Original Article

Enrichment of Wheat Flour with Shorts at Flour-Milling Enterprises

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Abstract

The article covers the chemical composition of wheat shorts obtained from various milling systems, based on which it is concluded that it is expedient to use it for enriching wheat varietal flour. At present, the world is experiencing high growth rates of grain processing enterprises. Flourmills are considered one of the leading enterprises in the food industry. The most important task is to improve the quality of flour and increase its biological value. It is important that the volume of grain production, its quality depend on the agro-meteorological conditions of cultivation.

Keywords: Flour Milling, Flour Quality, Shorts, Composite Mixtures, Technological Properties of Grain, Properties of Dough, Gas Formation, Vitamins, Flour Minerals, Improvers.

INTRODUCTION

In order to staging the technological properties of flour and increase its biological value in flour milling, to add various additives, i.e. improvers to flour is practiced. Shorts obtained from various milling systems can also serve as such an additive. An analysis of the chemical composition of wheat shorts showed that it significantly exceeds varietal wheat flour in terms of the content of vitamins, minerals, and essential fatty acids.

The samples of shorts taken in the flow were mixed, sifted, and a fine fraction, characterized by an increased protein content, was separated using pneumatic separating. According to the organoleptic and physical-chemical parameters, the resulting product met the requirements for additives in the flour milling industry, namely, it was finely dispersed, light, free-flowing enough for accurate dosing and uniform distribution in flour.

MATERIALS AND METHODS

In order to determine the optimal ratio of flour and meal, composite mixtures (CM) were prepared, in which 3 (CM-1), 5 (CM-2) and 10% (CM-3) of the wheat flour of the first grade was replaced with shorts. The comparison sample was wheat flour of the first grade (K).

Technological properties of composite mixtures were studied based on the results of a series of laboratory baking [1; 3].

The research results are given in Table 1 and Fig.1.

An analysis of the indicators characterizing the properties of the dough showed that the process of gas formation in it in samples from blended flour mixtures was most intense in the initial period of fermentation (Fig. 1.).

Thus, after 69 minutes from the start of fermentation, the rate of gas formation reached 256, 2248 and 244 cm^3 CO_2/h for the CM-1 CM-2 and CM-3 respectively, then there was a decrease in the intensity of gas formation over the next 60 minutes and again an increase by the 120th minute from the start of fermentation to values, respectively, 214, 216 and 220 cm^3 CO_2/h. The total accumulation of carbon dioxide for three hours of dough fermentation was 694, 678 and 670 cm^3 for CM-1, CM-2 and CM-3 at a rate of its accumulation of 231, 226 and 223 cm^3 CO_2/h [2; 5].

The control sample also had two maximum peaks, but they were observed later than in the test samples with the use of shorts, on average, by 30 minutes. The total accumulation of carbon dioxide for 3 hours of dough fermentation was 636 cm^3 at an accumulation rate of 212 cm^3 CO_2/h.

Comparative assessment of the intensity of gas formation in the studied samples showed that with an increase in the percentage of shorts in the blended mixture, the rate of formation of carbon dioxide in the dough increases, that is, the fermentation activity of yeast is activated, which is explained by the different content of biologically active nutrients in the dough with shorts and without it. Acceleration of the process of gas formation when using composite mixtures with shorts will reduce the duration of maturation of the dough by 30 minutes.

