Встановлено, що найбільша інтенсивність накопичення цукрів у гірких заварках масової частки вологи 78,0 % відбувається протягом однієї години оцукрення. Запропонований чотирифазний спосіб приготування тіста: «оцукрена «гірка» заварка → заквашена заварка гомоферментативними термофільними МКБ L. Delbrükii-76 → хмельова закваска, збродженa дріжджами раси S. cerevisiae Л-1 і гомоферментативними мезофільними МКБ L. Plantarum-30 → тісто»

Ключові слова: гіркі заварки, хмельові закваски, опара, молочнокислі бактерії, хліб, черствіння

Установлено, что наибольшая интенсивность накопления сахаров в горьких заварок с массовой долей влаги 78,0 % происходит в течение одного часа осахаривания. Предложен четырехфазный способ приготовления теста: «осахаренная горькая» заварка → заквашенная заварка гомоферментативными термофильными МКБ L. Delbrükii-76 → хмелевая закваска, сброженная дрожжами расы S. cerevisiae Л-1 и гомоферментативными мезофильными МКБ L. Plantarum-30 → тесто»

Ключевые слова: горькие заварки, хмельные закваски, опара, молочнокислые бактерии, хлеб, черствение

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RESEARCH INTO TECHNIQUES FOR MAKING WHEAT BREAD ON HOP LEAVEN

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1. Introduction

The main tasks in bread making are to improve the quality of baked goods, to extend their assortment and to increase production efficiency. In order to resolve the main tasks, technologists in the industry employ accelerated technologies, apply nutritional supplements, use active yeast, etc. [1].

One of the problems in the baking industry is the rapid staling of bakery products [2]. It is known that the rate of staling depends on the organization of the technological process, specifically when accelerated technologies are utilized. Such technologies involve physicochemical, colloidal, biochemical and microbiological processes that may prove insufficient, which affects the staling of bread [3].

In addition, there is a growing consumer demand for products made according to the classic technology that provides high taste quality, good consumer properties of bread [4]. That is why bakery plants, along with the use of accelerated technologies, return to the classic, largely lost, technologies that ensure high quality of products [5].

These include the technology of bread making based on hop leaven, which was once used mainly for the production of bread from a second-grade flour [6]. Moreover, the main role of hop was to apply it as an antiseptic. Bread on hop leaven had a pleasant taste and flavor, it retained its freshness longer; however, it had high acidity [7].

The new, recently published, scientific data indicate the functional, physiological properties of hop, which is why current developments in bread and bakery industry are also focused on the enrichment of bread with it biologically active substances [8, 9].

When working out a technology for bread making using the hop leaven one should take into consideration the level of development of the industry, the high degree of mechanization of technological processes, as well as advances in the microbiology of bread making.

A relevant direction for solving the task on increasing the production efficiency and improving the quality of bakery products prepared from wheat flour or a mixture of wheat-rye flour is to improve the composition of hop leaven and the dough preparation techniques.

2. Literature review and problem statement

The known techniques for making bread on hop leaven were developed and are used primarily for the manufacture of wheat bread from the flour with high yield, or rye-wheat bread with a low content (10...12 %) of rye flour [10, 11]. In this case, rye flour, which contains active enzymes with amylolytic effect, is used for scalding and preparation of sourdough, making the dough without pressed yeast. The sourdough starters contain yeast and lactic acid bacteria

with spontaneous reproduction, or obtained from pure cultures [12, 13].

The shortcoming of such techniques is the insufficient fluffiness of dough, small volume, and dense, elastic, bread crumb, as well as rather high acidity.

The acidity of the bread "On hop", which is made from rye flour and wheat flour of first grade (12 % and 88 %, respectively), should not exceed 7 degrees to comply with the standard [14]. Such acidity is high for the bread that contains 88 % of wheat flour of first grade, and one of the reasons for insufficient fluffiness of bread is a short period of fermentation of semi-finished products and the small amount of flour, which is fermented in sourdough.

