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# STUDY OF THE INFLUENCE OF POLLEN ON THE QUALITY OF FERMENTED ICE CREAM

**Abstract.** Probiotics are living microorganisms that, when consumed in sufficient amounts, provide proven health benefits, including the improvement of intestinal microflora, activation of the immune system, cholesterol reduction, and inhibition of pathogens. The present study addresses the limited data on the use of pollen as a functional ingredient in fermented ice cream with probiotics. To enrich fermented ice cream, different concentrations of pollen (3%, 5%, and 7%) were introduced into the formulations. The results demonstrated that 5% and 7% negatively affected the sensory and rheological properties, while 3% pollen maintained acceptable organoleptic quality and improved nutritional value. This highlights the potential of pollen as a novel functional ingredient for probiotic fermented ice cream. The findings provide both scientific novelty, by evaluating the optimal concentration of pollen, and practical recommendations for its application in the food industry.

**Keywords:** ice cream, probiotic, pollen, functional products, fermented ice cream.

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**Introduction.** To ensure a complete diet, it is necessary to develop products designed for different age groups. These products must meet the physiological needs of the body, have a balanced composition and high nutritional and biological value. This category of products primarily includes dairy products, which are easily absorbed by the human body.

In the food industry, the development of functional food production based on the use of milk and vegetable raw materials opens up vast prospects for the creation of products with high biological value and safety. The variety of dairy products is achieved through the use of multicomponent products such as honey and pollen, which enrich the food with functional substances. In addition, bee products, including pollen, are a natural source of biologically active substances that are used in the production of functional foods. In this regard, the increased interest in the use of bee products in the production of functional foods is due to their high nutritional value and biological activity [1].

Ice cream, being one of the most popular dairy products, has significant potential for enriching the human diet due to its valuable and irreplaceable components. However, in order to preserve the organoleptic properties and storage stability of this product, care must be taken to change its formulation, especially to reduce the main ingredients or add new components.

Within the framework of the state policy aimed at providing the population with high-quality food, one of the key aspects is the development of innovative technologies for the production of high-quality and unique products from complex raw materials. Advanced and promising developments based on high technologies are used to create new functional products, such as fermented dairy products.

In this regard, it is important to develop a technology for the production of functional ice cream, enriched with valuable components such as pollen and probiotics, which ensures balanced nutrition and corresponds to the concept of functionality [2]. The aim of the research is to develop and evaluate a technology for the production of functional fermented ice cream enriched with pollen and probiotics. The objectives of the study were: to prepare formulations of fermented ice cream enriched with different concentrations of pollen (3%, 5%, and 7%); to evaluate the sensory, physicochemical, and rheological properties of the developed products; to assess microbiological safety and compliance with food safety standards; to compare the obtained results with existing literature and highlight scientific novelty.

**Materials and methods.** The objects of research were enriched fermented ice cream and the raw materials used to prepare the mixture for its production.

– Raw cow's milk – according to the State Standard of the Republic of Kazakhstan (SSRK) 1760-2019 Cow's milk – raw material. Specifications.

– Condensed milk – according to National Standard Russian Federation (NSRF) 34312-2017 Condensed milk – raw material. Specifications.

– Skimmed milk powder – according to NSRF 33629-2015 Canned milk. Dry milk. Specifications.

– Sugar – according to NSRF 33222-2015 White sugar. Specifications.

– Unsalted butter – according to NSRF 32261-2013 Butter. Specifications.

– Pollen – according to NSRF 28887-2019 Pollen. Specifications.

– Stabilizer – emulsifier – according to the Technical Regulations of the Customs Union (TR CU) 029/2012 Safety requirements for food additives, flavorings and technological aids.

– Starter culture – according to NSRF 34372-2017 Bacterial starter cultures for the production of dairy production. General specifications.

– Vanillin – according to the TR CU 029/2012 Safety requirements for food additives, flavorings and technological aids.

Sampling and their preparation for analysis were carried out in accordance with NSRF 26809.1-2014 Milk and milk products. Acceptance regulations, methods of sampling and sample preparation for testing [3,4].

Experimental studies were conducted using analytical methods corresponding to the objectives of the research. The physico-chemical, chemical, and microbiological composition and properties of the samples were determined. The safety of raw materials and finished products, as well as their chemical composition, were evaluatedin accordance with the requirements of TR CU 021/2011 On food safety, and TR CU 033/2013 On the safety of milk and dairy products [5].

Formulations of ice cream mixtures with 0% (control), 3%, 5%, and 7% pollen were developed (Table 1).

