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Effect of long, low-temperature fermentation on properties of dough and quality of rich bakery products made from wheat flour

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Abstract. The paper reports the findings obtained in the study of the effect of long, low-temperature fermentation on properties of dough and quality of rich bakery products made from wheat flour. This technological solution is one of the promising and generally accepted approaches used for production of bakery products in many countries. The study objects were samples of semi-finished bakery products and rich bakery products with a sugar and fat content of 17% by flour weight made in accordance with the baking formula. We studied the effect of long fermentation of dough for 8, 16, 24, and 48 h at low temperatures of +5, +10, +15 °C on the moisture content, acidity, shape stability and the duration of its proofing, and on acidity, the moisture content, porosity, shape stability, the content of aromatic substances and the mass fraction of sugar, as well as on the organoleptic quality indicators of bakery products. During fermentation, the acidity of dough pieces increased under all temperature conditions. The moisture content in all the dough samples was similar in value to that in the control and ranged from 40.2 to 40.8%. The shape stability of all dough pieces decreased during fermentation at temperatures of +5, +10, and +15 °C. The porosity and shape stability of rich bakery products were less compared to the control. The moisture content in all rich bakery products was similar in value to that in the control and ranged from 39.2 to 39.8%. The mass fraction of sugar in the test samples of rich bakery products was found to decrease during dough fermentation for 8 to 48 h under all temperature conditions. The maximum decrease in the sugar mass fraction was revealed in products made from dough fermented for 16, 24 and 48 h at +15 °C; it amounted to 2.5, 2 and 1.1% in terms of dry matter, respectively, which was 35.9–71.8% less compared to that in the control. The study showed the optimal duration of fermentation for sweet dough, which attained 8 and 16 h at +5 and +10 °C, and 8 h at +15 ºC.

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1 Introduction

At present, bakery intensively employs refrigeration technologies [1, 2, 3] to optimize the operating mode of the plant bakery (reduce working hours, timely respond to market needs) and significantly expand the range of products [4]. These technologies imply an increased time of dough fermentation due to decreased temperature, which imparts a pronounced taste and flavor to bread due to the colloidal processes occurring in the dough [5, 6].

The population tends to purchase fresh bakery products, which increased the share of products sold through the retail network of supermarkets and shops owned by plant bakeries, where products are baked from cooled semi-finished products.

The long, low-temperature fermentation technology implies the time of dough fermentation increased by 10–36 h at low temperatures. Semi-finished products slowly rise to the required degree of ripeness within this time due to the decreased temperature varying from + 28–30 °C to 0–5 °C. The low-temperature fermentation technologies of compelling interest are currently as follows: preparing cooled dough for shaping; preparing cooled shaped dough pieces for proofing [7].

At present, the optimal technological parameters for dough making (temperature and duration of fermentation) have not been determined [8, 9], and their effect on the properties of semi-finished products and the quality of the finished rich bakery products was not assessed.

The aim of the study was to analyze the effect of long, low-temperature fermentation on the properties of dough and the quality of rich bakery products made from wheat flour.

2 Materials and methods

The raw materials used in the study were as follows: wheat flour of the highest grade – in compliance with GOST 26574; baker's pressed yeast – in compliance with TU 9182-038-48975583; table salt – in compliance with GOST R 51574; white sugar – in compliance with GOST 33222; table margarine with a fat content of not less than 82% – in compliance with GOST 32188; drinking water – in compliance with SanPiN 2.1.3684.

The study objects were samples of semi-finished bakery products and rich bakery products with a sugar and fat content of 17% by flour weight made in accordance with the baking formula.

Dough pieces were analyzed for moisture by drying the sample, for acidity through sodium hydroxide titration of all acid-reactive substances of the semi-finished product, and for shape stability calculated as the height-to-diameter ratio [10, 11].

The procedure for making test dough samples was as follows: the raw materials taken in accordance with the baking formula were mixed in a dough mixer for 5–10 min until a homogeneous mass; then the dough was cut into pieces weighing 0.25 kg each and placed on sheets. After shaping, the dough pieces were placed in a MIWE GVAS fully automatic proofer cabinet for fermentation for 8, 16, 24, and 48 h at +5, +10, and +15 °C. At the end of fermentation at each of the specified temperatures, the dough pieces were, if needed, placed for proofing in a proofing chamber at temperatures of +30–32 °C and relative air humidity of 75–80%. The proven dough pieces were baked in a MIWE FBC laboratory electric oven for 19 min at 170–180 °C.