The intensity of sourdough and dough fermentation is predetermined by the availability of nutrients for the vital activity of microorganisms, specifically sugars whose amount depends on the intensity of accumulation and the content of dry substances in semi-finished products [15]. In the technology for preparing dough on hop leaven, the content of dry substances in them will depend, first of all, on the parameters of scalding.

Essential for providing taste quality of the bread on hop leaven is the selection of races and strains of microflora. Owing to the optimum composition of pure cultures of microorganisms, it is possible to focus technological processes on ensuring the best taste of bread.

It is known [15] that as a result of vital activity of homofermentative lactic acid bacteria the sourdough accumulates lactic acid (85...90 %) and a small amount (5...15 %) of volatile acids, as well as di- and tricarbon acids (4...5 %). Heterofermentative lactic acid bacteria produce lactic acid – 60...80 %, volatile acids – 13...34 %, di- and tricarbon acids – 6...7 %, as well as ethanol and carbon dioxide. Lactic acid provides bread with a nice flavor, while volatile acids, specifically acetic acid, lead to a sharper smell and more acid taste. It is desirable that the content of volatile acids should not exceed 30 % of the overall content of acids.

The Ukrainian bakery plants widely use, in order to prepare liquid rye sourdough, including hop leaven [16], the homofermentative lactic acid bacteria L.plantarum-30 and L.Brevis-1, and the heterofermentative lactic acid bacteria L.casei-26 and L.fermenti-34 with the acid-resistant yeast S. minor. However, the application of this microflora does not ensure high taste quality of products. The products have rather sharp and sour taste, characteristic of the rye bread, although the rye flour content in the bread "On hop" is only 12 %.

Thus, it appears promising to investigate the influence of parameters of scalding, as well as different techniques for preparing the dough on hop leaven, on the quality indicators of the semi-finished products and bread. It is also important to examine the impact on the fluffiness of crumb, bread volume, on the lower acidity of dough and products, and to choose pure cultures of microorganisms in order to improve the taste quality of bread. Of theoretical and practical interest is also to establish the influence of dough preparation techniques on the content of organic acids in dough, the degree of retaining the freshness of bread and its content of aromatic (bisulfite binding) substances.

3. The aim and objectives of the study

The aim of present work was to substantiate techniques and technological parameters for the preparation of semi-finished products at different stages of bread making using hop leaven to ensure high quality of products.

To accomplish the aim, the following tasks have been set:

– to explore the influence of parameters of scalding using hop in the saccharification process;

– to study the influence of techniques for the preparation of dough on quality of the semi-finished products and bread;

– to examine and propose the composition of microflora for preparing hop leaven, which ensures the best taste quality of bread and slowing down of the process of staling.

4. Materials and methods for examining the influence of microflora of hop leaven and techniques of dough preparation

In the first series of experiments we studied the effect of ratio between flour and hop decoction in scalding at 1:2, 1:3 and 1:4 on the dynamic of sugar accumulation of sugars in scalding and parameters of sourdough quality. Mass fraction of moisture in scalding at a given ratio was 72 %, 78 % and 82 %, respectively. The moisture content of sourdough prepared using these scaldings in all cases was 78.0 %. The amount of flour introduced to the sourdough in scalded form amounted to 6 % and 12 % to the weight of flour in the dough. The total amount of flour in sourdough was 12 %. Scalding for making the sourdough was used in one or two hours after saccharification. Scaldings and sourdough starters were prepared from rye flour. The dynamics of sugar accumulation was examined over 4 hours of scalding saccharification.

