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PRODACTION OF BAKERY PRODUCTS USING FLOUR FROM GERMINATED WHEAT GRAINS

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Abstract
This article reflects the results of a study of the technology for the production of bakery products using flour from germinated wheat. The composition and value of this type of raw material is given. It is noted that thanks to germinated wheat, it is possible to preserve as much as possible an acceptable part of the shell and aleurone layer, which includes many vitamins, proteins, macro- and microelements. The influence of this type of raw material on the technological process of bread production has been studied. A review of the literature in the databases Scopus, Web of Science, as well as publications recommended by the Committee for Quality Assurance in the Field of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan. The organoleptic and physico-chemical parameters of the product were determined. Formulations of a new therapeutic and prophylactic product of increased biological and nutritional value have been developed. As a result, it was concluded that the best sample is bread with a dosage of 10% flour from germinated wheat.
Keywordrs: bakery products, germinated wheat, nutritional value, humidity, acidity, porosity, organoleptic evaluation.

Introduction

For many years, work has been carried out in the field of baking aimed at increasing the nutritional and biological value of products due to natural non-traditional types of raw materials.

Replacing or supplementing wheat flour with flour of various origins improves the composition and content of protein, vitamins, minerals or dietary fiber in the final products [Obadi M., 2021: P.110066].

One of the progressive directions in the development of the production of functional nutrition products is the creation of enriched grain-based products, since, due to the low cost of raw materials, they are available to a wide range of the population and are able to compensate for the lack of biologically active substances in the diet, increase the body's resistance to adverse environmental factors, and, consequently, increase the life expectancy of the population. This is evidenced by a large number of studies in the development of functional, enriched and specialized products [Urbanchik E.N., 2022: P.107].

The purpose of the study is to study the technology of production of bakery products using flour from sprouted wheat grain.

Sprouted wheat is a biologically valuable product containing B vitamins, vitamin E, proteins with essential amino acids, lipids. The utilization of sprouted grain ingredients is an emerging trend due to consumers' desire for health-promoting and natural food products [Salt L.J., 2006: P.285].

Sprouted wheat is given the opportunity to preserve as much as possible an acceptable part of the shell and the aleurone layer in the final product, as the most biologically active parts of the grain [Dapkekar A., 2020: P.54].

The use of flour from sprouted wheat grain makes it possible to obtain bakery products for therapeutic and preventive purposes, diversifying the product range [Finnie S., 2019: P.114]. It is worth noting that germination promotes the transition of hard-to-digest substances into an easily accessible form,

the content of vitamins and minerals increases. In this regard, research aimed at creating a bread recipe with a properly developed technology for including grain from sprouted wheat is relevant.

Main body

Bread production is a branch of the processing industry, which tends to be renewed and developed. Getting the highest quality bread is a difficult mission, because this product is susceptible to a variety of factors. As a rule, the main factors affecting the quality of finished bread include the quality and storage conditions of the main and additional raw materials, technological parameters of production, compliance with sanitary and hygienic standards for the production of safe products.

At bakery enterprises, it is planned to obtain a mixture of weak flour with strong flour. In the absence of the possibility of improving the quality of wheat flour by preparing this mixture, complex technologies are used to ensure the production of finished products that meet quality standards. The technological process of making bread with flour from sprouted wheat grain consists of the following stages: preparation of flour from germinated wheat grain, kneading dough and other semi-finished products, fermentation of semi-finished products, division of dough into pieces of a certain mass, formation and proofing of dough blanks, baking, cooling and storage of products.

Examples can be given when optimizing the parameters of dough preparation: temperature, humidity, duration of fermentation, acidity, etc., the use of starter cultures and acid-containing semi-finished products, complex improvers for the intended purpose.

The textural/sensory properties of a food are closely related to its rheological properties and the latter are determined by its composition (starch, protein and dietary fiber) and the structure of the food matrix [Joyner (Melito) H.S., 2018: P.7]. Rheology is therefore the well-established, preferred approach, to link the physicochemical properties of foods to their structure and texture [Day L., 2016: P.125]. Wheat flour dough is a viscoelastic system that exhibits an intermediate rheological behaviour between a viscous liquid and elastic solid. The viscoelastic protein network plays a predominant role in dough processing as well as in textural characteristics of the finished bread [Rossel C.M., 2007: P.452].