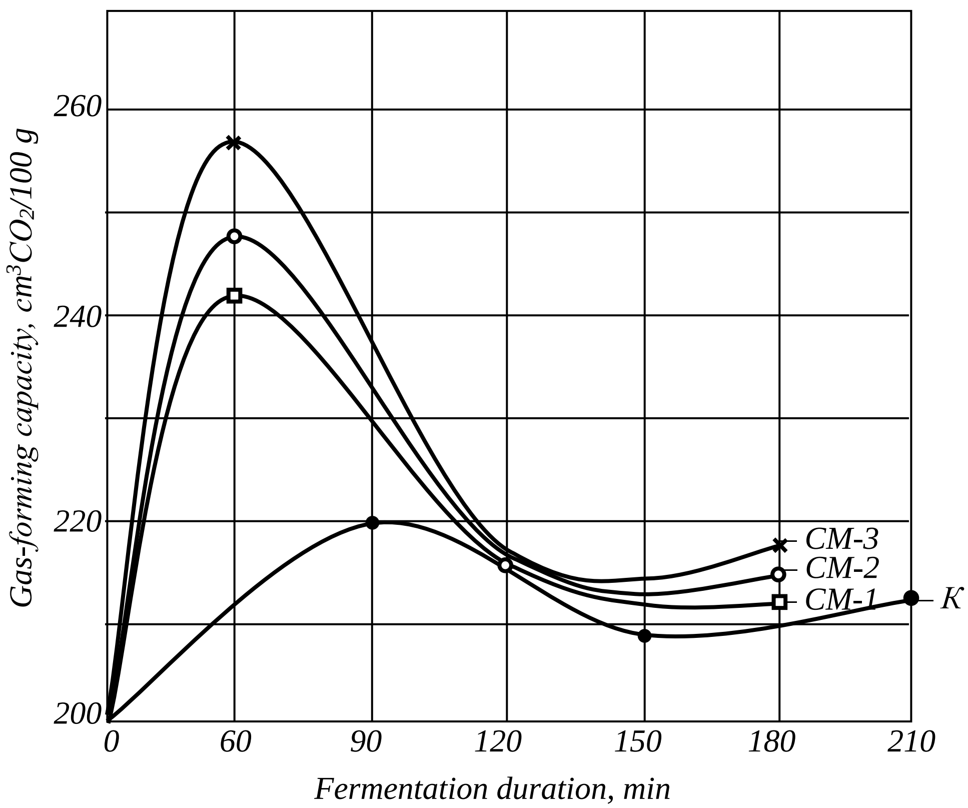

Fig.1. Influence of shorts dosage in a blended mixture on the gas-forming capacity of flour

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With an increase in shorts dosage in composite mixtures, the yield of crude gluten naturally decreased, respectively, by 2.2; 3.4 and 6.7% relative to the comparison sample and averaged 31.3; 30.9 and 29.84% with a control value of 32.0%. This is due to the low content of the gluten fraction in flour. Slight strengthening of gluten was also noticed, thus the value of the $H_{деф}^{ИДК}$ indicator decreased by 3-7 units of the IDK-1 (gluten strain gauge) device in the test samples relative to the control, as a result, the spreading of the dough in terms of H:D (the ratio of the height of the dough ball to its diameter) decreased from 0.40 in the control up to 0.45-0.48 in variants with flour [6; 7].

The change in the values of the lifting force of the test correlated with its gas-forming capacity. The best lifting force was in the sample with 10% shorts and was 19 min at 22 and 25 min in the variants with 5 and 3% flour and 28 min in the control.

The indicators given in Table.1 estimated the quality of finished products.

Table 1: Influence of different shorts dosages on the quality of bread

The name of indicators	The values of the quality indicators of bread prepared			
	without additives (control)	with the addition of shorts, % to the mass of the blend mixture		
		3 (CM-1)	5 (CM-2)	10 (CM-3)
Humidity, %	43.6	43.5	43.5	43.4
Acidity, degree	3.1	3.2	3.4	3.8
Porosity, %	72.2	70.8	68.4	60.0
Specific volume, cm^3/g	3.69	3.57	3.45	2.86
Organoleptic evaluation, score	86.7	82.2	71.4	54.6

From the data of Table 1 it follows that with an increase in the percentage of wheat shorts in the composite mixture, the values of porosity and specific volume of products decreased by 1.9-16.9% and 3.2-22.5%, respectively, relative to similar data in products from wheat flour of the 1st grade. When adding wheat shorts for 3% to the mass of the mixture, the bread had indicators that met the requirements of GOST 27669-88 for this type of product. Products practically did not differ from the control samples and were characterized by a smooth, rather intensely colored crust; tender, elastic crumb with a relatively uniform, thin- and medium-walled porosity structure; well baked, with a taste and smell characteristic of wheat bread [8; 9].

