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TECHNICAL SCIENCES

SOUR MILK DRINK WITH PREBIOTIC PROPERTIES

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Abstract

The range of fermented milk products is quite diverse on the world market, but bifidogenic enriched dairy products are not common. Fermented milk products probiotics to restore the beneficial intestinal microflora in combination with probiotics and natural ingredients of plant origin is of great interest.

Industrial processing of functional ingredients allows to apply the principles of waste-free technologies, increasing food resources, thereby increasing the economic efficiency of the technology and eliminates environmental pollution. The implementation of research results in the production will create a competitive acidophilic product that combines harmonious organoleptic and functional properties, intended for use in both therapeutic and prophylactic purposes, and for mass use.

The use of bee pollen for the production of acidophilic products will give them bifidogenic and immunostimulatory properties that improve human health.

The dose of bee pollen (1.0%) and the technological stage of its introduction in the production of acidophilic product by thermostatic method have been recommended, i.e. pre-dissolution in hot milk for 5 minutes and cooled to fermentation temperature, application to the prepared milk base during fermentation before bottling.

The effectiveness of acid formation in the fermentation of acidophilic product with bee pollen have been investigated. When adding the additive, the acid formation process is more efficient reducing the fermentation time by 1.5 hours.

Keywords: acidophilus, sour milk drink, bee pollen, quality, sourdough.

Milk is the first and most valuable product for people on Earth. Breast milk is the first food and drink of a small child. For some time, they do not consume anything but milk growing very quickly and getting all the necessary nutrients for their development, i.e. proteins, fats, carbohydrates, vitamins, and sugar. All nutrients contained in milk are incorporated into the developing organism where it is needed [1].

The Russian scientist and academician I.P. Pavlov called milk amazing and the most perfect food prepared by nature.

Later, people noticed that the milk is not heat-treated, simply by boiling, it ferments quickly. Thus, the milk began to turn into a different product, a different consistency and taste. Hence the emergence of various fermented milk products.

The quality of sour milk drinks depends on the biochemical processes occurring under the action of yeast microorganisms, it also directly depends on the type of milk.

Milk of different mammal species is used for preparation of sour-milk products. Depending on the type of animal, the taste and consistency of the finished product will vary. For example, sheep milk and buffalo milk have a high fat content, so yogurt obtained from such milk will have a creamy consistency and the taste will be dominated by yogurt obtained from skim milk. Lactose, which is contained in milk, is a nutrient for yeast microorganisms, and proteins play an important role in the formation of the clot structure. Thus, the consistency and viscosity of the product will depend on the protein content in the raw material [2].

Cow milk of different breeds is used as a raw material for yogurt production in most world countries.

However, cows of the same breed will have different chemical compositions of milk. This is caused by the following factors, i.e. the age of the animal, the stage of lactation, time of year and air temperature, the completeness of milking and the interval between milking, feeding, animal health and others.

It is necessary to normalize or enrich the milk ensuring compliance with current or newly introduced standards for yogurt in terms of fat content and / or dry skimmed milk residue, obtaining a product meeting the standards for acidity, sweetness and consistency in order to meet consumer requirements; if the acidity and content of sugar or sweetener can be adjusted during production, the viscosity and consistency of yogurt, as noted above, is determined by the protein content of the source milk; in this regard, it is very important to enrich the milk (increase in dry skimmed milk residue) [3].

Whole milk powder or skimmed milk is also widely used in the production of dairy products to obtain a thick homogeneous yogurt. It is necessary for the enrichment of natural milk. The amount of added milk can range from 1 to 6% of the amount of source milk. 3-4% are widely used.

Powdered milk is an ideal raw material for the production of fermented dairy products. Depending on the heat treatment, and the storage temperature of the product, its quality may change, and subsequently the quality of yogurt made from this milk.

It is better to use skimmed milk powder because the use of dry whole milk can lead to an oxidized taste [4].

Milk processing enterprises have mastered the production of various types of fermented milk products.

The products fermented by acidophilic bacteria, i.e. acidophilic milk, acidophilic sour milk, acidophilic paste and acidophilic-yeast milk are the most interesting from a scientific point of view.