Dough prepared by straight-dough method with a fermentation time of 180 min at +30–32 °C was used as the control. The fermented dough was cut into pieces weighing 0.25 kg each and manually shaped. The shaped dough pieces were placed on baking sheets for final proofing at +30–32°C and relative air humidity of 75–80%. Readiness of dough pieces for baking was evaluated organoleptically. The proven dough pieces were baked in a MIWE FBC laboratory electric oven for 19 min at 170–180 °C.

The quality of rich bakery products was analyzed 14–16 h after baking with regard to organoleptic quality indicators in compliance with GOST 5667, physical and chemical indicators: crumb acidity (GOST 5670); crumb moisture (GOST 21094); crumb porosity (GOST 5669); shape stability (GOST 27669); sugar mass fraction (GOST 5672). The aromatic content was determined by measuring the amount of bisulfite binding compounds (binding of aldehydes and ketones with sodium bisulfite).

3 Results and discussion

The baking wheat flour used in the study was of the highest grade and in terms of its physicochemical and organoleptic quality indicators it met the requirements of GOST 26574 Baking wheat flour. Specifications. Rheological characteristics of the dough made from the test flour recorded by the Alveograph device indicated high elasticity and insufficient extensibility of the test flour with respect to the P/L ratio, which attained 1.68. The gas production value of the flour recorded by the rheofermentometer, was 1663 ml, which indicates its high baking properties.

To analyze the effect of long, low-temperature fermentation of dough on properties of dough, its acidity and moisture content, shape stability of dough pieces, and the duration of their proofing were assessed.

The acidity (Figure 1) of the dough pieces increased during fermentation under all temperature conditions, which was related to the formation and accumulation of a number of organic acids (lactic, acetic, succinic, malic, etc.).

The acidity value of the dough pieces at 5 and 10 °C, with allowance for the experimental error, was similar to that in the control, and ranged from 2.2 to 3.0 deg. The acidity of the test dough pieces after 48-hour fermentation at +15 °C was higher by 81.8% compared to the control.

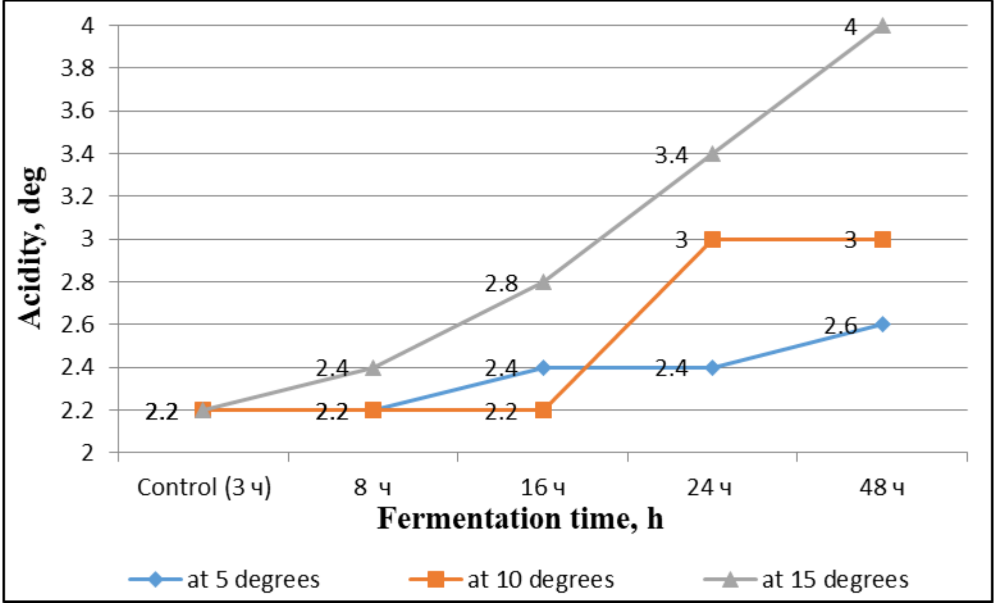

Fig. 1. Graphs of changes in the acidity of dough pieces with a sugar and fat content of 17% during long fermentation at different temperatures

The moisture content in all dough pieces was similar in value to that in the control and varied from 40.2 to 40.8%.