Table 1

Formulations of fermented ice cream with different concentrations of pollen

| Raw material | Control | Fermented ice cream with the addition of pollen | | |
|---|---|---|---|---|
| | | 3% | 5% | 7% |
| Cow's milk (2.5% fat), ml | 500 | 500 | 500 | 500 |
| Butter (82.5% fat), g | 100 | 100 | 100 | 100 |
| Condensed milk (8.5% fat), g | 200 | 200 | 200 | 200 |
| Skimmed milk powder (93% NFMS*), g | 200 | 200 | 200 | 200 |
| Pollen, g | - | 3 | 5 | 7 |
| Stabilizer (xanthan gum), g | 4 | 4 | 4 | 4 |
| Starter, g | 0.5 | 0.5 | 0.5 | 0.5 |
| Vanillin, g | 1 | 1 | 1 | 1 |
| Total, g | 1000 | 1000 | 1000 | 1000 |
| **nonfat milk solids* | | | | |

Stabilizers have the ability to bind water. By binding a large amount of free water, they increase the viscosity of the mixture and prevent the formation of large ice crystals during freezing. They also provide the product with a fine crystalline structure and an elastic consistency [12,13].

Xanthan gum was used as a stabilizer to form the structure of fermented ice cream enriched with pollen. A total of 4 g of stabilizer was added to the fermented ice cream samples containing 3%, 5%, and 7% pollen.

Taste, appearance, odor, consistency, and color were evaluated by organoleptic analysis in accordance with NSRF ISO 6658-2016 Organoleptic analysis – Methods. Quantitative values of sensory perception were obtained using a ten-point assessment scale. Based on the results, an organoleptic characteristic of the samples was established [6,7].

The energy value, taking into account the absorption coefficients of nutrients by the body, was calculated according to Formula 1 [8]:

$$EV = A\times4.0 + M\times9.0 + K\times4.0 \quad (1)$$

where: *EV* – the energy value of 100 g of product; *A* – proteins (g/100 g of product), *M* – fats (g/100 g of product), *K* – carbohydrates (g/100 g of product).

Viscosity is one of the main criteria for the consistency of a product. It depends on the amount of solids, their spatial distribution, and the number of particles per unit volume. To increase viscosity and improve the consistency of the ice cream mixture, stabilizers were incorporated [4, 6].

The viscosity of fermented ice cream was determined using Formula (2) [9]:

$$D_B = T(D - D_1) \times K \quad (2)$$

where: $D_B$ – dynamic viscosity, Pa·s; $T$ – time until the balloon falls, s; $D$ – density of the ball, kg/m$^3$; $D_1$ – density of the ice cream mixture after pasteurization, kg/m$^3$; $K$ – viscometer constant.

*Microbiological studies.* For microbiological analyses, samples were taken in accordance with NSRF 26809.1-2014 Milk and dairy products. Acceptance

regulations, methods of sampling and sample preparation for testing; Sample preparation for microbiological analyses was carried out according to NSRF 26669-85 Food-stuffs and food additives. Preparation of samples for microbiological analyses; The number of lactic acid microorganisms was determined according to NSRF 33951-2016 Milk and milk products. Methods for determination of the lactic acid bacteria; The viable cell count of *Bifidobacterium bifidum* was determined in accordance with NSRF 33491-2015 Product fermented-milk, enriched bifidobacteria bifidum. Specifications [10,11]. Each experiment was carried out in triplicate (n=3). Statistical analysis of the data was performed using one-way ANOVA, and differences between means were considered significant at $p<0.05$. Results are expressed as mean ± standard deviation (SD).

**Research results and discussion.** As a biologically active additive intended for the enrichment of fermented ice cream, pollen was used, which meets the requirements of NSRF 28887-2019 Pollen beebred. Specifications, and TR CU 021/2011 On food safety (Tables 2,3).

Table 2

Organoleptic parameters of pollen

| Indicator | NSRF 28887-2019 Pollen beebred. Specifications | Results of the study |
|---|---|---|
| Appearance | Granular mass, easily loose | Complies |
| Colour | From cream to purple and black | Complies |
| Consistency | Hard, does not stretch in the fingers, flattens or partially crumbles when pressed with a hard object | Complies |
| Smell | A specific honey-flowery, characteristic of pollen | Complies |
| Taste | Pleasant, sweet, may be bitter or sour | Complies |
| Grain size:<br>transverse, mm, not less<br>longitudinal, mm, not more | <br>1.0<br>4.0 | Complies |
| Disintegrated legs in the amount of not more than 1.5% of the sample weight are allowed | | |

Table 3

Microbiological characteristics of pollen

| Indicator | TR CU 021/2011 On food safety | The results of the study |
|---|---|---|
| QMA&OAMO CFU/g, max | $1\times10^4$ | $1,6\times10^3$ |
| Coliform bacteria | Not allowed | Not detected |
| *E.coli* | Not allowed | Not detected |
| *S.aureus* | Not allowed | Not detected |
| *Salmonella* | Not allowed | Not detected |
| Yeast CFU/ g, max | 100 | Not detected |
| Mold CFU/g, max | 100 | Not detected |

The research results shown in Tables 2 and 3 indicate that the safety indicators of pollen used for fortification of fermented ice cream comply with technical requirements.

