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Study of the possibility of energy saving in bakery production technology based on the optimization of the dough-making process

Elena Belokurova [*] , *Martin* Sargsyan, *Nikita* Sotnikov

Voronezh State University of Engineering Technologies, Revolyutsii Ave., 19, Voronezh, Russia

Abstract. This article considers the possibility of replacing part of the wheat flour with cereals made of buckwheat, rice and millet. The proposed solution will reduce the technological cycle of production of bakery products, which will reduce energy costs. On the other hand, the enterprises of the food industry will be able to reduce production residues and educate the consumer in the culture of rational nutrition. The authors considered the change in physical and chemical parameters of dough in the process of fermentation, proposed ways to optimize dough management.

1 Introduction

As you know, in the daily diet of proper nutrition must be present cereals, because they make it balanced, nourishing and full. After all they contain a lot of vitamins and trace elements important for normal development of the human body. At the same time, cereals of various kinds are not a daily component in the diet of Russian residents, which leads to an excessive consumption of fats, proteins, simple carbohydrates and a critical lack of complex carbohydrates and minerals [1, 2, 4]. One way to solve this problem could be to offer porridges made of different types of cereals for breakfast at catering enterprises, thereby fostering a culture of rational nutrition among consumers. Obviously, for a long time, catering enterprises will accumulate residues of unsold cereal dishes, which will have a negative impact on the profitability of these enterprises. Therefore, this paper proposes to use the unsold remnants of cereal dishes (porridge) in the production of bakery products at the same catering enterprise. In turn, bakery products are one of the favorite and preferred snacks of consumers [3, 5, 6, 7]. The proposed solution will not only enrich the flour products, but also reduce the technological cycle of their production, thereby reducing energy costs in their production, as well as the use of residues from unreleased products for the day.

2 Materials and methods

In this study we considered porridges of three types of cereals: buckwheat, rice and millet, the choice of these types in the manufacture of bakery products associated with the features

[*] Corresponding author: zvezdamal@mail.ru

of the chemical composition of the formulated components and their impact on the human body.

The chemical composition of buckwheat, rice and millet porridge is presented in tables 1 - 3.

Table 1. Chemical composition of buckwheat porridge.

Component name	Contents, in units.
Dietary fiber	11,3%
Saturated fatty acids	0,6%
Unsaturated fatty acids	2,28%
Vitamins, mg:	
Beta Carotene	0,01
Vitamin E	6,65
Vitamin A (RE), μg	2
Vitamin B1 (thiamine)	0,43
Vitamin B2 (riboflavin)	0,2
Vitamin B6 (pyridoxine)	0,4
Vitamin B9 (folic acid), μg	32
Vitamin PP (Niacin equivalent)	9,2
Minerals, mg:	
Calcium	20
Magnesium	200
Potassium	380
Phosphorus	298
Chlorine	33
Sulfur	88
Iron	6,7
Selenium	8,3
Silicon	81

Table 2. Chemical composition of rice cereal porridge.

Component name	Contents, in units.
Dietary fiber	9,7%
Saturated fatty acids	0,4%
Unsaturated fatty acids	1,9%
Vitamins, mg:	
Vitamin E	0,8
Vitamin B1 (thiamine)	0,34
Vitamin B2 (riboflavin)	0,08
Vitamin B6 (pyridoxine)	0,54
Vitamin B9 (folic acid), μg	35
Vitamin PP (Niacin equivalent)	8,1
Minerals, mg:	
Calcium	40
Magnesium	116
Sodium	30
Potassium	314
Phosphorus	328
Chlorine	133
Sulfur	60
Silicon	1240

Table 3. Chemical composition of millet porridge.

Component name	Contents, in units.
Dietary fiber	3,6%
Saturated fatty acids	0,3%
Unsaturated fatty acids	2,4%
Vitamins, mg:	
Vitamin E	2,6
Vitamin B1 (thiamine)	0,42
Vitamin B2 (riboflavin)	0,04
Vitamin B6 (pyridoxine)	0,52
Vitamin B9 (folic acid), µg	40
Vitamin PP (Niacin equivalent)	5,2
Minerals, mg:	
Calcium	27
Magnesium	83
Sodium	10
Potassium	211
Phosphorus	233
Chlorine	24
Sulfur	77
Iron	2,7
Zinc	1,7

The data in Tables 1-3 show what substances are additionally introduced into the recipe for cereal porridge of different types of cereals, replacing part of the wheat flour of the highest grade, which is a refined and rather "poor" product in terms of rational nutrition.