It was found that the shape stability of dough pieces during fermentation decreased within the whole temperature range (Table 1).

Table 1. Effect of the duration of sweet dough fermentation (8, 16, 24, 48 h) at low temperatures (+5, +10, +15 °C) on the shape stability and proofing time of dough pieces

Indicators			Quality indicators		
			Shape stability of dough pieces after cutting	**Shape stability of dough pieces after proofing**	**Proofing time for dough pieces, min**
Control (3 h)			0.5±0.04	0.4±0.04	45
Dough fermentation temperature	5 °C for	8 h	0.5±0.04	0.5±0.04	30
		16 h	0.5±0.04	0.5±0.04	-
		24 h	0.5±0.04	0.4±0.04	-
		48 h	0.5±0.04	0.3±0.04	-
	10 °C for	8 h	0.5±0.04	0.5±0.04	-
		16 h	0.5±0.04	0.4±0.04	-
		24 h	0.5±0.04	0.2±0.04	-
		48 h	0.5±0.04	0.2±0.04	-
	15 °C for	8 h	0.5±0.04	0.4±0.04	-
		16 h	0.5±0.04	0.3±0.04	-
		24 h	0.5±0.04	0.2±0.04	-
		48 h	0.5±0.04	0.2±0.04	-

Proofing of dough pieces was required only after 8-hour fermentation at +5 °C; the rest of the samples were not proved due to spreading of dough, and dough pieces were immediately sent for baking. The optimal time of dough fermentation at +15 °C was found to range within 6–8 h.

After baking, we assessed physical and chemical properties (acidity, moisture content, porosity, shape stability, aromatic content and sugar mass fraction), and organoleptic quality indicators of the bakery products.

The acidity of bakery products grew at increased duration of fermentation, but it remained similar in value to that in the control and amounted to 2.0–2.4 deg. The moisture content in all bakery products was similar in value to that in the control and varied from 39.2 to 39.8%. The porosity of bakery products made from dough fermented for 8–48 h at +5, +10 and +15 °C was lower by 10.8–16.9%, 8.4–15.7%, and 7.2–9.6%, respectively, compared to the control. The minimum shape stability was found for bakery products made from dough fermented for 16, 24, and 48 h at +15 °C. For other samples, this indicator was similar in value to the shape stability in the control and attained 0.4–0.5.

The results in Figure 2 indicate the decreased mass fraction of sugar in bakery products during dough fermentation for 8–48 h under all temperature conditions. At the same time, the mass fraction of sugar in products made from dough fermented for 8, 16, 24, and 48 h at +5 °C was 20–92% higher compared to the control, which is due to long fermentation with subsequent sugar formation and decreased activity of yeast cells. The decreased mass fraction of sugar was recorded for bakery products made from dough fermented for 24 and 48 h at +10 ºC.

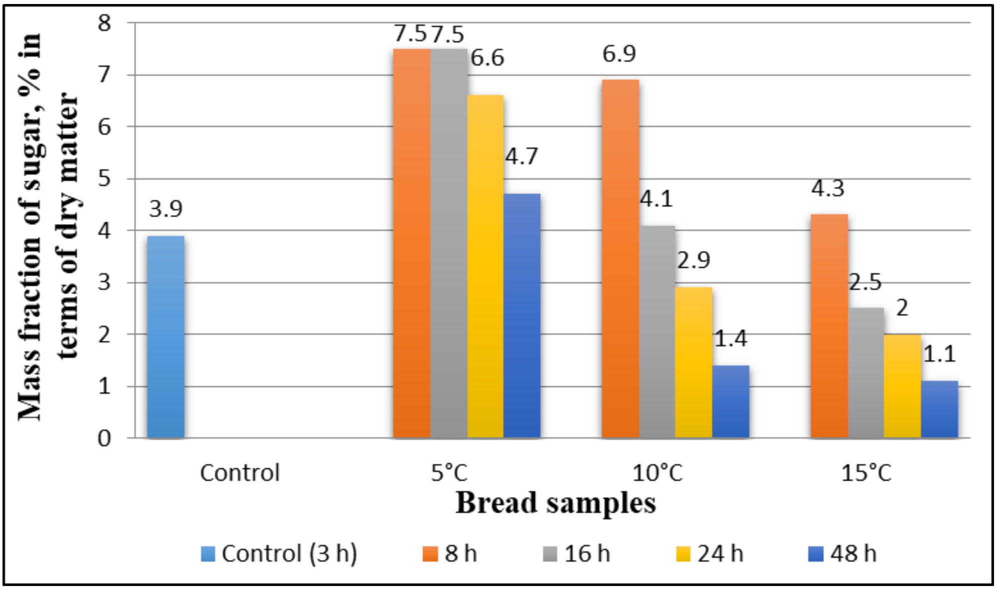

Fig. 2. Effect of long, low-temperature fermentation (8, 16, 24, and 48 h) of dough with sugar and fat content of 17% at +5, +10, and +15 °C on the sugar mass fraction in bakery products