The dairy industry has developed a large number of different types of fermented milk products, products with acidophilic bacteria are of great interest. The *E. coli* was later called acidophilic; it was for the first time researched by I.O. Pidhaietskyi in 1903. He determined that the acidophilus bacillus takes root well in the intestine, and the products of its activity have a bactericidal effect. Acidophilic bacillus is a lactic acid bacterium that does not break down under the action of gastric juice, like other lactic acid bacteria [5].

Fermented milk products are enriched with acidophilic microorganisms, they contain B vitamins. The use of these products makes it possible to restore the intestinal microflora after aggressive exposure to antibiotics or chemotherapy. Acidophilic products are recommended for people with reduced immunity because acidophilic bacteria help the body produce interferon giving a person protection against the virus, it is the prevention of cancer.

Acidophilic microorganisms have found application in the pharmaceutical industry. This mixture of microorganisms is a dry or liquid biomass, it serves as a multifactorial treatment. We can conclude that the enrichment of fermented milk products with acidophilic bacteria as a probiotic is a promising area.

Lactobacillus acidophilus (acidophilic bacillus), the form of cells in milk, is long and short rods 3-40 μm in size and 1.0-1.5 μm thick. There is a granularity (polyphosphate grains) in cells.

The optimum growth temperature is 37-38°C. Milk coagulates in 5-8 hours; the maximum acidity of milk is 260-280°T. Some strains form a mucous clot. *Acidophilus bacillus* is a normal representative of the intestinal microflora of humans and warm-blooded animals. Therefore, it is resistant to the alkaline reaction of the medium (pH 8.3); presence in the environment of phenol (0.3-0.4%) and bile (20 %).

Acidophilic bacillus has a high antagonistic activity against putrefactive, opportunistic and pathogenic microflora. It produces two bacteriocins, i.e. acidophilin and lactocidin.

L. acidophilus is a valuable probiotic culture. Lactic acid rods of this species are used for the preparation of acidophilus, acidophilic milk, children fermented milk products [6].

Acidophilic bacillus is one of the species of lactic acid bacteria, it does not break down like others under the action of the aggressive environment of the stomach, its products have a broad bactericidal effect inhibiting the growth of pathogenic microorganisms, inhibiting putrefactive and fermentation processes. Due to the high content of B vitamins, acidophilic drinks should be consumed in the absence of these vitamins in the body. Acidophilic bacteria show endurance and are quite resistant to antibiotics and chemotherapeutic drugs. They actively suppress many types of pathogenic and opportunistic microorganisms, helping to restore their own normal intestinal microflora [7].

Acidophilic bacteria secrete enzymes promoting

the active digestion of proteins, fats and carbohydrates, the assimilation of trace elements, essential amino acids. They have a high vitamin-forming ability. Acidophilic bacteria stimulate the body production of interferon playing a very important role in antiviral and anti-cancer protection due to the production of a large number of harmless antibiotics.

Acidophilic products are useful in chronic intestinal diseases. Systematic consumption of such products eliminates intestinal disorders, and improves the general condition. Acidophilic products are also recommended for those who suffer from colitis, and liver disease. They are very valuable in cases where you have to take antibiotics for a long time. They prevent the development of diseases that can occur as a result of antibiotic suppression of the beneficial intestinal microflora. Acidophilic products are recommended for patients with tuberculosis, as well as for children with tuberculosis intoxication. They also serve as a good tonic for exhaustion, anemia, and weakness [8].

Beekeeping has been a source of honey and other valuable products for people. Wax is used in various industries. Bee pollen collected by bees is widely used in medicine and medicinal cosmetics. Bee pollen has recently succeeded. Thus, it is quite possible to place it next to honey.

Bee pollen is a fine powder of different colors depending on the species of plants, and the pollen of insect-pollinated plants is larger than the pollen of wind-pollinated (up to 250 μm), or very small (2-5 μm) and very sticky [9].

Dry pollen is a granular light loose mass with a grain size of 4.0-10.0 mm. Pollen color is from yellow to black, the characteristic smell is honey-floral, the taste is sweet, spicy, sometimes bitter or sour; the presence of toxic impurities is not allowed; the mass of non-toxic impurities should not exceed 0.1%; mass fraction of water is not more than 12%, crude protein is not less than 23.5%, crude ash is not more than 4%, ash of mineral impurities is not more than 0.6%, flavonoid compounds is not less than 10%; active acidity of pollen is not less than 4.04 units pH.

