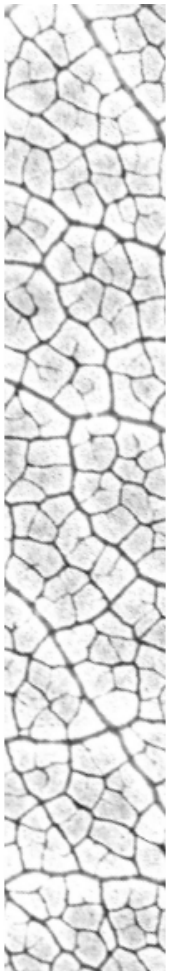

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Impact of baking properties of wheat flour on change the parameters of kneading and rheological characteristics of the dough

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Abstract
The most important task facing the baking industry is to ensure the production of high quality products and of diverse range.
Carrying out kneading has a great influence on the course of the technological process of preparation of wheat bread and its quality.
Kneading the dough is the most important initial stage of the production of wheat bread, which occurs, first, the formation of the dough as a single homogeneous system, and, secondly, giving this system certain rheological properties, ensuring the optimal flow of all technological processes in the next stages of production.

Keywords: farinograf E, strukturometr, wheaten flour, wheat bread

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INTRODUCTION

When assessing the quality of bakery products, the consumer pays special attention to the texture indicators. Considering the fact, that in the production of bakery products, wheat flour is the most unstable raw material, the production of finished products with a given texture can be achieved only by controlling the rheological properties of semi-finished products, taking into account the baking properties of raw materials and product formulations.

At the same time, we determined that the same consistency of the dough at the time of its readiness when mixing the quality of bakery products is different (Kihlberg et al. 2004, Maximov 2004, Puchkova 2004).

Therefore, it was assumed that the value of such a parameter as the value of the torque on the drive of kneading bodies can be used not only to determine the water absorption capacity of flour (ACF) and establish the optimal dosage of water when kneading the dough, but also to predict the quality of bakery products in conjunction with the measurement of the complex rheological characteristics of the test (Bucsella et al. 2016, Dobraszczyk and Morgenstern 2003), such as: effective viscosity, specific work (Oke et al. 2013), relaxation speed (Alekseev et al. 2012, Kuznetsov et al. 2005), etc.

Therefore, the aim of this work is to study the effect of baking properties of wheat flour on the change of mixing parameters and rheological characteristics of the dough after mixing.

MATERIALS AND METHODS

Research was carried out using the following three instruments for measuring the qualities of the wheat dough:

- the «Farinograf E » which determines the changes in the consistency of dough during kneading, setting the time it is ready for baking, and adjusting the amount of mechanical energy expended during tests (Maximov 2004, Puchkova 2004, Létang et al. 1999);
- the «Strukturometr ST-2M» which determines the complex rheology of the wheat dough after mixing;
- the discometer «Rheotest 2.1» which determines the effective viscosity of wheat dough after mixing (Maximov 2004).

RESULTS

The studies were carried out using two samples of wheat flour of the highest grade, the baking properties of which are shown in **Table 1**. The dough was prepared in a non-sourdough way according to the recipe of the “Rifled” loaf.

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Table 1. Quality indicators of wheat flour of the highest grade

Name of indicators	Value of indicators	
	Sample №1	Sample №2
Humidity, %	13.6	13.0
Acidity, degrees	2.5	2,6
The content of wet gluten, %	30	28
General deformation of gluten, IDK	63	53
Falling number, s	240	340

Table 2. Effect of baking properties of wheat flour on the change of the frequency of rotation of the kneading bodies

Sample of flour	Rotational speed *n*, rpm	Parameters at the moment of readiness			
		Kneading time, *τ,s*	Specific intensity, *Ysp*	Specific work, *Asp*	Number of deformation cycles, μ
1	60	180	0.213	37.70	180
	90	150	0.334	41.90	226
	120	130	0.368	44.90	260
	150	100	0.411	44.50	250
	180	90	0.484	47.30	270
	210	80	0.512	48.10	280
2	60	220	0.077	11.73	220
	90	215	0.088	14.21	230
	120	210	0.160	27.41	320
	150	170	0.218	32.60	325
	180	130	0.254	27.40	390
	210	120	0.313	36.97	490