Complex baking technologies also imply the use of modern technological techniques and tools in the preparation of flour semi-finished products in order to intensify the biochemical transformations of dough ingredients, including the dosage order and composition of raw materials.

The use of dispersed germinated grain in the composition of bread increases the level of food and biologically active substances [Wang Y., 2022: P.1]. Despite the nutritional and sensory improvements associated with sprouted grains, their use in baking has been limited until recently. Indeed, severe and uncontrolled grain sprouting induces high accumulations of enzymatic activities that negatively affect dough rheology and baking performance [Marti A., 2018: P. 237]. Recently, the development of bakery products of a functional orientation has become relevant. Samples of bakery products were prepared in accordance with the recipes presented in Table 1.

Table 1

Recipe of bakery products samples

Names of raw materials	Quantity of raw materials, g				
	Control	3%	5%	10%	15%
Wheat flour of the highest grade	200	194	190	180	170
Dry baking yeast	2	2	2	2	2
Table salt, food	4	4	4	4	4
Granulated sugar	2,5	2,5	2,5	2,5	2,5
Flour from germinated wheat grain	-	6	10	20	30
Drinking water	100	100	100	100	100

The proposed formulation makes it possible to identify among the four samples the most successful ratio of premium flour with flour from sprouted wheat. Since baking flour has a number of characteristics that ensure the production of bread with the desired properties. The task was set to develop and justify the feasibility of producing bread for therapeutic and preventive purposes. Such a product will allow for daily consumption to have a positive effect on human health, providing the necessary amount of nutrients, minerals, vitamins.

The technological process of making bread with flour from sprouted wheat grain consists of the following stages:
- preparation of flour from sprouted wheat grain,
- preparation and dosing of raw materials,
- kneading dough, maturation of dough,
- fermentation of semi-finished products,
- division of dough into pieces of a certain mass,
- formation and proofing of dough blanks,
- baking,
- brakering,
- cooling and storage of products.

The first stage of the experimental part of the study was carried out on the basis of the laboratory for the analysis of the quality of plant raw materials.

Production stages were used to obtain flour from sprouted grain:
1 - washing the grain at a water temperature of 25^0C;
2 - laying out a layer of 1,5-2 cm and pouring water 25^0C;
3 - germination of grain 24-36 hours;
4 - washing of sprouted grain;
5 - drying of sprouted grain at 100^0C to a constant mass fraction of moisture 11%;
6 - grinding and brightening.

The mechanical process of grinding sprouted wheat was carried out in a laboratory mill. The resulting flour was sifted through laboratory sieves. On the basis of the laboratory for the production of food products, the remaining stages of the study were implemented.

Literature review

Germinated seeds and cereals are natural sources of enzymes. Germinated grains are being used as an ingredient in multiple food product developments because of their high nutritional value, interesting technological properties and sensory attributes. The sprouting of whole wheat leads to noticeable changes in gluten, changes the rheological properties of the dough for bread [Gao K., 2022: P. 107254].

The authors studied the effects of sprouting duration (24 h, 38 h, 48 h and 62 h), evaluated the characteristics of durum wheat kernels (hardness, dough weight), the chemical composition of semolina, gluten properties for gluing and aggregation, as well as the baking powder and the quality of bread baking (bread volume and crumb porosity). Germination reduced both the hardness of the kernels (~29%) and the mass of the dough (~19%). A multidimensional approach based on the analysis of the main components and clustering was applied. It confirmed the relationship between all the variables considered and allowed us to estimate three levels of germination: 24-38 hours with improved bread baking performance; 48 hours with a decrease in overall quality; 62 hours with the worst quality. It was concluded that germination of durum wheat for 38 hours can improve its baking properties [Cardone G., 2020: P.110021].