The mass fraction of sugar was found to significantly decrease in products made from dough fermented for 16, 24, and 48 h at +15 °C; it was 2.5, 2.0, and 1.1% in terms of dry matter, respectively, which was 35.9–71.8% lower compared to the control. This is due to the duration of dough fermentation that decreased the amount of fermentable sugar. In this case, the mass fraction of sugar in bakery products made from dough fermented for 8 h remained similar in value to that in the control.

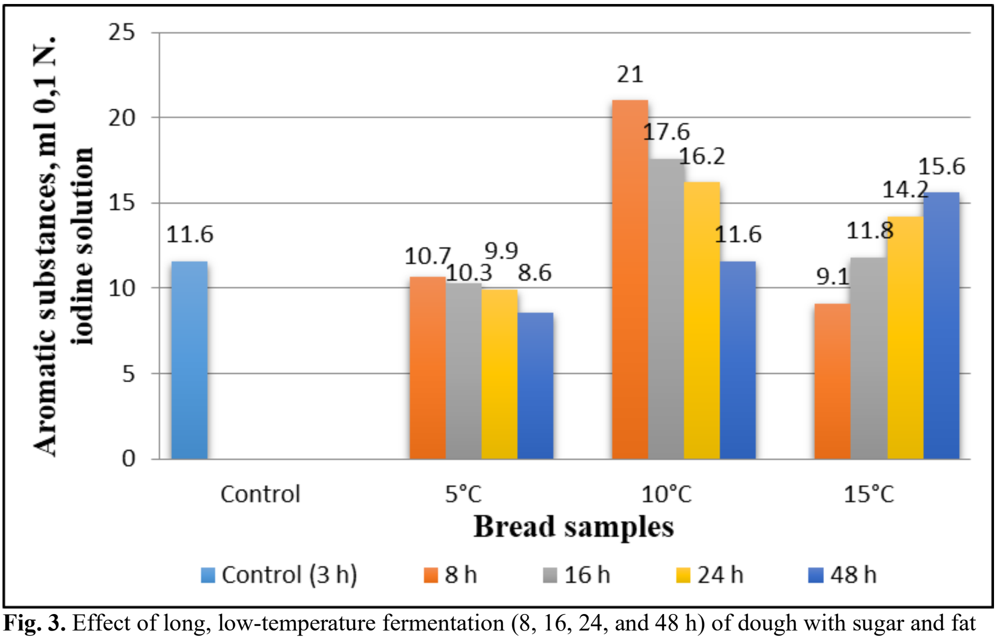

Fig. 3. Effect of long, low-temperature fermentation (8, 16, 24, and 48 h) of dough with sugar and fat content of 17% at +5, +10, and +15 ºC on the content of aromatic substances in bakery products

Substances that impart taste and flavor to bread start to form during dough making and proofing of dough pieces. At these technological stages, alcoholic and lactic acid fermentation occurring in semi-finished dough pieces yields final, intermediate and by-products, as well as products of their interaction (alcohols, organic acids, esters, carbonyl compounds). In this case, biochemical processes occurring during baking are of paramount importance for flavor formation in bread.

The results in Figure 3 show that the content of aromatic substances decreases during fermentation at +5 and +10 °C. The content of aromatic substances in bakery products made from dough fermented for 8, 16, 24, and 48 h at +5 °C was 7.7–25.9% lower compared to that in the control. This is due to rather low fermentation temperatures that hinder formation of reducing sugars and substances such as alcohol, organic acids, esters, and carbonyl compounds responsible for taste and flavor in finished products. The content of aromatic substances in bakery products made from dough fermented for 8, 16, and 24 h at +10 °C was 39–81% higher compared to the control. During 48-hour fermentation, the content of aromatic substances remained similar in value to that in the control and amounted to 11.6 ml. The highest content of aromatic substances was found for bakery products made from dough fermented for 48 h at +15 °C, and it amounted to 15.6 ml of 0.1 N. iodine solution, which is 25.6% higher than that in the control.

