Досліджено вплив концентратів тваринних білків з колагенвмісної сировини на в'язкість водно-борошняних суспензій та ефективну в'язкість бездріжджового тіста. Встановлено позитивний вплив добавок на реологічні властивості тіста та борошна. Доведена зміцнююча дія поліпшувачів на структуру напівфабрикату. Борошняні вироби з використанням концентратів тваринних білків володіють високими показниками якості та відповідають вимогам нормативної документації

Ключові слова: водно-борошняні суспензії, бездріжджове тісто, «Скан-про Т-95», «Геліос-11», «Gitpro D», в'язкість

Исследовано влияние концентратов животных белков из колагенсодержащего сырья на вязкость водно-мучных суспензий и эффективную вязкость бездрожжевого теста. Установлено положительное влияние добавок на реологические свойства теста и муки. Доказано укрепляющее действие улучшителей на структуру полуфабриката. Мучные изделия с использованием концентратов животных белков обладают высокими показателями качества и отвечают требованиям нормативной документации

Ключевые слова: водно-мучные суспензии, бездрожжевое тесто, "Скан-про Т-95", "Гелиос-11", «Gitpro D», вязкость

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RESEARCH OF FUNCTIONAL ANIMAL PROTEINS INFLUENCE ON FOOD SYSTEMS' VISCOSITY

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1. Introduction

In the food industry unleavened dough is widely used for production of bread, pasta, doughnuts, molded products and many others. However, a recent study showed that bread and flour molded products with high nutritional value have the highest demand [1].

It is known that dough is a structured system, which is characterized by flexibility, elasticity, tenacity and viscosity. Dough has also thixotropic properties. These factors determine behavior of dough during its compilation and cause the volume and shape stability of products [2].

Purposeful influence on rheological properties of dough can increase efficiency of forming dough operations, to optimize the conditions of its occurrence, and comprehensively assess the structure of flour products [3, 4].

2. The analysis of recent research and publications

Rheological properties of dough depend on the process parameters and components of the recipe with a large extent. The addition of functional animal proteins (FAP) to weak flour improves flours' strength and quality of wheat bread. It is proved that products' formstability with weak flour increased from 0.20 to 0.38 (with FAP Helios-11) and 0.37 (with FAP Skanpro T-95) [5]. Also, previous studies have found positive effects of FAP on the structural and mechanical properties of flour dough for molded products. The addition of Skanpro T-95 in the amount of 1.5% improved straining shear of dough by 20%, thereby reinforcing its structure [6].

Therefore, we can claim that adding of FAP to flour in quantities of 1 - 2% by weight of flour significantly strengthens the structure of dough and finished products.

There is a possibility that this effect is similar to that of the famous bakery improvers.

We have previously investigated the impact of ozone-air mixture on the rheological properties of flour dough and bread [7] and established the high efficiency of ozone compared with others oxidative action improvers (including gases). The appropriateness regularity of effective viscosity changes of unleavened dough was studied [8] and the increase of this indicator of dough obtained from ozonized flour was proven.

3. Materials & methods

The aim of our study was to determine the appropriateness regularity of effective viscosity changes of unleavened dough from weak flour by adding FAP and in the enzymatic processes conditions. And also study of influence of FAP on flour-water suspension viscosity.

The objects of studies were: unleavened wheat dough with the addition of FAP (0, 1, 2% by weight of flour) with humidity about 56%, flour mixtures for molded product "Veselka" [9] with the addition of FAP (1.5% by weight of flour) and humidity about 12%.

The wheat premium flour with gluten content about 30% and FAP trademarks Skanpro T-95, Gitpro D and Helios-11 were used.

Research of effective viscosity of unleavened dough was conducted at a temperature of 18-20 °C on a rotary viscometer [10]. Viscometers can determine main rheological parameters of liquids - effective viscosity and its dependence on shear rate for samples that were investigated as non-Newtonian fluids.

Dependences of viscosity $\mu(\gamma)$ on the axes of double logarithmic coordinates $ln\ \mu(ln\ \gamma)$ have almost linear appearance. Therefore, the processing of the experimental data was conducted by Ostwald model approximation:

$$\tau = K \cdot \gamma^n \text{ та } \mu = \tau / \gamma = K \cdot \gamma^m, \quad (1)$$

where τ – straining shear, μ – effective viscosity, K – consistency parameter that numerically equal to viscosity at shear rate $\gamma = 1\ s^{-1}$, and the degree indices n and $m = n - 1$ determine inclination angles of rheogram curves $\tau(\gamma)$ and viscosity $\mu(\gamma)$ in double logarithmic coordinates. The value of consistency parameter K corresponds to the intersection of rheogram curves or viscosity with the ordinate axis (Fig. 1, 2) in these coordinates.

The viscosity of flour-water suspensions was studied by standard method on Amilograph test.

4. Results & discussion

The laboratory test results of bread baking products that contained FAP additives Helios and Skanpro showed that the most effective action of these additives by the formstability criterion of products was observed in the content of additives about 1...2% by weight of flour. The further increasing of additives content decreases specific volume of bread due to significant increase of viscosity

Therefore, on the first stage we investigated rheological properties of dough with addition of FAP. The content of additives ranged from 1 to 3%.

Dough viscosity measurements with FAP were conducted in direction of growth, and then in reverse - with decreasing shear rate. The results of measurements in the reverse direction gave lower values of viscosity, indicating presence of thixotropy in these samples of dough. The results of measurements of shear stress and effective viscosity of the samples are presented for reverse direction of shear rate changes, which is more accurate because of their greater uniformity for better mixing liquids (dough) during high speed rotation of the cylinder unit.