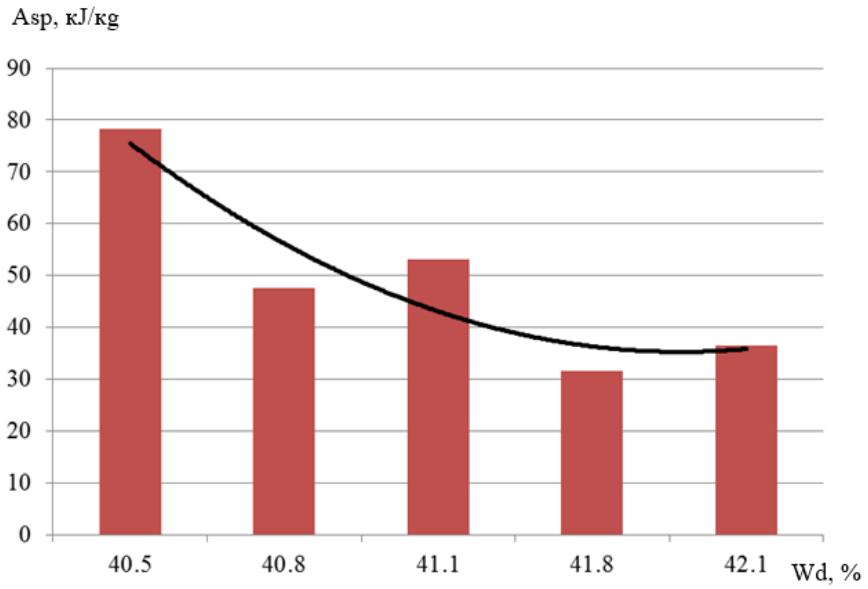

Fig. 1. The change of the specific work in kneading wheat dough with different moisture content

For each sample of flour, the optimal conditions for the behavior of the test were determined, i.e. the rotation frequency of the kneading bodies of the kneading machine, the optimal amount of water and the duration of kneading. At the same time, the rotation of the kneading bodies was changed in the range from 60 to 240 rpm with an interval of 30 rpm.

Influence of baking properties of wheat flour on change the parameters of kneading wheat dough are presented in **Table 2**.

It was determined that the speed of the kneading bodies of the kneading machine affects the change in torque and specific intensity. The degree of influence depends on the baking properties of wheat flour (Ivanoski et al. 2002).

Further, the effect of the consistency of the test on the specific work spent on the formation of the test was studied.

The diagram of the changes in the specific work when kneading dough with different humidity is presented on the **Fig. 1**.

Based on the conducted research (**Fig. 1**) it was determined that the increase in the moisture content of the dough from 40.5 % to 42.1 % led to a decrease in the amount of mechanical energy spent on the formation of the test structure to readiness, from 78.2 to 36.5 kJ/kg.

Further, study of the influence of changes in the rheological characteristics of wheat dough (wheat flour sample №1) depending on its consistency (Kosoy 2005), modeled by applying different amounts of water was conducted (**Table 3**).

Table 3. Changes in the rheological characteristics of wheat dough after kneading, depending on its consistency (or humidity)

Indicators	Values of indicators at different humidity of dough				
	40.5%	40.8%	41.3%	41.8%	42.1%
Consistency of dough, EF	740	690	640	590	540
The effective viscosity of the dough, Pa*s	1916	1429	1197	856	1024
Share a quick relaxation of the tension, K_1	0.53	0.48	0.56	0.60	0.58
Share of slow tension relaxation, K_2	0.27	0.28	0.24	0.22	0.23
Share of residual voltage, K_3	0.19	0.23	0.18	0.16	0.58
Instant strain relaxation speed λ_1, s^{-1}	0.479	0.525	0.571	0.663	0.636
Long-term strain relaxation speed λ_2, s^{-1}	0.033	0.034	0.036	0.040	0.038
Specific work Asp, kJ/kg	78.2	46.7	52.8	31.8	36.5