In the composition of pollen collected from various plant species, there is a change in the proportions of the color components. During the spring harvest, pollen is colored yellow, and by autumn it acquires brown and dark blue shades.

The percentage of color components in the composition of pollen is clearly shown in Figure 1.

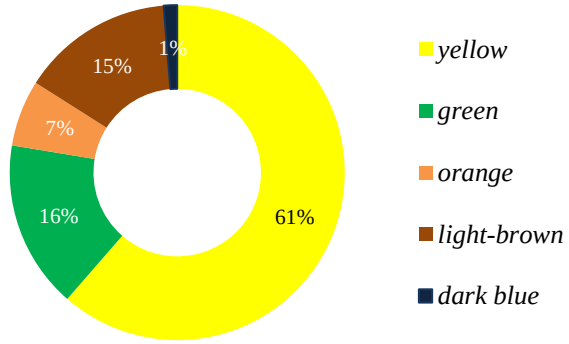
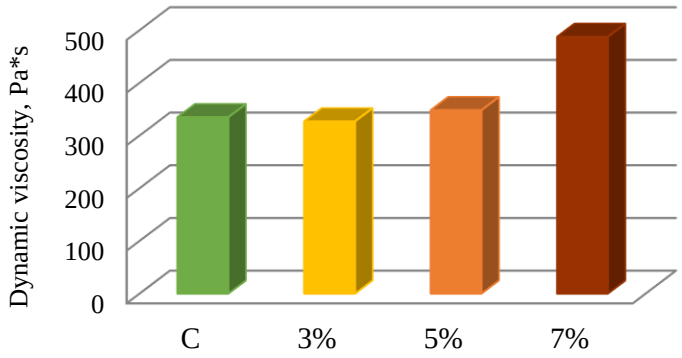



Fig. 1. Distribution of pollen mass by color

According to the data shown in the figure, 3/5 of the pollen is colored yellow, which indicates the presence of pigments in the pollen, and also suggests that the material was collected in the summer. Thus, pollen can be used as a natural dye to improve the consumer properties of fermented ice cream. In order to enrich it with pollen, concentrations of 3%, 5% and 7% were added.

The study determined the degree of influence of the stabilizer and pollen on the dynamic viscosity of the ice cream mixture. The viscosity of the mixture was measured using a VZ-246 viscometer. The results of mathematical calculations are shown in Figure 2.




C – the control sample, 3%, 5%, 7% – concentration of pollen in sample

Fig. 2. The dependence of the change in dynamic viscosity on the number of components in the mixture

During the study of the dependence of the dynamic viscosity (η, Pa·s) of fermented ice cream mixtures on pollen concentration, it was found that an ice cream sample enriched with pollen at a concentration of 7% showed the maximum value of dynamic viscosity. An increase in viscosity can negatively affect the organoleptic properties of the finished product, so the optimal concentrations of pollen are 3% and 5% [15,16].

In accordance with the presented recipe, fermented ice cream enriched with pollen and probiotic bacteria, organoleptic parameters were studied, in which 10 tasters participated. The results of this assessment are presented in the form of a profilogram in Figure 3.

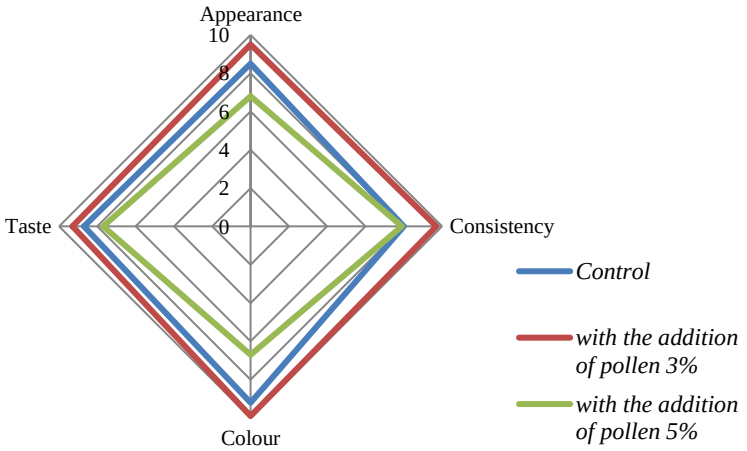



Fig. 3. Profilogram of organoleptic parameters of fermented ice cream

As a result of organoleptic studies, it was found that fermented ice cream enriched with 3% flower pollen received a score of 8.6 points on a ten-point scale. This indicator is the closest to the control sample (9.6 points). At the same time, ice cream enriched with 5% concentration of pollen was rated at 7.3 points. Based on the results of the study, it was revealed that the organoleptic properties of fermented ice cream enriched with 3% flower pollen are the most acceptable for further research.