In the second series of experiments we compared a three-phase dough preparation technique to the four-phase technique. The three-phase technique implied the following: "bitter saccharized scalding → sourdough → dough." The four-phase dough preparation technique implies the following: "bitter saccharized scalding → sourdough → sponge dough → dough". The essence of preparing a "bitter" scalding is the scalding of part of the flour with a hop decoction and saccharification. The sourdough was introduced to the dough in the amount of 50.0 % to the weight of flour in the dough (variant No. 1), to the sponge dough – in the same amount (variant No. 2), and to the sponge dough in the amount of 25.0 % to the weight of flour in the dough (variant No. 3). In the latter case, the sourdough dosage reduction by two times is due to the necessity of reducing the acidity of the dough. The sourdough was prepared using pure cultures of the homofermentative lactic acid bacteria L.plantarum-30 and L. Brevis-1 and the heterofermentative lactic acid bacteria L. casei-26 and L.fermenti-34 and the acid-resistant yeast S. minor. 50.0 kg of sourdough contains 12 % of rye flour, half of which was introduced with a scalding in the scalded form. The sourdoughs were fermented for 3.5 hours; acidity of the ferments was 7.8 degrees, lifting force – 17 minutes. The sponge dough contained 60 % of flour (large thick sponge dough), duration of sponge dough fermentation was 3 hours. The sponge dough and dough were prepared without pressed yeast. Mass fraction of moisture in the dough was 44.0 %, duration of fermentation – 30 minutes.

In the subsequent series of experiments, we studied the proposed four-phase technique for preparing dough. The scheme is shown in Fig. 1: "saccharized", "bitter" scalding → the scalding fermented with the homofermentative thermophilic lactic acid bacteria L. Delbrükii-76 → hop leaven, fer-

mented with yeast of the race S. cerevisiae L-1 and homofermentative mesophilic lactic acid bacteria L. Plantarum-30 → dough". The saccharized "bitter" scalding is added as a nutrient to the scalding, fermented with thermophilic lactic acid bacteria, at a temperature of 50...52 °C. Half of the fermented scalding is used for recovery, and the second half is cooled to 30 °C and is utilized as a nutrient for the sourdough. Hop leaven is fermented by the yeast S. cerevisiae L-1 and the mesophilic lactic acid bacteria L. Plantarum-30 at 30 °C. Thus, the selection of microflora is aimed at lowering the amount of volatile acids in semi-finished products and at improving the taste quality of bread.

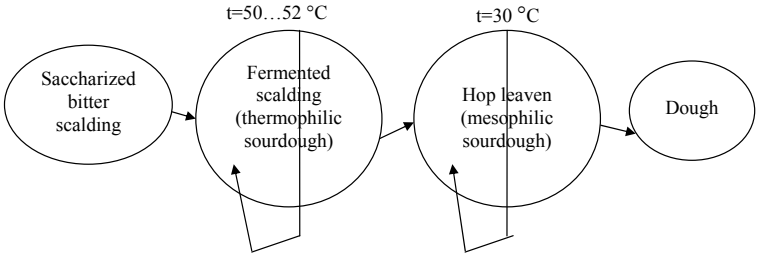

Fig. 1. Scheme of dough preparation

Thinning cycle of the fermented scaldings and sourdoughs was carried out under laboratory and industrial conditions at DP VAT "Kyivkhlib" (Ukraine). The sourdough was obtained from pure cultures of lactic acid bacteria and yeast, borrowed from the collection of museum cultures at the control-production laboratory of Ukrhlibprom (Ukraine). The thinning was conducted in four phases. At each phase, to feed the fermented scalding, we used a saccharize "bitter" scalding, cooled to 50...52 °C in quantities starting from 2 kg; in this case, mass of the thermophilic sourdough at each phase increased by 2 times. Duration of saccharification was 1 hour at a temperature of 60 °C.

Total length of the thinning cycle of the fermented scalding was 40 hours.

At the first phase of thinning, fermented scalding reached the required acidity of 11.8 degrees in 20 hours, at the second – 11.6 degrees, in 10 hours, at the third – 11.2 degrees, in 6 hours, and at the fourth it reached the required acidity in 3 hours. When the fermented scalding reached acidity of 11 degrees, it acquired a pleasant fruity aroma and taste, no sharp sour taste was sensed.

Under production cycle, the fermented scalding was taken in the amount of 50 % while the rest was fed with the saccharized "bitter" scalding in the ratio of 1:1. The sourdough was fed with the fermented scalding also in the ratio of 1:1.