At the same time, samples with 5% shorts in the composite mixture had a rough surface, an insufficiently convex upper crust, a compacted crumb with a poorly developed porosity structure, baked, with a taste and aroma characteristic of wheat bread.

In the variant with 10% shorts in the blend mixture, the products had a flat upper crust, a dense, insufficiently baked crumb, a sour taste, and were characterized as products of “unsatisfactory” quality in terms of the sum of organoleptic indicators.

Because of the planning of experiments carried out according to the Box-Wilson time plan, a regression equation was obtained that adequately describes the dependence of the values of the specific volume of bread on the gluten content in the composite mixture and the moisture content of the dough, at which the criterion takes on the experimental values:

$$y = 294.9 + 15.38\, x_1 + 4.20\, x_2 + 8.52\, x_3 + 2.20\, x_1x_2 + 0.51\, x_1x_3 - 5.40\, x_2x_3$$

The adequacy of the obtained mathematical regression model was evaluated by Fisher's criterion $K_{f.tab}$=3.50. Considering that $K_{f.exp} < K_{f.tab}$, the model of the indicator for the volume of bread made from various composite mixtures can be considered adequate with a 95% confidence level. This means that the levels of variation of the input factors in the planning of experiments were taken quite correctly.

FFE plan 2^3 allows calculating 8 (No. 8) coefficients of the regression equation

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3 + b_{123}\, x_1x_2x_3 \qquad (1)$$

We calculate the coefficients of the process equation according to the results of the implementation of the FFE plan 2^3 presented in Table 2.

Table 2: Results of FFE plan 2^3 realization

U	Main columns			Auxiliary columns				Specific volume of bread, cm³/100g			
	x_{1u}	x_{2u}	x_{3u}	$x_{1u}x_{2u}$	$x_{2u}x_{3u}$	$x_{1u}x_{3u}$	$x_{1u}x_{2u}x_{3u}$	y_{1u}	y_{2u}	y_{3u}	$\bar{y}_u u$
1	-	-	-	+	+	+	-	275	270	270	271.7
2	-	+	-	-	-	+	+	280	278	285	281.0
3	+	-	-	-	+	-	+	285	290	288	287.7
4	+	+	-	+	-	-	-	300	305	310	305.0
5	-	-	+	+	-	-	+	284	280	286	283.3
6	-	+	+	-	+	-	-	280	282	284	282.0
7	+	-	+	-	-	+	-	320	318	322	320.0
8	+	+	+	+	+	+	+	328	325	332	328.3
Cp	0	0	0	0	0	0	0	294.0	293.5	297.1	294.9
C_i	C_{10}	C_{20}	C_{30}								
λ_i	λ_1	λ_2	λ_3								

Notes:

X_1 is mass fraction of gluten in flour (*25.6 – 32.0* %), %;

X_2 is mass fraction of gluten in shorts (*8.2 – 10.4* %), %;

X_3 is humidity of the dough (40 – 45 %), %;

y is specific volume of bread, cm³/100g.

Calculation of coefficients of the regression equation

$$b_o = \frac{\sum_{u=1}^{N} y_u}{N} = \frac{271{,}7 + 281{,}0 + 287{,}7 + 305{,}0 + 283{,}3 + 282{,}0 + 320{,}0 + 328{,}3}{8} = 294{,}9$$

$$b_1 = \frac{\sum_{u=1}^{N} x_{1u} y_u}{N} = \frac{-271{,}7 - 281{,}0 + 287{,}7 + 305{,}0 - 283{,}3 - 282{,}0 + 320{,}0 + 328{,}3}{8} = 15{,}38$$