3 Results and discussion

For the preparation of wheat dough as the basis we chose the classic recipe for muffin buns, and to develop new recipes for buns used buckwheat, rice and millet cereals in the amount of 10, 15, 20, 25, 30, 35 and 40% to replace part of the flour in the recipe.

To assess the feasibility of using buckwheat, rice, and millet cereal porridges, studies were conducted on the physical and chemical parameters of wheat dough. The results of measuring the acidity of wheat dough during fermentation are presented in Table 4-6.

Table 4. Changes in the acidity of wheat dough with the addition of buckwheat gruel during fermentation.

Duration fermentation (min)	Sourness of wheat dough, deg							
	Control	Amount of additive (%)						
		10	15	20	25	30	35	40
1	2	3	4	5	6	7	8	9
0	2,8	2,8	2,8	3,0	3,0	3,0	2,8	2,8
30	3,0	3,2	3,2	3,4	3,4	3,4	3,0	3,0
60	3,2	3,6	3,6	3,8	3,8	3,8	3,6	3,4
90	3,4	3,8	3,8	4,0	4,0	4,0	3,8	3,6
120	3,6	4,0	4,0	4,2	4,2	4,2	4,0	4,0
150	3,8	4,2	4,2	4,4	4,6	4,6	4,2	4,0
180	4,2	4,6	4,6	4,6	4,8	4,6	4,4	4,2

In terms of dough acidity, compared with the control, the addition of buckwheat gruel in the dosage of 10, 15, 20 and 30% increased the final acidity of the dough by 9.5%, in the dosage of 25% increased by 14.3%, in the dosage of 35% increased by 4.8%, in the dosage of 40% is not inferior to the control.

Table 5. Changes in the acidity of wheat dough with the addition of rice cereal porridge during fermentation.

Duration fermentation (min)	Control	Amount of additive (%)						
		10	15	20	25	30	35	40
0	2,8	2,8	3,0	3,0	3,2	3,0	2,8	2,8
30	3,0	3,2	3,6	3,4	3,6	3,6	3,0	3,0
60	3,2	3,6	3,8	4,0	4,0	3,8	3,2	3,4
90	3,4	3,8	4,0	4,2	4,2	4,0	3,6	3,8
120	3,6	4,0	4,2	4,4	4,4	4,2	4,0	4,2
150	3,8	4,2	4,2	4,6	4,6	4,4	4,0	4,4
180	4,2	4,4	4,4	4,6	4,8	4,6	4,4	4,4

In terms of dough acidity, compared with the control, the addition of rice cereal porridge at dosages of 10, 15, 35 and 40% increased the final acidity of the dough by 4.8%, at dosages of 20 and 30% increased by 9.5%, at dosage of 25% increased by 14.3%.

Table 6: Changes in the acidity of wheat dough with the addition of millet gruel during fermentation.

Duration fermentation (min)	Control	Amount of additive (%)						
		10	15	20	25	30	35	40
0	2,8	2,8	2,8	3,0	3,2	3,0	2,8	2,0
30	3,0	2,8	3,0	3,2	3,4	3,2	3,0	2,6
60	3,2	3,0	3,4	3,6	3,6	3,6	3,4	3,0
90	3,4	3,2	3,6	3,8	3,8	4,0	3,8	3,4
120	3,6	3,4	3,6	4,2	4,2	4,4	4,0	3,6
150	3,8	3,6	3,8	4,4	4,6	4,4	4,2	3,8
180	4,2	3,8	4,2	4,6	4,8	4,6	4,4	3,9

In terms of acidity of the dough compared to the control, the addition of porridge from millet groats at a dose of 10% decreased the final acidity of the dough by 10.5%, at dosages of 15 and 40% is not inferior to the control, at dosages of 20 and 30% increased by 9.5%, at dosages 25 and 35% increased by 14.3 and 4.8% respectively.

The increase in the acidity of the dough during fermentation indicates an increase in the rate of acid accumulation and the possibility of reducing the technological cycle, which leads to energy savings in the production process of bakery products and the possibility of using production residues.

In the process of fermentation dough also measured its gas retention capacity, a characteristic of the ability of the dough to retain released carbon dioxide, which provides a good porosity of the finished product.

Plots of dependence of gas retention capacity (GHC) of wheat dough during fermentation on the amount of added additive - buckwheat, rice and millet cereals, are shown in Figures 1-3.