Researchers Jerson Duvan Peñaranda, Marta Bueno, Francisco Álvarez, Patricio David Pérez, Laura Perezábadab described the process of self-production of flour from sprouted wheat and studied two applications of sprouted grains: the effect of wheat germination time on the production of new flour for baking and the assessment of the microbiological risk of home production of fermented beverage

based on sprouted wheat. Their research appeared as a result of the authors' great interest in the variety of use of sprouted grains in the food industry and gastronomy. In this case, the authors have developed a fermented drink based on sprouted wheat. They described a safe protocol for germinating wheat grains, in addition, in connection with the growing interest in fermented beverages, an alternative drug cultured with a commercial strain of Lactobacillus acidophilus has been developed. It was found that with short-term germination for 12 hours, the functionality of sprouted wheat flour for final use can be achieved without compromising the functional properties of the dough. Thus, sprouted wheat offers innovative products that can potentially be incorporated into the gastronomic experience [Peñaranda D., 2021: P.10375].

Foreign scientists Tekmile Cankurtaran-Kömürcü and Nermin Bilgiçli studied bread made from sprouted and unprocessed wheat flour of the Eincorn and Emmer varieties, as well as unsweetened wheat of the Esperia variety. They have developed prototypes with the addition of 0,5%, 10%, 15% and 20% flour from unsweetened flour to improve the functional and nutritional properties of bread.

In this study, the influence of sprouted and wheat flour on the properties of bread was studied. The results obtained were evaluated according to the main factors. Physico-chemical analysis of ash content, chemical analysis to calculate the total amount of dietary fiber, total yellow pigment were carried out. The total phenol content, antioxidant activity, Ca, Fe and Mg content in bread were determined. Among the three wheat varieties, Emmer has improved the nutritional and functional properties of bread the most. The utilization of flour from sprouted wheat in the production of bread increased the amount of minerals: Ca, Fe, Mg, total amount of dietary fiber, total phenol content, values of antioxidant activity. Sprouted wheat flour reduced the average phytic acid content in bread samples from 313,32 mg/100 g to 291,81 mg/100 g. The usage of wheat flour from sprouted wheat of the Eincorn and Emmer varieties gave a smaller volume of bread compared to wheat flour of the Esperia variety. As a result, an increase in the amount of flour from sprouted wheat increased the functional component and nutritional value of bread, and at the same time its use in a low ratio positively affected the technological quality of bread [Cankurtaran-Kömürcü T., 2023: P.103293].

The authors Naumenko N.V., Pajmulina A.V., Slobozhanina E.V., Poroshina K.A. considered the possibility of using crushed sprouted grain of hard and soft wheat varieties. They examined the quality indicators of bread made from wallpaper flour, prepared according to a traditional recipe. When kneading the dough, shredded sprouted grain in the amount of 10%, 20% and 30% to the total mass of flour was added to the wallpaper wheat flour (the "Кудесник" trademark). Soft and hard spring wheat of the Ural region was used for germination. A total of 6 samples were studied, in 3 of which crushed sprouted wheat of the soft variety was added, and in 3 of the hard varieties. As a result of the data obtained, samples with the addition of crushed sprouted wheat grains of soft varieties showed pronounced crust undermining, uneven crumb with the presence of voids. Meanwhile, the samples with the addition of a mixture of flour and crushed sprouted wheat from durum varieties were close to the control in organoleptic properties. Sample No 3 (30% content of crushed sprouted durum wheat) had higher values of crumb elasticity and chewability. Especially fragrant were samples from durum wheat varieties No 2 and No 3 with 20% and 30% content, respectively.

The validity of the use of pre-sprouted and ground durum wheat was the addition as a natural improver and at the same time enriching additives of functional purpose. The consistency of the dough can be adjusted, therefore dry wheat gluten and other improvers will not be used in the process of dough preparation. Optimal organoleptic, physico-chemical and rheological parameters were achieved by introducing a sprouted crushed mixture of wheat grain with wallpaper flour [Naumenko N.V., 2019: P.52-54].

Based on the literature review, it follows that the development of enriched bread in order to obtain a high-quality and competitive product that satisfies sensory and physico-chemical characteristics is becoming a promising direction of food products.