Over a production cycle of thinning, we renewed the fermented scalding 11 times, the sourdough – 7 times. During experiments, the fermented scalding reached acidity of 10 degrees in 3 hours, the sourdough reached the required acidity of 8...10 degrees and a lifting force of 18...22 minutes over 2.5...3.0 hours of fermentation. After a series of sourdough renewal, its indicators greatly improved. The finished sourdough was used to prepare the dough in line with a formulation of the bread "On hop". The dough fermented over 60 minutes. Under similar conditions we baked bread from the dough prepared by a three-phase technique on hop leaven.

Methods of research into quality of rye-wheat bread are described in detail in paper [17].

5. Results of research into the impact of microflora of hop leaven, and the dough preparation techniques

Results of research into influence of the ratio between flour and hop decoction in a scalding at 1:2, 1:3 and 1:4 [18] on the dynamics of sugar accumulation in scaldings and parameters of scalding quality are given in Table 1. An analysis of the data obtained revealed that the accumulation of sugar in all samples of scalding grows over 4 hours of saccharification. However, the largest growth in sugar content, about 100 % of the original amount, is observed in the first hour of saccharification. During second hour of saccharification, and later, the intensity of sugar accumulation reduces. With an increase in the mass proportion of moisture in scalding from 72 % to 78 %, the intensity of sugar accumulation grows; in this case, the starting content of sugar increases. After the first hour of saccharification, the scalding, prepared at a ratio of flour to hop decoction of 1:3, has the content of sugar similar to the thicker scalding (ratio 1:2), which is reached in 2 hours of saccharification. A further increase in the mass proportion of moisture to 82 % exerts almost no impact on the intensity of sugar accumulation.

Table 1

Sugar content in scalding with a different mass fraction of moisture, n=3, p≤0.95

Saccharification duration, hours	Sugar content, % to of dry substances, at the ratio of flour to hop decoction (mass fraction of moisture, %)		
	1:2 (W=72)	1:3 (W=78)	1:4 (W=82)
0	6.5	10.8	10.9
1	16.1	21.1	21.9
2	22.0	24.6	25.0
3	32.5	32.9	32.8
4	39.3	39.4	39.5

Thus, it is advisable to prepare the scalding at the ratio of flour to hop decoction of 1:3 and to saccharize over 1 hour. If it is required to obtain the thinner scalding to ensure easier rolling, it is possible to prepare scalding at the ratio of flour to hop decoction of 1:4 and to saccharize for one hour. The effect of mass fraction of moisture in scalding on the degree of saccharification can be explained by the fact that enzymes are more active in the thinner environment [19, 20].

Further studies involved comparing a three-phase and a four-phase techniques of dough preparation. The three-phase dough preparation technique on hop leaven using the "bitter" scaldings implies the following scheme: "bitter saccharized scalding → sourdough → dough". The four-phase dough preparation technique implies the following scheme: "bitter saccharized scalding → sourdough → sponge dough → dough" [3]. An analysis of results (Table 2) revealed that when introducing the sourdough to the sponge dough in the amount of 50.0 %, the acidity of dough and bread was similar to the case of applying a three-phase dough preparation technique. When using the sourdough in the amount of 25.0 %, the acidity of dough and bread was 2.0 degrees lower. When introducing the sourdough in the amount of 50.0 % and 25.0 % to the sponge dough, the quantity of lactic acid in the dough decreases by 1.75 times

and by 3.5 times, respectively. The content of other organic acids decreased in the case of using 25.0 % of sourdough by 2 times. Duration of curing of dough pieces in the case of applying the sponge dough was shorter by 28 minutes and 14 minutes, respectively.