In the process of fermentation of fermented ice cream, in addition to increasing its biological value, its nutritional and energy values also increases, which is due to biochemical processes. The nutritional and energy value of the resulting product is shown in Table 4.

Table 4

Nutritional and energy value of fermented ice cream enriched with pollen

| Indicator | Control | The finished product |
|---|---|---|
| Fat, g | 11.90 | 12.11±0.01 |
| Protein, g | 8.60 | 9.35±0.03 |
| Carbohydrates, g | 24.50 | 25.85±0.02 |
| Energy value, kcal | 45.00 | 47.31±0.02 |

According to the data in Table 4, when adding 3% of the concentration of pollen to the composition of fermented ice cream, the fat content increases by 1.7 g; protein – by 0.75 g; carbohydrates – by 1.35 g, which led to an increase in energy value by 4.9 kcal.

Given the high biological, nutritional and energy value of pollen, it can be concluded that adding 3% pollen to 100 grams of fortified fermented ice cream can provide a daily intake rate of 15%. The functional properties of fermented ice cream are ensured by the presence in it of biologically active amounts of probiotic

microflora and in the required amount of biologically active substances characteristic of livestock products.

The functionality of fermented ice cream is due to the presence in its composition of biologically active components inherent in natural bee products, as well as the presence of probiotic microflora in the required amount [17,18].

In accordance with the requirements of TR CU 033/2013 On the safety of milk and dairy products, the developed fermented ice cream meets the safety requirements according to the research results presented in Table 5 [19,20].

Table 5

Safety indicators of fermented ice cream

| Indicator | TR CU 033/2013 | The finished product |
|---|---|---|
| QMA&OAMO CFU/cm$^3$(g) | $1\times10^7$ | $3\times10^8$ |
| Yeast (Y), mold (M), CFU/cm$^3$(g), max | Y-10, M-50 | Not detected |
| Coliform bacteria (not allowed) | 1 cm (g) | Not detected |
| *E.coli* (not allowed) | 10 cm (g) | Not detected |
| Pathogenic, including *Salmonella* and *L.monocytogenes* (not allowed) | 100 cm (g) | Not detected |
| *S.aureus* (not allowed) | 10 cm (g) | Not detected |

The safety indicators of fermented ice cream enriched with pollen comply with the established standards in accordance with TR CU 033/2013, which indicates that they do not pose a danger to consumer health and are recommended for production. Statistical analysis (one-way ANOVA) confirmed that viscosity values differed significantly between samples ($p<0.05$). In particular, the 7% pollen sample showed a significantly higher viscosity compared with 3% and control. Similarly, sensory evaluation scores differed significantly: the 3% pollen sample was closer to the control, while the 5% and 7% samples were rated lower ($p<0.05$).

The results demonstrated that fermented ice cream enriched with 3% pollen provided the best balance between sensory properties and rheological stability. Higher concentrations (5% and 7%) led to excessive viscosity and a decrease in consumer acceptability, likely due to the bitter compounds and textural changes introduced by pollen.

These findings are consistent with earlier reports on the influence of bee products in functional foods, although previous studies mainly focused on honey or propolis. For example, Malakhov and Ogneva [10] observed that honey can improve flavor but may negatively affect texture at higher dosages. Similarly, Tvorogova et al. [11] emphasized the importance of balancing additives in fermented milk ice cream to maintain sensory quality. Our study extends this knowledge by showing that pollen at 3% concentration enhances nutritional and functional value without compromising consumer acceptance.

From a biochemical perspective, the protein-peptide spectrum and amino acid composition of pollen [21] likely contribute to improved nutritional properties, while its high content of polyphenols and pigments explains the negative impact on taste and texture at higher levels. Technologically, the addition of pollen increases viscosity, which can be beneficial up to a certain threshold but becomes undesirable when excessive.

**Conclusion.** The choice of fermented ice cream as an enrichment with bee products is theoretically and practically justified, which makes it possible to ensure the consumer properties of the finished product and bring its composition closer to the physiological consumption standards.