It is very difficult to distinguish the varieties of bee pollen collected from different plants; we have to deal with its mixture. Pollen grains have an extremely diverse shape. GOST 28887-90 Flower pollen applies to dried flower pollen collected by bees from flowering plants. This document regulates the use of pollen for food purposes and for industrial processing in the food industry, beekeeping and other sectors of the economy [10].

Bee pollen is the male gametes of flowering plants. When visiting flowering plants, many pollen grains stick to the hairy body of the bee. The foot brushes are tamped in the form of lumps in special bags on the paws.

Many beekeepers collect pollen with the help of special devices, i.e. dust collectors. A person can take up to half of all collected pollen. The rest of the raw materials must remain at the disposal of bees. They use pollen to feed the larvae. The bee will process most of the pollen into perga, i.e. pollen processed by bee glands and sealed in honeycombs for stock [9].

Bee pollen grains are treasure of excellent nutrients and medicinal substances, i.e. proteins, fats, carbohydrates, various vitamins, enzymes, minerals, and volatile substances. It is proved that the human body requires a protein that contains all ten essential amino acids (arginine, valine, histidine, isoleucine, leucine, lysine, methionine, threonine, tryptophan, phenylalanine), they can enter the body with food only because they are not synthesized by the body. Bee pollen contains large quantities of the essential and non-essential amino acids creating the body cells. Each pollen grain contains vitamins C (ascorbic acid), B₂ (riboflavin), B₆ (pyridoxine), B₅ (PP-nicotinic acid), B₃ (pantothenic acid), H (biotin), B₉ (folic acid), provitamin A (carotene), D (calciferol), E (tocopherol) and others.

It is proved that bee pollen contains at least 28 elements, i.e. sodium, potassium, nickel, titanium, vanadium, chromium, phosphorus, zircon, beryl, zinc, lead, silver, arsenic, tin, gallium, strontium, barium, uranium, silicon, aluminium, magnesium, manganese, molybdenum, copper, calcium, iron, copper, and cobalt. It is high in potassium, so necessary element for the body to support the heart muscle. Calcium, phosphorus, magnesium, zinc, iodine and others are very important for the human body. Bee pollen is rich in carotenoids, phytohormones and bactericidal substances [11].

The pollen contains fats and fat-like substances, i.e. phospholipids, phytosterols and others. Lauric, myristic, palmitic, stearic, arachidonic, oleic, linoleic, linolenic and other fatty acids have been found in bee pollen fats. The arachidonic acid is collected by bees from buckwheat and clover, it is mainly found only in animal fats [12].

A large number of carbohydrates (about 30%) were found in bee pollen, i.e. glucose and fructose. Bee pollen contains also disaccharides, i.e. maltose and sucrose, polysaccharides, i.e. fiber, starch, pectin. Bee pollen also contains large quantities of phenolic compounds, i.e. flavonoids and phenolic acids. They have a fairly wide range of effects on the human body, i.e. anti-inflammatory, anti-atherosclerotic, radioprotective, choleric, diuretic, antitumor and others.

Bee pollen contains enzymes that play an important role in metabolic processes. Bactericidal substances contained in bee pollen activate the body to fight viruses and bacteria.

Enzymes contained in bee pollen are essential for metabolic processes. They regulate (accelerate or slow

down) the most important biochemical processes.

Bee pollen is a component of highly active therapeutic and prophylactic drugs, vitamin and dietary foods. It is known that the Indians of pre-Columbian America ate bee pollen, namely, prepared delicious pies stuffed it [9].

Due to the high content of vitamins and trace elements, bee pollen is used in complex therapy for the treatment of cardiovascular diseases, atherosclerosis, meningitis, nervous and mental diseases, endocrine disorders, prevents hemorrhage.

Bee pollen is recommended for physical exhaustion, anemia, in the recovery period after severe illness. The use of bee pollen increases immunity, and therefore it is recommended to use it during epidemics of influenza and to raise the level of hemoglobin in the blood.

Bee pollen is recommended for weather-sensitive people. It is noted that bee pollen has pronounced antisclerotic properties [10].

Bee pollen is universal for the cardiovascular diseases' treatment. It improves the condition of hypotonics, relieves dizziness, and prevents headaches. It has a good effect on coronary heart disease, heart disease, cardioneurosis, and rheumatism.