Table 2

Quality indicators of semi-finished products and bread when applying different techniques for dough preparation n=3, p≤0.95

Indicators	Dough		
	on sourdough (50.0 %)	on sourdough (50.0 %) and sponge dough	on sourdough (25.0 %) and sponge dough
	Variant No. 1	Variant No. 2	Variant No. 3
Sourdough			
Acidity, degrees	7.8	7.8	7.8
Lifting force, min.	17	17	17
Dough			
Acidity, degrees	6.4	6.2	4.4
Duration of curing, min.	103.0	75.0	89.0
Non-volatile acids in dough, mg/100 g:			
Lactic acid	630.0	360	180
Apple and succinic acid	62.0	62.0	31.0
Tartaric and citric acid	55.2	55.2	27.6
Bread			
Specific volume, cm^3/100 g	219	248	272
Acidity, degree	6.0	6.2	4.2
State of surface	Smooth, no cracks		
Color of crust	light brown		
Crumb elasticity	elastic	elastic	
Porosity structure	Not sufficiently developed	thin-wall, developed	
Flavor	hop, expressed	hop, better expressed	
Overall deformation, units initial	50.0	51.0	56.0
in 24 hours	32.0	44.0	42.0
Degree of retaining the freshness	65.0	87.0	75.0
Amount of bisulfite binding substances, mg-equiv./100 g	10.4	11.5	12.0

When using the four-phase technique of dough preparation, bread had a larger specific volume, by 13.2 % in the case of applying 50.0 % of sourdough, and by 24.2 % in the case of using 25.0 % of sourdough. The crumb of bread prepared by a four-phase technique was less elastic while a degree of retaining the freshness of bread for the indicator of crumb deformation increased by 10...22 %, obviously due to the longer fermentation of biopolymers in dough. Bread on sponge dough had attractive physical appearance, elastic crumb, uniform, thin-wall, well-developed porosity, better expressed flavor. The latter was confirmed by a higher content of bisulfite binding substances (11.5... 12 mg-equiv./100 g).

Thus, applying a four-phase technique of dough preparation according to the scheme "scalding → sourdough → sponge dough → dough" improves the quality of bread at hop leaven. Reducing the dosage of sourdough to the sponge dough from 50.0 % to 25.0 % to the weight of flour in the dough makes it possible to reduce the acidity of bread by 2 degrees. This allows us to recommend it for the preparation of bread from graded wheat flour.

An analysis of the influence of microflora of sourdough on the quality of products revealed (Table 3) that bread manufactured using a three-phase technology is inferior to that prepared on the developed hop leaven in both organoleptic and physicochemical indicators.

Table 3

Quality indicators of semi-finished products and bread prepared using different technologies n=3, p≤0.95

Indicators	Dough was prepared	
	by a three-phase technique (control)	by a four-phase technique
Dough		
Acidity, degrees	6.0	5.2
Duration of curing, min.	70	100
Organoleptic indicators of bread quality		
Color of crust	Light brown	
Color of crumb	Light grey, depending on flour grade	
Crumb elasticity	Not elastic enough, dense	Elastic
Porosity	Non-uniform, thin-walled	Uniform, thin-walled, developed
Bread flavor	Not expressed enough	Expressed
Physical-chemical indicators of bread quality:		
Mass fraction of moisture, %	42.5	42.5
Acidity, degrees	4.6	3.2
Porosity, %	68.0	71.0
Specific volume, cm^3/100 g	268	270
Content of volatile acids, %	21.0	15.0
Content of bisulfite binding substances, mg per 100 g of dry substances	9.4	12.6
Compression deformation, units:		
in 4 hours	55	58
in 24 hours	30	38
Retaining the freshness, %	55	66

The resulting sample had pleasant taste, flavor, lighter-colored elastic crumb. Owing to the application of homofermentative lactic acid bacteria, acidity of the product decreased by 1.4 degrees and amounted to 3.2 degrees, the content of volatile acids decreased by 6 % and reached 15 % of the total amount of acids. The use of the proposed technique of dough preparation provided bread with a

better flavor (the content of bisulfite binding substances increased by 34 %) and a better taste. The degree of freshness of the examined sample was higher after 24 hours of storing by 11 %.

The quality of bread for organoleptic indicators have also been estimated by experts using a point scale, based on which we constructed the polygons of quality that show a significant advantage in the estimated quality of the examined sample of bread (Fig. 2).