Methods

To solve the tasks set in the work, organoleptic, physico-chemical methods of analysis for the study of raw materials and finished products were applied. The objects of the study were bread samples. The variety of the research object was due to the fact that bread is considered one of the main foods in the daily diet.

Control sample No 1 was prepared from wheat flour according to the traditional recipe. Sample No 2 was made with the addition of flour from sprouted wheat grain in an amount of 3% (by weight of flour). Sample No 3 was prepared with the addition of flour from sprouted wheat grain in an amount of 5% (by weight of flour). Sample No 4 is made with the addition of flour from sprouted wheat grain in the amount of flour from sprouted wheat grain in the amount of 10% (by weight of flour). Sample No 5 is prepared with the addition of flour from sprouted wheat grain in an amount of 15% (by weight of flour).

The determination of the moisture content of the crumb (%) was carried out according to GOST 21094-75. The physico-chemical index of acidity (^{0}T) was determined according to GOST 5670-96. GOST 10846-91 was used to determine the mass fraction of protein (%). Organoleptic evaluation of finished bakery products on flour from sprouted wheat grains was carried out according to GOST 5667-65.

Results

The results of the study of the humidity content of the crumb in the samples of bakery products are shown in Figure 1.

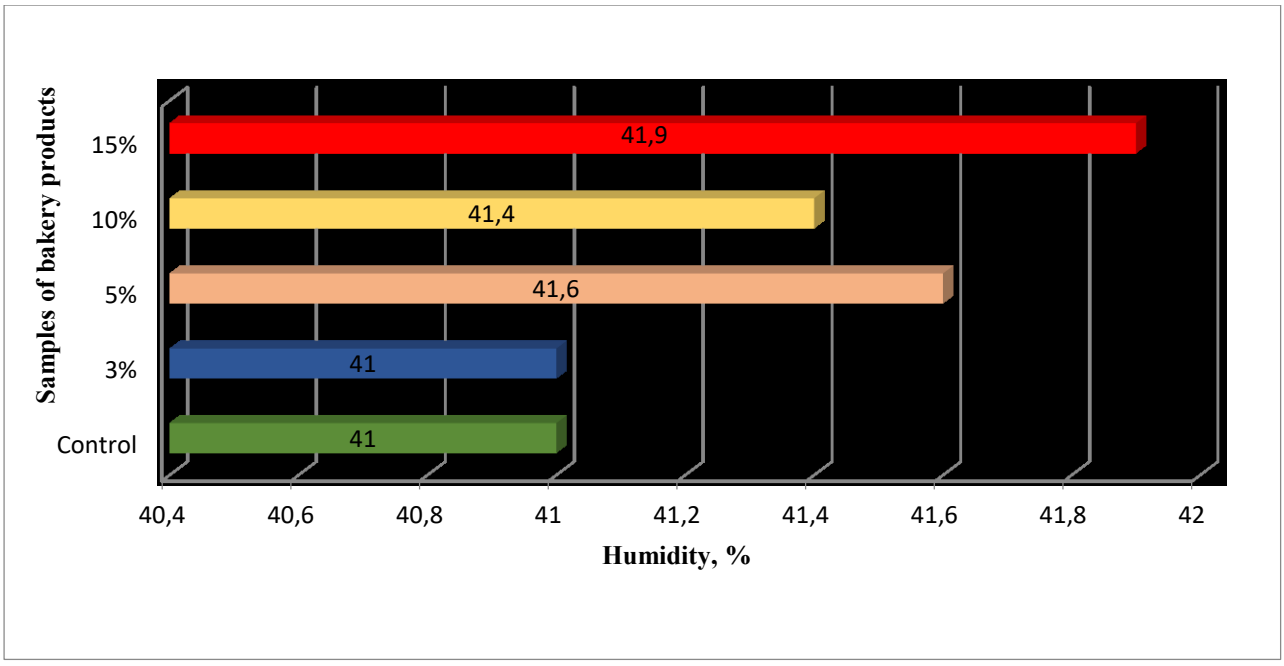

Figure 1. The humidity content of the crumb in the samples of bakery products

The lowest humidity content of the crumb was 41% in the control sample and the sample with the addition of 3% flour from sprouted grain (Figure 2).