Parallel intake of bee pollen enhances the effect of phytotherapeutic agents. The complex intake of bee products leads to the best effect in chronic diseases of the lungs and other respiratory organs.

Many women take bee pollen preventing the breakdown of proteins in the body, while the amount of adipose tissue is significantly reduced.

Some doctors warn that the consumption of large amounts of bee pollen can cause a violation of the vitamin balance of the body. Therefore, after a course of treatment with bee pollen need a break.

Thus, the application of bee pollen in the production of fermented milk beverages is appropriate and relevant.

The aim of the work is to develop the technology of acidophilic product with prebiotic properties on the basis of bee pollen and evaluation of its functional properties.

Commonly accepted and standard methods were used to determine the properties of the studied objects and technological processes.

The structural and logical scheme of research is presented in Figure 1.

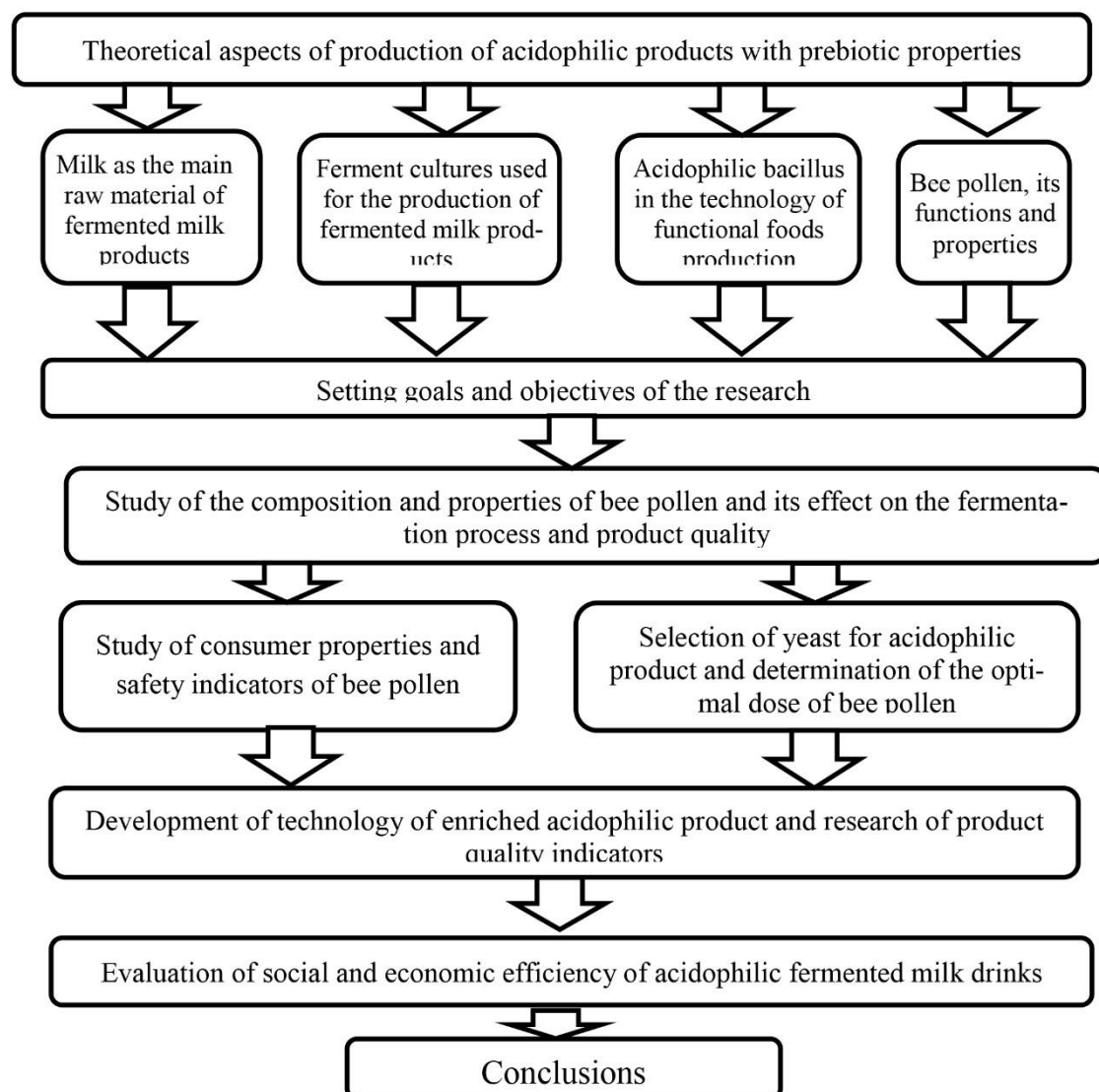


Fig. 1. Structural and logical scheme of research

The new generation of food products with their nutritional and energy value, organoleptic and physical properties meet modern ideas of nutrition science and consumer demand. The consumer properties of products are characterized by three components, i.e. nutritional value, taste and directed physiological action. In today's market, traditional foods are characterized by these components.

Bee pollen was chosen to enrich the acidophilic fermented milk drink.

Bee pollen is a complex, concentrated plant-bee product with unique consumer and medicinal properties. It is a collection of pollen grains, or male gametophytes, of seed plants collected and processed by the nectar and secretion of the salivary glands of bees.

The organoleptic properties of the product are one of the important factors assessing the quality of the product. Thus, the organoleptic parameters of the researched bee product were investigated (Table 1).

Table 1

Organoleptic indicators of bee pollination	
Characteristic	Characteristics according to SSU 3127 - 95
Appearance and consistency	Dried lumps with a diameter of 1-2 mm or partially crumbs of pollen
Taste and smell	Honey-flower, without extraneous tastes and smells
Colour	From light yellow to brown

Bee pollen is a source of valuable nutrients. It also contains lipids (phospholipids, mono- and diacylglycerols, free phytosterols, esterified phytosterols). Bee pollen is characterized by a high content of fatty acids, in particular monounsaturated and polyunsaturated. Depending on the species affiliation, the content of