1. The optimal concentration of pollen in probiotic fermented ice cream was determined to be 3%, ensuring improved nutritional value without compromising sensory quality.

2. Pollen at 5% and 7% concentrations increased viscosity and negatively affected taste, limiting their application.

3. The study confirmed the microbiological safety and compliance of the developed product with food safety standards. During fermentation, it was found that a multicomponent mixture intended for fermented ice cream contains QMA&OAMO in an amount of $3\times10^8$ CFU/g and favorably contributes to the fermentation process

4. Practical recommendation: fermented ice cream enriched with 3% pollen and probiotics can be recommended for industrial production.

5. As a result of the study, it was proved that the expansion of the range of dairy products is also possible due to enrichment of bee products, including flower pollen. Future research should focus on shelf-life evaluation, consumer preference studies, and investigation of biochemical mechanisms behind sensory changes at higher pollen concentrations.

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## ҚЫШҚЫЛ СҮТТІ БАЛМҰЗДАҚТЫҢ САПА КӨРСЕТКІШТЕРІНЕ ГҮЛ ТОЗАҢЫНЫҢ ӘСЕРІН ЗЕРТТЕУ

**Аңдатпа.** Пробиотиктер тірі микроорганизмдер болып табылады, оларды жеткілікті мөлшерде тұтынған кезде тұтынушылардың денсаулығына бірқатар пайда әкеледі. Оларға ішек микрофлорасын жақсарту, иммундық жүйені белсендіру, қан құрамындағы холестеринді төмендету және ауру қоздырғыштардың өсуін тежеу жатады. Зерттеу жұмыстарының барысында *Bifidobacterium bifidum* және *Lactobacillus acidophilus* бактерияларының дақылдарын балмұздақ құрамына енгізу арқылы функционалды өнімдер ассортиментін ұлғайту көзделді. Қышқыл сүтті балмұздақты байыту мақсатында гүл тозаңының 3%, 5% және 7% концентрациясы енгізілді және балмұздақ қоспасының рецептуралары дайындалды. Байытылған қышқыл сүтті балмұздақ қоспасына жүргізілген зерттеулер нәтижесінде гүл тозаңының 5% және 7% концентрациясын енгізу органолептикалық және физикалық көрсеткіштеріне теріс әсерін тизгізетіндігі анықталды. Балмұздақ өнімдерінің тартымдылығын жоғары деңгейде сақтау үшін тағам өнеркәсібі үнемі қиындықтарға тап болады, өйткені функционалды балмұздақ пайдалы ғана емес, сонымен қатар дәмді болуы керек. Осы орайда, гүл тозаңының 3% концентрациясымен байытылған қышқыл сүтті балмұздақ барлық зерттеулер бойынша ең жақсы көрсеткіштерді көрсетті және өндісірке енгізу ұсынылды.

**Тірек сөздер:** балмұздақ, пробиотикалық бактериялар, гүл тозаңы, функционалды тағамдар, қышқыл сүтті балмұздақ.

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## ИССЛЕДОВАНИЕ ВЛИЯНИЯ ЦВЕТОЧНОЙ ПЫЛЬЦЫ НА ПОКАЗАТЕЛИ КАЧЕСТВА КИСЛОМОЛОЧНОГО МОРОЖЕНОГО

**Аннотация.** Пробиотики – это живые микроорганизмы, которые при достаточном потреблении приносят потребителям ряд преимуществ для здоровья. К ним относятся улучшение микрофлоры кишечника, активизация иммунной системы, снижение уровня холестерина в крови и подавление роста патогенных микроорганизмов. В ходе исследований планировалось увеличить ассортимент функциональных продуктов за счет включения в состав мороженого культур бактерий *Bifidobacterium bifidum* и *Lactobacillus acidophilus*. Для обогащения кисломолочного мороженого вводили концентрацию цветочной пыльцы в 3%, 5%, 7% и готовили рецептуры смесей для мороженого. В результате проведенных исследований смеси обогащенного кисломолочного мороженого было установлено, что введение 5% и 7% концентрации цветочной пыльцы оказывает негативное влияние на органолептические и физические показатели. Чтобы сохранить потребительские качества мороженого на высоком уровне, пищевая промышленность постоянно сталкивается с трудностями, ведь функциональное мороженое должно быть не только полезным, но и вкусным. В связи с этим кисломолочное мороженое, обогащенное 3% концентрацией цветочной пыльцы, показал наилучшие показатели во всех исследованиях и рекомендовано к внедрению в производство.

**Ключевые слова:** мороженое, пробиотические бактерии, пыльца, функциональные продукты, кисломолочное мороженое.