Table 4. Change in the unit rheological characteristics of wheat dough after kneading, depending on its consistency (or humidity)

Indicators	Values of indicators at different humidity of dough				
	40.5%	40.8%	41.3%	41.8%	42.1%
Consistency of dough, EF Farinograf	740	690	620	590	540
The effective viscosity of the dough, Pa*s	2013	1324	1068	746	1013
Share a quick relaxation of the tension, K_1	0.44	0.47	0.58	0.61	0.57
Share of slow tension relaxation, K_2	0.26	0.29	0.24	0.21	0.20
Share of residual voltage, K_3	0.19	0.23	0.18	0.17	0.59
Instant strain relaxation speed λ_1, s^{-1}	0.378	0.425	0.471	0.553	0.534
Long-term strain relaxation speed λ_2, s^{-1}	0.032	0.033	0.035	0.041	0.039
Specific work Asp, kJ/kg	73.0	45.7	51.7	32.4	35.2

Table 5. The influence of the consistency of the dough on the quality of the «Rifled» loaf

Consistency of dough, EF	Specific volume, cm^3/g		Porosity, %		Crumbness,%	
	№ 1	№ 2	№ 1	№ 2	№ 1	№ 2
540	3.20	3.00	79	68	10.5	10.0
590	3.60	3.50	81	70	10.8	10.2
620	3.75	3.60	82	80	5.0	5.4
690	4.10	4.00	81	78	9.6	9.0
740	4.20	4.30	80	76	9.0	8.5

Table 6. Influence of baking properties of wheat flour (sample number) on the change of the single rheological characteristics of wheat dough with the same consistency – 620 EF

Indicators	Samples of the wheat dough	
	sample №1	sample №2
Share a quick relaxation of the tension, K_1	0.570	0.490
Share of slow tension relaxation, K_2	0.250	0.250
Share of residual voltage, K_3	0.180	0.260
Instant strain relaxation speed $\lambda 1$, s^{-1}	0.571	1.162
Long-term strain relaxation speed $\lambda 2$, s^{-1}	0.036	0.058
The effective viscosity of the dough, Pa*s	1197	1907

Table 7. Influence of baking properties on rheological characteristics of bread crumb

Indicators	The value of rheological characteristics at different baking properties of flour	
	sample №1	sample №2
Long-term relaxation period λ, s	26.5472	28.1392
The dynamic viscosity η_1, Pa*s	0.57504	0.62222
The dynamic viscosity η_2, Pa*s	0.037669	0.035538
Elastic modulus E_1, Pa	5600	9971
Elastic modulus E_2, Pa	2594	5474
Elastic modulus E_3, Pa	8463	13922
Instantaneous velocity of stress relaxation λ_1, s^{-1}	9740	16025
The rate of long-term stress relaxation λ_2, s^{-1}	68876	154037
Elastic deformation h_{up}, mm	2.52	2.9
Plastic deformation h_{pl}, mm	2.94	2.54
Crumbliness, %	5.0	5.5
Sponginess, %	82	78

Changes in the single rheological characteristics of wheat dough (wheat flour sample №2), depending on its consistency, modeled by inputting the different amounts of water, are presented in **Table 4**.

After a trial laboratory baking it was confirmed the best quality indicators had bread with a consistency of 620 EF (**Table 5**).

Also, studies of the effect of baking properties of wheat flour (provided kneading dough with the same consistency) on the change of the rheological characteristics of the wheat dough (**Table 6**) and the quality of the «Rifled» loaf have been conducted (**Table 7**).

On the basis of the data obtained, it was found that the viscosity of the wheat dough is due to the gluten content and the value of the “number of drops”, i.e. the autolytic activity of flour.

Thus, it is determined that the baking properties of flour have the impact on such indicators as the duration of kneading the dough until ready; the amount of mechanical energy spent on the formation of the structure of the dough when kneading; on change the unit rheological characteristics of the wheat dough at the same consistency, as well as the quality of finished products.

With an optimal consistency of the dough crumbs of finished bakery products had the least crumbliness crumb, this confirms our assumption that the wheat dough with a consistency of 620 EF has the greatest gel-forming ability.

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