It can be seen that the acidity of the control sample is 1,1°T. Replacing wheat flour with flour from sprouted wheat grain in an amount of up to 10% leads to a slight change in the acidity index (Figure 3).

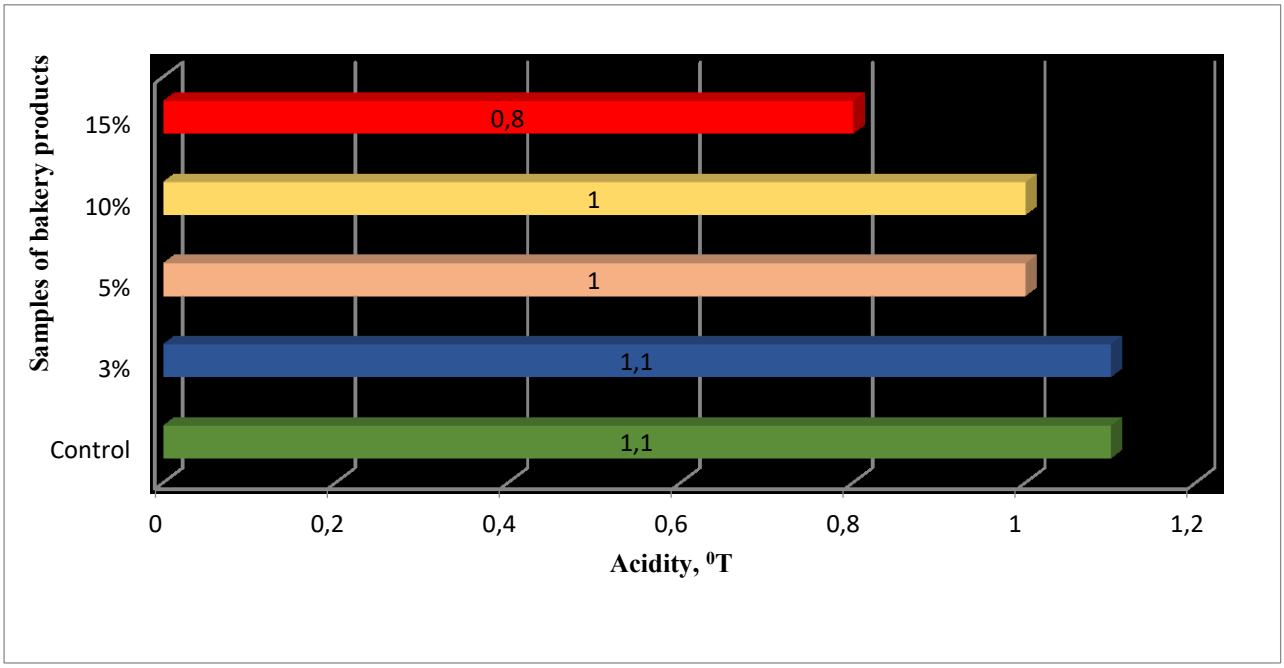

Figure 2. The acidity in samples of bakery products

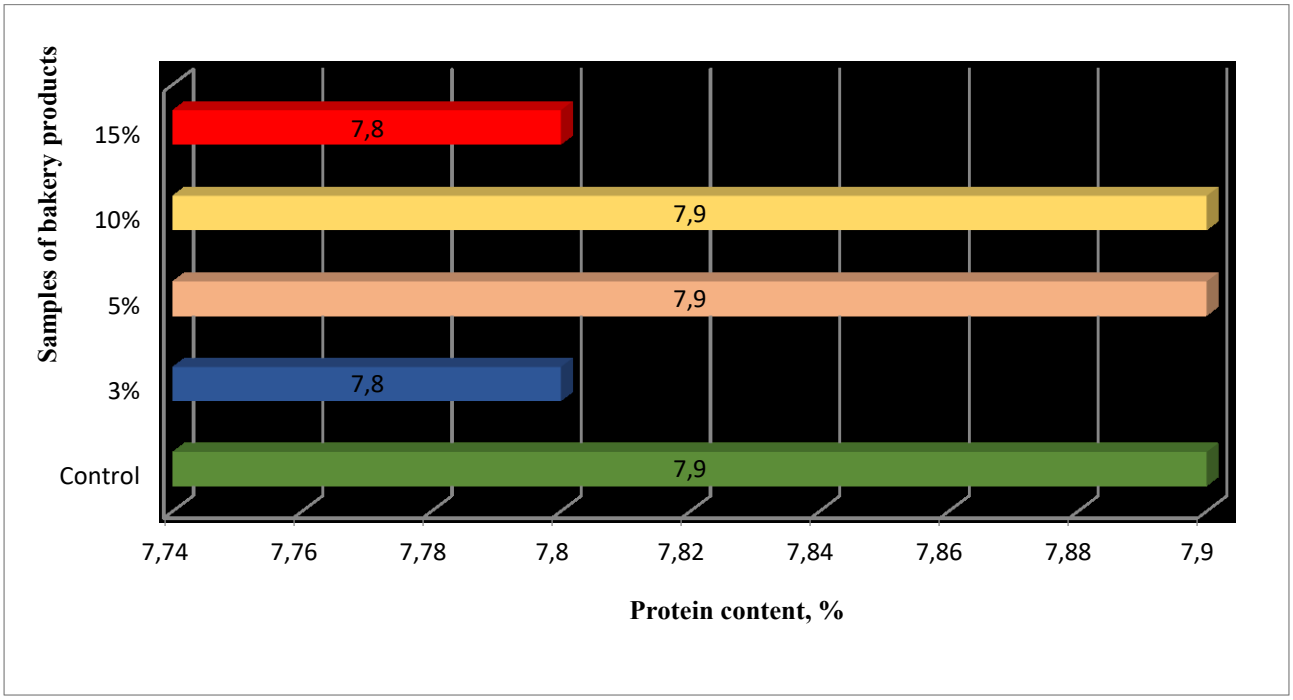

Figure 3. Protein content in bakery products samples

All samples of bakery products had approximately the same protein content. The deviations did not exceed 0,1%, which fits into the experimental error (Figure 4).

The porosity of the control sample is 78%. The introduction of an additive from sprouted wheat grain in an amount of up to 10% contributes to a slight change in the porosity of bread, within 1-2%.

The determination of organoleptic parameters of bakery products was carried out in accordance with the requirements of GOST 5667-65 using a 5-point scale.

The studied samples of bakery products were compared with the control, which had a total of 5 points for all indicators.

