172.39 + 1.43\ x_1 + 2085.83\ x_2 + 0.31\ x_1^2 - 2683.33\ x_2^2 + 2.50\ x_1\ x_2 = 800, \quad (2)$$

or

$$0.31\ x_1^2 - 2683.33\ x_2^2 + 2.50\ x_1\ x_2 + 1.43\ x_1 + 2085.83\ x_2 = 627.61, \quad (3)$$

which defines hyperbole, the schematic graph being shown below:

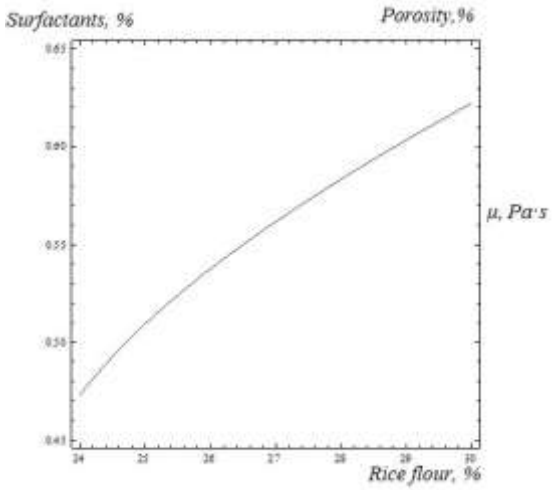

Fig. 3. The line of viscosity of fondant dough depending on rice flour and surfactant dosage

In addition to viscosity of the product, its porosity was investigated as well.

Based on the experimental data, the following equation of the quadratic regression was obtained:

$$Y = -88.50 + 8.93\ x_1 + 129.17\ x_2 - 0.14\ x_1^2 - 50.00\ x_2^2 - 3.50\ x_1\ x_2. \quad (4)$$

Multiple determination coefficient R2 = 0.8132, that is accuracy is quite high.

The corresponding surface looks as follows:

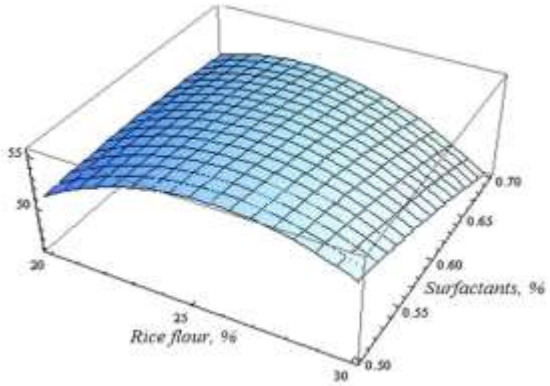

Fig. 4. Response surface of dosing rice flour and surfactant on the porosity and viscosity of dough 800 Pa.s. for special purpose fondants

The investigation of the porosity function of the extremum was done on the condition that the viscosity of the product is 800 Pa·s. The task was done on conditional extremum. The analysis was carried out, giving the point of maximum x_1 = 24,583% rice flour, x_2 = 0.495% ester of citric acid, Ymax = 55.52%.

An important factor is to ensure appropriate adhesive properties of gluten-free dough. Accordingly, we investigated the adhesion strength of the recipe composition according to the optimized structure by comparing to the control sample– Figure 5.