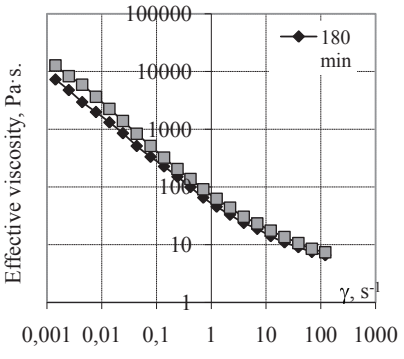

Fig. 1. Dependence of effective viscosity of dough samples with 2% Skanpro from the time of maturation and shear rate

On the next step effects of content and type of FAP on effective viscosity changes of dough samples after 180 minutes of maturation (Fig. 2) were researched.

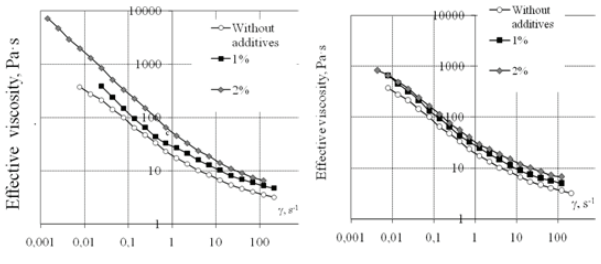

Fig. 2. Dependence of effective viscosity of the dough samples from shear rate after maturation in 180 min: a) with Scanpro, b) with Helios

Fig. 1 shows viscosity of dough sample (on the example of 2% Skanpro) after 20 minutes and 180 minutes of maturation. Viscosity of samples with FAP addition decreased after 180 minutes of dough maturation due to enzymatic processes complex.

When shear rate greater than $10 \cdot s^{-1}$, the beginning of outlet of dough's viscosity on constant values of ruined structure viscosity was observed (Fig. 2).

It was found that with increasing of additives content from 1 to 2% the increasing of dough's viscosity was observed. After dough maturation during 180 minutes (Fig. 2) the similar dependence of viscosity increasing of dough with Skanpro and Helios was found. Despite presented figures we made efforts to increase FAP content. In this case, significant increase of dough's rheological properties and, as

consequent, deterioration in quality of finished products was found.

Using the obtained results values of consistency parameter K and degreeal index m were calculated for all samples in shear rate 0.1 ... 10 s^{-1} (Table 1) and consistency parameters ratio α ($\alpha = K_{20} / K_{180}$).

Table 1

Rheological parameters of weak flour dough with the addition of FAP by Ostwald

Type of additive	Content of additive, %	Duration of dough maturation, min				α
		20		180		
		K_{20}	M_{20}	K_{180}	M_{180}	
Without additive	0	20,0	-0,494	19,6	-0,549	1,02
Scanpro	1	40,4	-0,560	30,2	-0,480	1,34
	2	74,7	-0,683	52,8	-0,661	1,41
Helios	1	33,7	-0,521	28,0	-0,524	1,20
	2	52,1	-0,556	35,0	-0,508	1,49

From Tab. 1 we can see that adding Scanpro to dough led to higher growth of consistency parameter and viscosity of dough than adding Helios. At the same time, the degreeal index m increases by module, indicating that dough becomes more non- Newtonian fluid, i.e. forces between macromolecules and particles in dough amplify [11]. We can attribute this effect with addition of protein, which contained in additive and which actively binds water molecules.

After 180 min maturation values of rheological parameters of dough slightly reduced. Parameter α indicated how many times viscosity reduced (consistency parameter) during maturation. These changes can be linked with proteolytic processes that take place in dough [12, 13]. The composition, additives' pH difference, flour composition, enzyme activity, etc. may contribute to this process.

The influence of FAP on viscosity of flour-water suspensions was conducted on Amilograph, as rheological properties of dough depend on gelatinization process of starch and enzymatic activity of raw flour to a large extent. Results of the experiment (Tab. 2) showed increase in the maximum viscosity of flour-water suspension and duration of gelatinization.

Table 2

The influence of FAP on viscosity of flour-water suspensions

Sample	Start temperature of gelatinization, °C	Finish temperature of gelatinization, °C	Viscosity maximum of flour-water suspensions, e.u.
Without additives	76	86,5	710
Helios	73	86,5	730
Scanpro	73	88	840
Gitpro D	75	90	800

It was found that flour-water gelatinization began a few minutes before when we add FAP, this process probably stems from the fact that proteins begin to swell at a slightly lower temperature than starch, so start of gelatinization moved. The reverse trend was observed in the end of gelatinization. It is noticeable that in the sample without additives, this indicator was lower than in samples with FAP. Therefore, it should be emphasized that addition of FAP promoted the stability of starch glue.

Based on the experimental data we can say about improving structural and mechanical properties of flour dough for molded products as increasing of flour-water suspensions' viscosity indicates strengthening of protein-polysaccharide interactions.

Data have been obtained during the study of rheological properties of colloidal solutions, dough and flour-water suspensions are in good agreement with each other and with the data of laboratory baking test and prove that excessive fortification of dough structure with increasing content of additives.

6. Conclusions

It was found that adding of FAP Skanpro and Helios to the weak wheat flour improves effective viscosity of dough and balance its structural and mechanical properties. Recommended content of additives is in the range of 1-2% by weight of flour. Bakery products, were made from this flour, have good organoleptic, structural and mechanical properties that meet the requirements of regulatory documents.

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