Figure 4 illustrates samples of bread made from dough fermented for 8–48 h at +5, +10, and +15 °C.

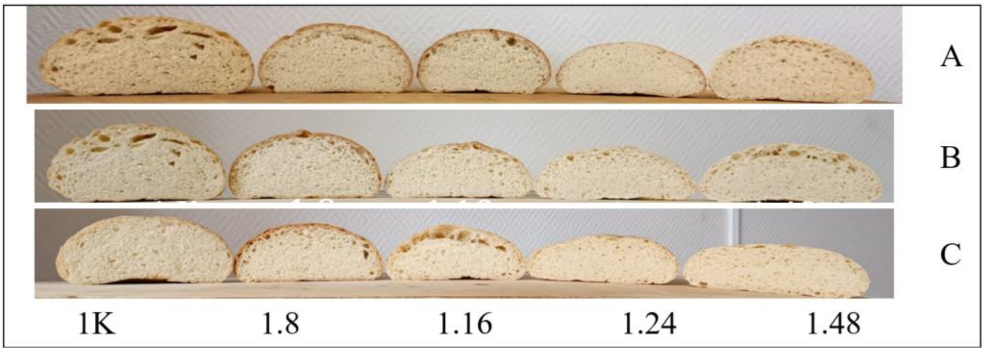

Fig. 4. Samples of bread prepared by straight-dough method (K) with long fermentation at +5 °C (A), +10 °C (B), and +15 °C (C) for 1.8 – *8 h*, 1.16 – *16 h*, 1.24 – *24 h*, and 1.48 – *48 h*

The organoleptic evaluation of bakery products showed that products made from dough fermented for 8 and 16 h at +5 and +10 °C, and for 8 h at +15 °C were round in shape; they showed a smooth brown surface without cracks and breaks, and had a good elastic crumb with a flavor peculiar to bakery products. Other bread samples were of a vague shape, exhibited a dense crumb texture, and poor elasticity and clumping.

The study results on technological features of long dough fermentation and their effect on the organoleptic and physicochemical indicators of the quality of rich bakery products made from wheat flour showed that the optimal time of dough fermentation attained 8 and 16 h at +5 and +10 °C, and 8 h at +15 ºC.

4 Conclusions

The study results on the effect of long, low-temperature fermentation on dough properties and the quality of bakery products made from wheat flour showed that during dough fermentation at +5, +10 and +15 °C the dough acidity increased. The maximum acidity level was recorded for dough fermented for 48 h at +15 °C, and it amounted to 4.0 deg, which was 81.8% higher than that in the control.

The shape stability of all dough pieces decreased during dough fermentation at +5, +10, and +15 °C. Proofing of dough pieces was required only after 8-hour fermentation at +5 °C. All other samples were not proved due to spreading of dough.

The mass fraction of sugar in bakery products made from dough fermented for 8, 16, 24, and 48 h at +5 °C was 20–92% higher compared to that in the control. A significant decrease in the sugar mass fraction was recorded for products made from dough fermented for 24 and 48 h at +10 °C, which was related to long dough fermentation. The sugar mass fraction decreased in products made from dough fermented for 16, 24 and 48 h at +15 °C, and it amounted to 2.5, 2 and 1.1% in terms of dry matter, respectively, which was 35.9–71.8% lower compared to the control.

The content of aromatic substances in bakery products made from dough fermented for 8, 16, 24, and 48 h at +5 °C was 7.7–25.9% lower compared to the control. The content of aromatic substances in products made from dough fermented for 8, 16, and 24 h at +10 ° C was 39–81% higher compared to the control. The content of aromatic substances remained similar in value to that in the control after 48-hour fermentation and amounted to 11.6 ml. The content of aromatic substances increased in bakery products made from dough fermented for 8–48 h at +15 °C. The highest content of aromatic substances was recorded for bakery products made from dough fermented for 48 h, and it amounted to 15.6 ml of 0.1 N. iodine solution, which is 25.6% higher compared to the control.

The study results were used to develop a manufacturer's specification for preparation of bakery products from wheat flour using the technology of long, low-temperature fermentation.

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