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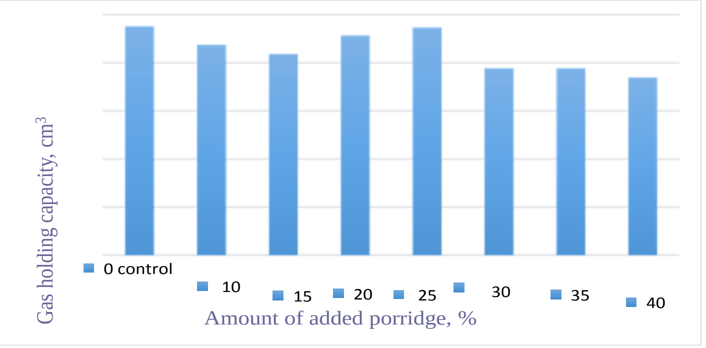

Fig. 1. Dependence of gas retention capacity of wheat dough on the amount of buckwheat porridge added.

In terms of GHC test compared to control, the addition of buckwheat gruel at doses of 10, 15, 20, 30, 35 and 40% reduced the GHC test by 9.2, 14.4, 4.4, 22.7, 22.7 and 28.7% respectively, at doses of 25% was not inferior to control.

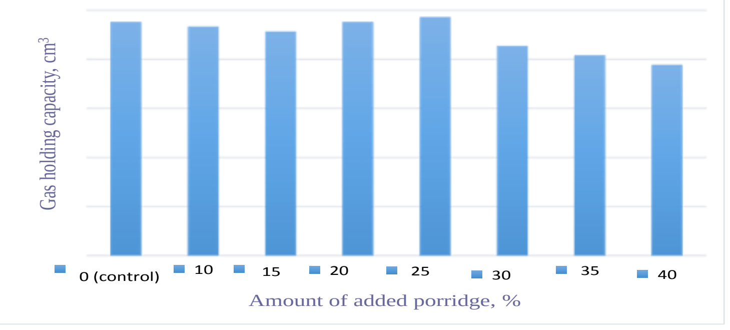

Fig. 2. Dependence of gas retention capacity of wheat dough on the amount of rice gruel added.

In the GHC test compared to control, the addition of rice cereal porridge at doses of 10 and 15% decreased GHC by 2.2 and 4.4%, respectively, the 20% dose was not inferior to control, the 25% dose increased by 2.1%, the 30, 35 and 40% doses decreased by 11.5, 16.7 and 22.4%, respectively.

The GUS indicator of the dough in comparison with the control when adding millet groats at the dosages of 10, 15, 20 and 25% increased by 10.2, 10.2, 12.3 and 16%, respectively; at dosages of 30, 35 and 40% it decreased by 8.9, 13.9 and 16.6%, respectively.

In this work, the construction of a regression model, based on the data obtained, was carried out using the "Data Analysis" add-on in MSExcel. Two variants of polynomial structure model for physico-chemical parameters of dough - acidity and gas retention capacity - were considered. The use of this toolkit made it possible to optimize the technological process of bakery products production with the introduction of cereals of different types of cereals.

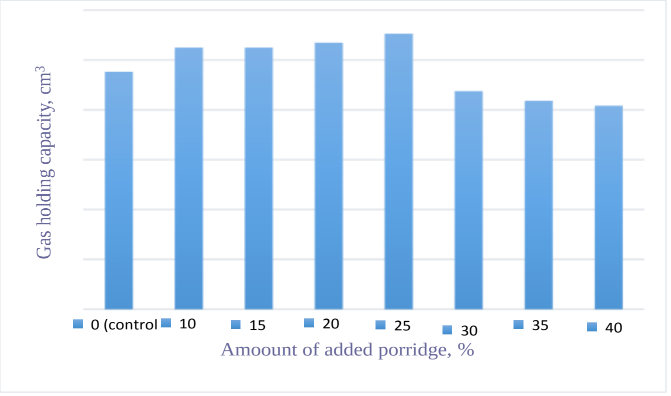

Fig. 3. Diagram of the gas retention capacity of wheat dough depending on the amount of wheat gruel added.

4 Conclusions

We can draw conclusions from the data obtained:

- The addition of buckwheat, rice and millet cereals can enrich the bakery products with trace elements, vitamins and dietary fiber.
- The proposed technology makes it possible to reduce the technological cycle, which will lead to energy savings in the production process of bakery products.
- This solution allows to educate consumers in the culture of rational food, and the enterprises of the food industry to reduce production residues.

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