$$b_2 = \frac{\sum_{u=1}^{N} x_{2u} y_u}{N} = \frac{-271{,}7 + 281{,}0 - 287{,}7 + 305{,}0 - 283{,}3 + 282{,}0 - 320{,}0 + 328{,}3}{8} = 4{,}20$$

$$b_3 = \frac{\sum_{u=1}^{N} x_{3u} y_u}{N} = \frac{-271{,}7 - 281{,}0 - 287{,}7 - 305{,}0 + 283{,}3 + 282{,}0 + 320{,}0 + 328{,}3}{8} = 8{,}52$$

$$b_{12} = \frac{\sum_{u=1}^{N} x_{1u} x_{2u} y_u}{N} = \frac{271{,}7 - 281{,}0 - 287{,}7 + 305{,}0 + 283{,}3 - 282{,}0 - 320{,}0 + 328{,}3}{8} = 2{,}20$$

$$b_{13} = \frac{\sum_{u=1}^{N} x_{1u} x_{3u} y_u}{N} = \frac{271{,}7 + 281{,}0 - 287{,}7 - 305{,}0 - 283{,}3 - 282{,}0 + 320{,}0 + 328{,}3}{8} = 0{,}54$$

$$b_{23} = \frac{\sum_{u=1}^{N} x_{2u} x_{3u} y_u}{N} = \frac{271{,}7 - 281{,}0 + 287{,}7 - 305{,}0 - 283{,}3 + 282{,}0 - 320{,}0 + 328{,}3}{8} = -5{,}40$$

$$b_{123} = \frac{\sum_{u=1}^{N} x_{1u} x_{2u} x_{3u} y_u}{N} = \frac{-271{,}7 + 281{,}0 + 287{,}7 - 305{,}0 + 283{,}3 - 282{,}0 - 320{,}0 + 328{,}3}{8} = 0{,}20$$

Therefore, the equation will be:

$$y = 294.9 + 15.38\, x_1 + 4.20\, x_2 + 8.52\, x_3 + 2.20\, x_1x_2 + 0.54\, x_1x_3 - 5.40\, x_2x_3 + 0.20\, x_1x_2x_3$$

Discussion

Because of the research of the effect of wheat shorts, depending on the method of dough preparation, on the quality of bread from wheat flour of the 1st grade, it was established that it is most expedient to use this product when preparing the dough in a leaven method and add shorts directly to the leaven. In this case, the shorts dosage should not exceed 5% of the prescription amount of flour. The optimal dosage of shorts is 3% to the prescription amount of flour. Non-leaven and leaven methods of dough preparation and the addition of shorts directly at the stage of dough preparation are less effective. Increasing the dosage of shorts by more than 5% of the prescription amount of flour is not advisable due to the production of "unsatisfactory" quality products.

Application of wheat shorts in activating pressed and dried yeast is very effective. At the same time, positive effects were obtained by replacing wheat flour of the second grade, used as a nutrient substrate for yeast, in an amount of up to 10% by weight of the flour.

Conclusion

1. Based on comprehensive research, the prospects for the use of wheat shorts for the enrichment of wheat varietal flour have been established. It has been shown that shorts used in research has a higher biological value compared to grade I wheat flour and is safe from a biomedical point of view. The content of protein and fat in shorts is 1.3 and 6.2 times higher, respectively, than in wheat flour of the 1st grade. The fiber content in shorts is 26 times higher. The mineral composition of shorts is characterized by higher content of calcium, potassium, magnesium and iron; vitamins B_1 and B_2; essential fatty acids.
2. Optimized composition of the composite mixture of wheat flour of the 1st grade and shorts that is 97:3 has been established.
3. Organoleptic and chemical indicators of the quality of shorts obtained from various milling systems have been studied. It has been established that the closest in organoleptic characteristics to wheat flour is varietal shorts, obtained on an aspiration system.
4. Measures for separating the high-protein fraction of the shorts have been substantiated.

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