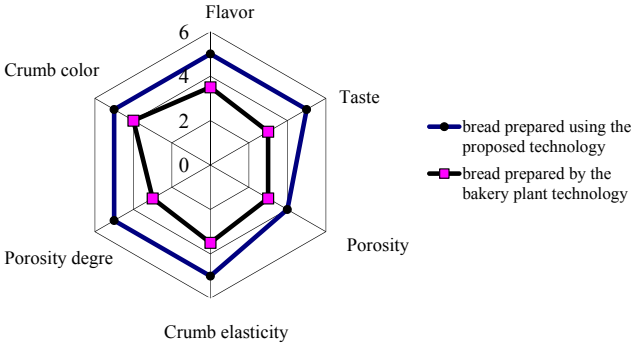

Fig. 2. Profilograms of organoleptic parameters of the quality of bread prepared using different techniques of dough preparation

Based on the results of present research, we constructed a technological scheme of production, which can be implemented at specialized lines of large and medium capacity (Fig. 3).

Bitter scalding is made from rye flour and a mixture of water with hop decoction at the ratio of 1:3. To prepare hop decoction, it is recommended to use fine-aromatic or aromatic varieties of hops with a duration of boiling the hop decoction for 60 minutes. Duration of the scalding saccharification is 60 minutes. The saccharized bitter scalding is the feed for the fermented scalding.

Bitter scalding, hop leaven are prepared in the scalding machine, saccharification of bitter scaldings, fermentation of hop leaven is carried out in reservoirs, dough kneading – in a dough making machine of periodic action.

Thus, we have proven the advantage of the proposed technology of dough preparation on hop leaven using the scaldings, soured by the thermophilic lactic acid bacteria L. Delbrükii, and the sourdough, fermented by the mesophilic lactic acid bacteria L. plantarum-30 and the yeast S. cerevisiae L-1. Using the proposed technology improves quality of rye-wheat bread and shows promises for making bread from graded wheat flour.

6. Discussion of results of studying the influence of hop leaven microflora and the dough preparation techniques

It was established that it is advisable to prepare the scalding at the ratio of flour to hop decoction of 1:3 and to saccharize it for 1 hour. To produce a liquid scalding, it is advisable to use the ratio of flour to hop decoction of 1:4 and to saccharize it for 1 hour as well.

An analysis of the influence of techniques for dough preparation showed that in the case of using 25.0 % of sourdough the acidity of dough and bread is reduced by 2.0 degrees, which substantiates the application of sourdough when preparing wheat flour bread.

Using the four-phase technique of dough preparation contributes to the longer retention of freshness of bread due to the growth of the degree of swelling of flour colloids, deeper fermentative hydrolysis of starch and protein in the process of dough preparation.

Research into the influence of microflora of sourdough has shown that the use of homofermentative lactic acid bacteria leads to a decrease in the total acidity and the content of volatile acids. There is also an increase in bisulfite binding substances, which positively affects the flavor of baked goods.