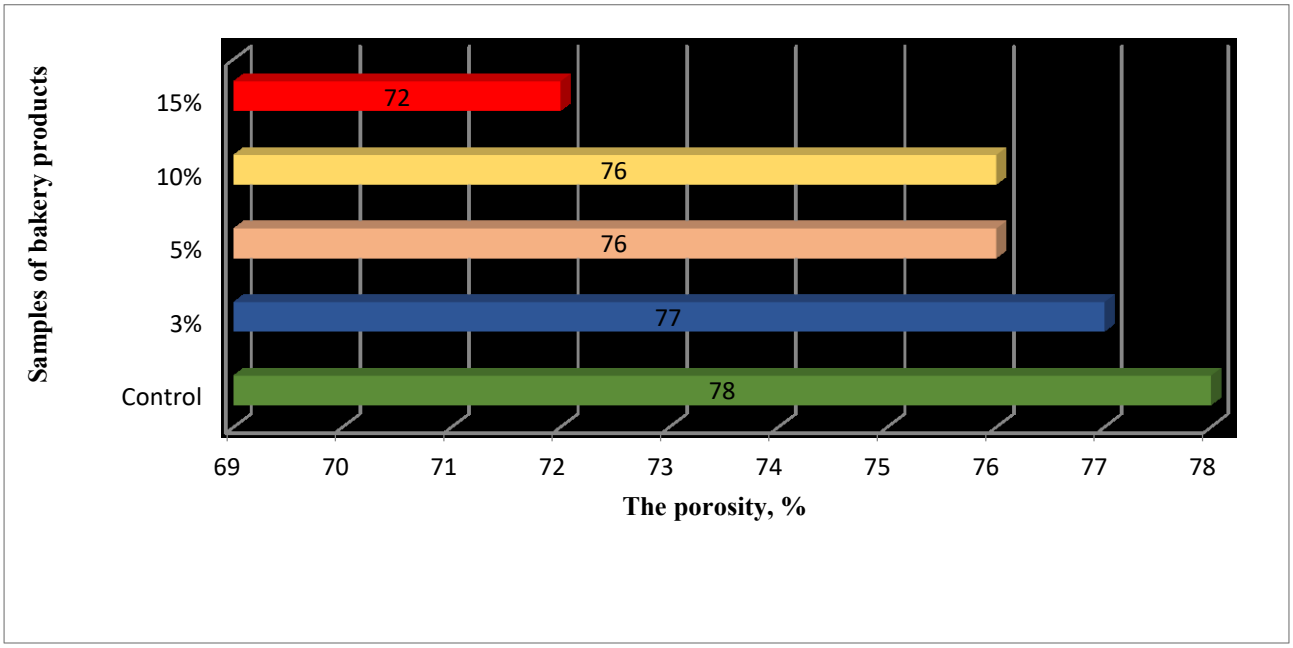

Figure 4. The porosity in bakery samples

Discussion

When making bread with and adding a mixture of flour from sprouted wheat grain and traditional bakery, technological difficulties should be highlighted, since the resulting mixture as a result of germination dramatically increases the activity of amylolytic enzymes, the number of flour drops decreases. This leads to a deterioration of such consumer properties as appearance, physico-chemical indicators: namely, a decrease in the volume of bread and less developed porosity [Naumenko N.V., 2019: P.54].

An increase in the amount of flour from sprouted grain in the recipe of bakery products leads to an increase in the moisture content of the samples. Moreover, the humidity increases in waves. Samples of bakery products to which flour from sprouted grain was added in the amount of 5 and 15% had the maximum humidity, while the addition of 10% of the additive led to a decrease in the moisture content of bread to a level close to the humidity of the control sample.

An increase in the amount of additives over 10% by weight of flour contributes to a sharp decrease in the acidity index, which in turn will affect the reduction of the shelf life of bread. Therefore, for bakery products with an additive of sprouted grain over 10%, it is necessary to conduct additional studies on microbiological safety in order to justify the shelf life.

Replacing wheat flour with flour from sprouted wheat grain in an amount of up to 10% leads to a slight change in the acidity index.

The addition of flour from sprouted grain in an amount exceeding 10% contributes to a sharp decrease in porosity, which leads to compaction of the product. For example, when adding flour from sprouted grain in an amount of 15%, the porosity of bread is reduced to 72%.

The decrease in the porosity of the crumb is explained by the use of soft wheat. Whereas high porosity values in earlier work were achieved with sprouted durum wheat grains. The increase in this indicator was associated with a slight intensification of the fermentation process and the accumulation of carbon dioxide [Naumenko N.V., 2019: P.54].

The introduction of flour from sprouted wheat grain in any amount into the recipe of bakery products does not affect the protein content in the final product.

Wang Y. noted that the use of flour from sprouted wheat grains complicates the technological process of obtaining bread with high consumer properties, since it contains less gluten proteins. This product

is characterized by a tendency to accelerated microbiological damage, the formation of a finely porous inelastic crumb of bread, a low specific volume of bread, a low shelf life of the product, which limits the expansion of the use of sprouted grain in the production of bakery products [Wang Y., 2022: P.4].

The section of bread samples with the addition of a mixture of flour and crushed sprouted wheat from soft wheat varieties in the study of Naumenko N.V. showed that the bread has an uneven consistency of crumb and emptiness. These defects of bakery products worsen the organoleptic quality indicators [Naumenko N.V., 2019: P.54].