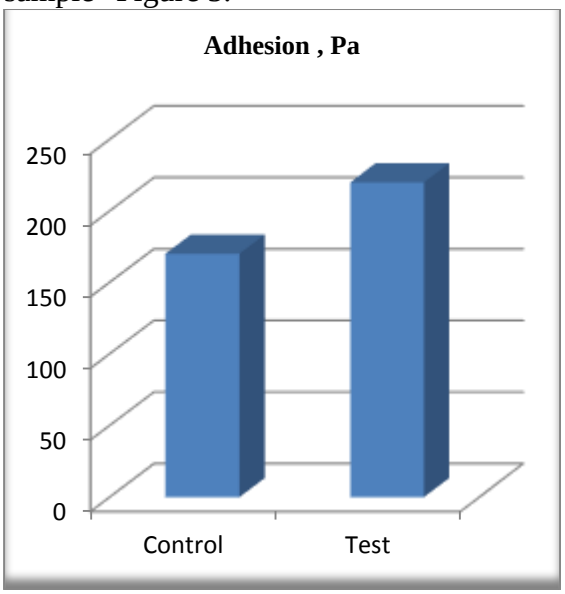

Fig. 5. Adhesion strength of test samples

As seen in Figure 5, the strength of experience is 1.3 times greater than the strength of the control. Thus, it is explained the action of gluten-free raw materials and surfactants due to the lack of gluten proteins. In addition to the positive physiological effects, rice flour provides higher emulsifying (ES) (stability of the emulsion from 42 to 65%) and fat binding (FBC) (from 28 to 68%) capacities as compared with the control sample.

Based on these investigations, the general deformation of the dense part of fondants was determined using penetrometer (Figure 6).

As seen in Figure 6, we can conclude that the experiment sample formed a more tender structure that is 11% less than the control one, due to the chemical composition of innovative recipe ingredients.

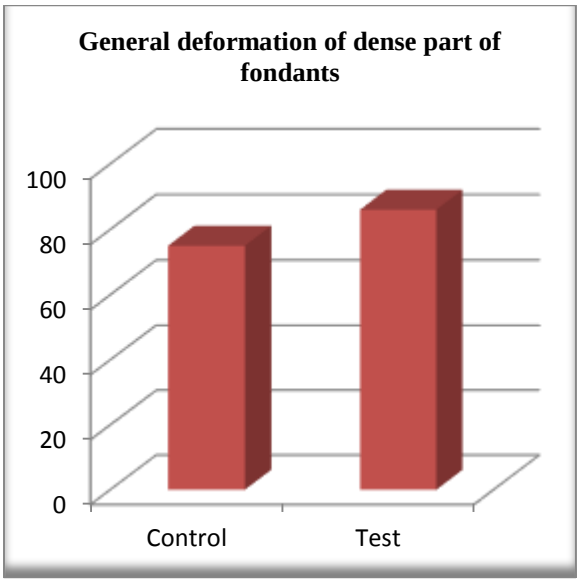

Fig. 6. General deformation of dense part of fondants

4. Conclusion

Thus, in conclusion we can remark based on the multifaceted complex researches of structural-mechanical properties that the formation of the structure by optimizing recipe fondants' composition of gluten-free rice flour is similar to traditional fondants made from wheat flour.

1. Based on the features of special purpose fondants, namely the presence of the liquid component during cutting, similar filling (cream ganache in traditional fondant) and dense part (porous shell) of sweet dish, indicators of structural-mechanical properties – dough viscosity and adhesion, porosity and overall deformation of dense part were selected.

2. As a result of research on viscosity of fondants' dough made from wheat flour and those made from rice flour for special purpose, the equation of quadratic regression was found, which roughly defines the dependence of dough viscosity on dosing of rice flour and surfactants, and of the constructed surface as response of this dependence.
3. From a practical point of view, an unacceptable viscosity value of the product is the value of Y = 800 Pa·s, similar to the viscosity of control sample dough, on the basis of experimental data and their mathematical processing the line of dough viscosity level is built for special purpose fondants (800 Pa·s), depending on the dosage of rice flour and surfactant.
4. The response surface of porosity of the dense part of special purpose fondants depends on the dosage of rice flour and a surfactant with a dough viscosity of 800 Pa·s.
5. It is found that the adhesion strength of dough in the test sample of fondants has by 23% greater importanc than that in the control sample, which is due to the technological properties of gluten-free raw materials and surfactant and the lack of gluten proteins.
6. In the special purpose fondants a more tender structure of the dense part than in control one was formed, fact that may be explained in terms of the overall deformation of the dense part of this sweet dish.

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