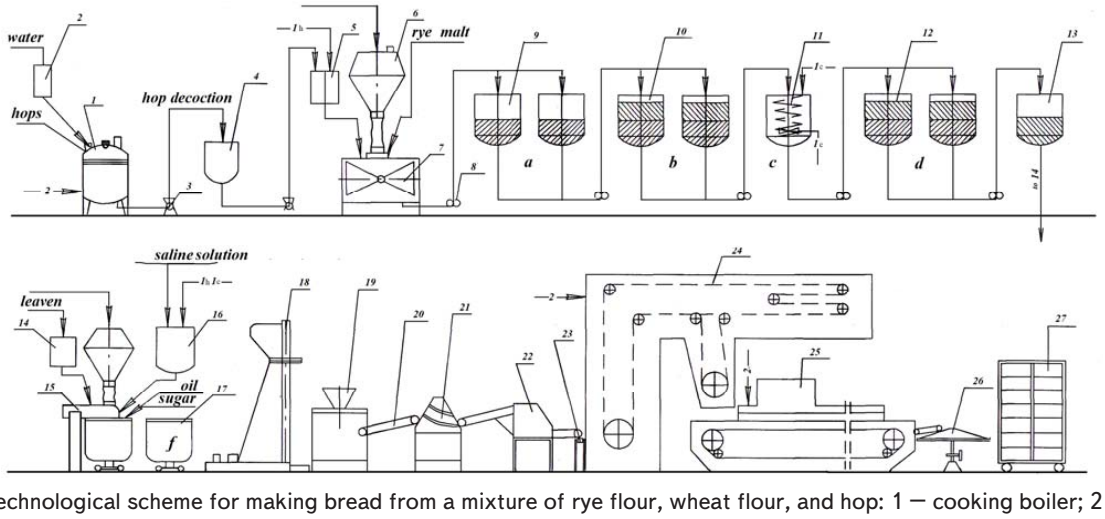

Fig. 3. Technological scheme for making bread from a mixture of rye flour, wheat flour, and hop: 1 — cooking boiler; 2 — water dispenser AVB-100; 3 – pump; 4 – reservoir for hop decoction; 5 – dispenser for hop decoction and water; 6 — flour dispenser Sh2-HDA; 7 — scalding machine HZM-300; 8 — gear pump; 9 – reservoir for saccharification of bitter scalding; 10 – reservoir for scalding fermentation; 11 – reservoir-refrigerator; 12 – reservoir for hop leaven; 13 — reservoir collector of hop leaven; 14 — hop leaven dispenser; 15 – dough stirring machine; 16 —dispenser for liquid components; 17 — barrel; 18 — barrel lifter; 19 – dough separator; 20 – transporter; 21 – dough rounder; 22 – dough-making machine; 23 — settler; 24 — curing chamber T1-HRZ-140; 25 — oven PPC-250; 26 — circulation table; 27 — container. Denotations: — 1c, 1h — cold, hot water; — 2 – steam; a — saccharification time is 1...2 hours at a temperature of 60...63 °C; b — souring time is 3.5...4 hours at a temperature of 50...52 °C; c — a temperature of 32 °C; d — sour fermentation time is 2.5...3 hours at a temperature of 30...32 °C; f — dough fermentation time is 1...1.5 hours at a temperature of 30...32 °C

The application of the four-phase technique of wheat bread dough preparation has a positive effect on the economic indicators, which is important in terms of social values, especially for the production of bakery products with extended shelf life.

The present study makes it possible to improve techniques for retaining the freshness of bakery products.

7. Conclusions

1. We examined the patterns of saccharification process of bitter scaldings depending on the parameters of preparation. It was established that the most intensive increase in the sugar content occurs within 1 hour of saccharification at a mass fraction of moisture in scalding of 78.0 %. Further increase in the mass proportion of moisture to 82.0 % does not affect the intensity of sugar accumulation. It is proved that the optimal ratio of flour to hop decoction in scalding is 1:3, the recommended duration of scalding saccharification is 1 hour.

2. Based on the result of present study, it is recommended to prepare rye-wheat bread with a small content of rye flour or wheat bread from graded flour employing a four-phase technique of dough preparation using bitter scaldings, hop leaven, sponge dough and dough. We have proved the need to reduce the amount of sourdough introduced to the sponge dough to 25.0 % of the weight of flour in the dough. The application of a given technology makes it possible to reduce the acidity of bread, to ensure its better fluffiness, improve the state of crumb, to prevent staling of bread.

3. It is proposed to use the thermophilic homofermentative bacteria L. Delbrückii-76 for souring the scaldings and the yeast S. cerevisiae L-1 and the mesophilic homofermentative lactic acid bacteria L. plantarum-30 for sourdough fermentation. We studied the cycle of thinning the soured scaldings and sourdough; established technological parameters and devised a technology for dough preparation using a four-phase technique that implies the preparation of bitter scaldings, souring and fermentation of sourdough applying selected microflora.

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