Whereas in our study, during organoleptic evaluation, samples No 1 and No 3 received the maximum score in all indicators (3% and 10% additives, respectively). Samples No 2 and No 4 received 4,5 and 4,1 points, respectively.

It is proposed to bake bread with 10% flour from sprouted wheat grains in the conditions of the Kostanay bakery according to the recipe in Table 2.

Table 2

Production recipe of bread with 10% addition of flour from sprouted wheat grains

Names of raw materials	Quantity of raw materials, kg
Wheat flour of the highest grade	90
Dry baking yeast	1,0
Table salt, food	2,0
Granulated sugar	1,250
Flour from germinated wheat grain	10
Drinking water	50

Since the use of sprouted wheat in the technology of bakery products contributes to an increase in nutritional value, it is necessary to strive to introduce the maximum amount of the proposed additive without compromising quality.

Conclusion

The task of the study was not only to enrich bakery products, but also to preserve and, if possible, improve the consumer properties of the finished product.

Based on the conducted research and the experimental data obtained, a technology for the production of bread with 3%, 5%, 10% and 15% replacement of wheat flour of the highest grade has been developed. The offered samples do not differ in appearance and taste from traditional wheat bread.

No 3 was recognized as the best sample, in which 10% of wheat flour was replaced with flour from sprouted wheat grain. It has a denser consistency than the control sample, however, its crumb does not crumble, and it retains its shape well after baking.

The data of the organoleptic study are consistent with the results obtained during the physico-chemical study of the samples. Thus, the developed bread samples comply with GOST 31805-2018. The proposed technological solutions will provide the population with functional products based on vegetable raw materials, with minimal losses during baking.

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Өсіп-өнген бидай дәндерінен алынған ұнмен байытылған нан-тоқаш өнімдерін өндіру

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Аңдатпа
Бұл мақалада бидайдың өсіп-өнген дәнінен алынған ұнды қолдана отырып, нан-тоқаш өнімдерін өндіру технологиясын зерттеу нәтижелері көрсетілген. Шикізаттың осы түрінің құрамы мен құндылығы келтірілген. Өсіп-өнген бидайдың арқасында көптеген дәрумендер, ақуыздар, макро- және микроэлементтерді қамтитын қабық пен алейрон қабатының қолайлы бөлігін мүмкіндігінше сақтауға мүмкіндік берілетіні атап өтілді. Шикізаттың бұл түрінің нан өндірісінің технологиялық процесіне әсері зерттелді. Әдебиеттерге, соның ішінде Scopus, Web of Science дерекқорына шолу жасалды. Өнімнің органолептикалық және физика-химиялық көрсеткіштері анықталды. Биологиялық және тағамдық құндылығы жоғары жаңа емдік-профилактикалық өнімнің рецептуралары әзірленді. Нәтижесінде өнген бидайдан алынған 10% ұн мөлшеріндегі нан ең жақсы үлгі болып табылады деген қорытындыға келді.
Түйін сөздер: нан өнімдері, өнген бидай, тағамдық құндылығы, ылғалдылығы, қышқылдығы, кеуектілігі, органолептикалық бағасы.

Производство хлебобулочных изделий с использованием муки из проросших зерен пшеницы

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Аннотация
В данной статье отражены результаты исследования технологии производства хлебобулочных изделий с использованием муки из пророщенного зерна пшеницы. Приведен состав и ценность данного вида сырья. Отмечено, что благодаря пророщенной пшенице предоставляется возможность максимально сохранить приемлемую часть оболочки и алейронового слоя, включающих в себя много витаминов, белков, макро- и микроэлементов. Исследовано влияние данного вида сырья на технологический процесс производства хлеба. Проведен обзор литературы, в том числе базы данных Scopus, Web of Science. Определены органолептические и физико-химические показатели продукта. Разработаны рецептуры нового лечебно-профилактического продукта повышенной биологической и пищевой ценности. В результате сделаны выводы, что лучшим образцом является хлеб с дозировкой 10% муки из пророщенного зерна пшеницы.
Ключевые слова: хлебобулочные изделия, пророщенная пшеница, пищевая ценность, влажность, кислотность, пористость, органолептическая оценка.

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