these acids varies within the following limits, i.e. palmitic (22–25% of the total acid), oleic (12–17%), linoleic and linolenic acids (the latter two are 22–25%) [13].

Bee pollen contains more than 250 components, i.e. proteins, essential amino acids, carbohydrates

(mainly fructose and glucose), minerals, a set of vitamins, enzymes, nucleic acids, lipids, phytosterols, vitamins (E, C, B₁, B₆, B₁₂, PP), macro- and microelements (potassium, calcium, magnesium, iron, zinc, copper, cobalt, phosphorus, manganese, sulfur, silver, nickel, sodium, chlorine), phenolic compounds (catechins, flavonoids, anthocyanins, chalcones and phenolic acids), phytohormones.

The main essential amino acids are arginine (4.4–5.7%), histidine (2.0–3.5%), isoleucine (4.5–5.8%), leucine (6.7–5, 9%), glycine (5.9–7.0%), methionine

(1.7–2.4%), phenylalanine (3.7–4.4%), and tryptophan (1.2–1.6%). Bee pollen contains up to 50 enzymes, including amylase, invertase, phosphatase, catalase, peroxidase, phosphorylase etc.

The nutritional value of fermented milk products is mainly determined by the quantitative content in their composition of proteins, fats, carbohydrates, vitamins, macro- and micronutrients.

Thus, it is important to research the nutritional value of supplements. The chemical composition of additives was established (Table 2).

Table 2

Chemical composition of bee pollen, %	
Indicators	Values
Humidity	10.73± 0.41
Dry matter	89.27±0.63
Lipids (fats and fat-like substances)	9.37± 0.79
Protein (crude protein)	35.62± 0.71
Carbohydrates (total)	42.06± 0.13
Ash	2.22± 0.42

According to table data, bee pollen is characterized by high protein and carbohydrate content, their total number was 77.68% of the total mass.

Bee pollen is an extremely useful, valuable and high-quality source of vitamins and trace elements necessary for the vital functions of the human body.

Amino acids are the building material for the body cells, so it is very important that they are present in daily foods.

Sourdough is one of the main factors influencing

the quality of sour milk drinks. A special role is given to the choice of fermenting bacteria that will provide the necessary organoleptic, microbiological and physicochemical parameters of the finished fermented milk product.

The technological process of production of fermented milk products with different types of sourdough in the laboratory is presented in Fig. 2.

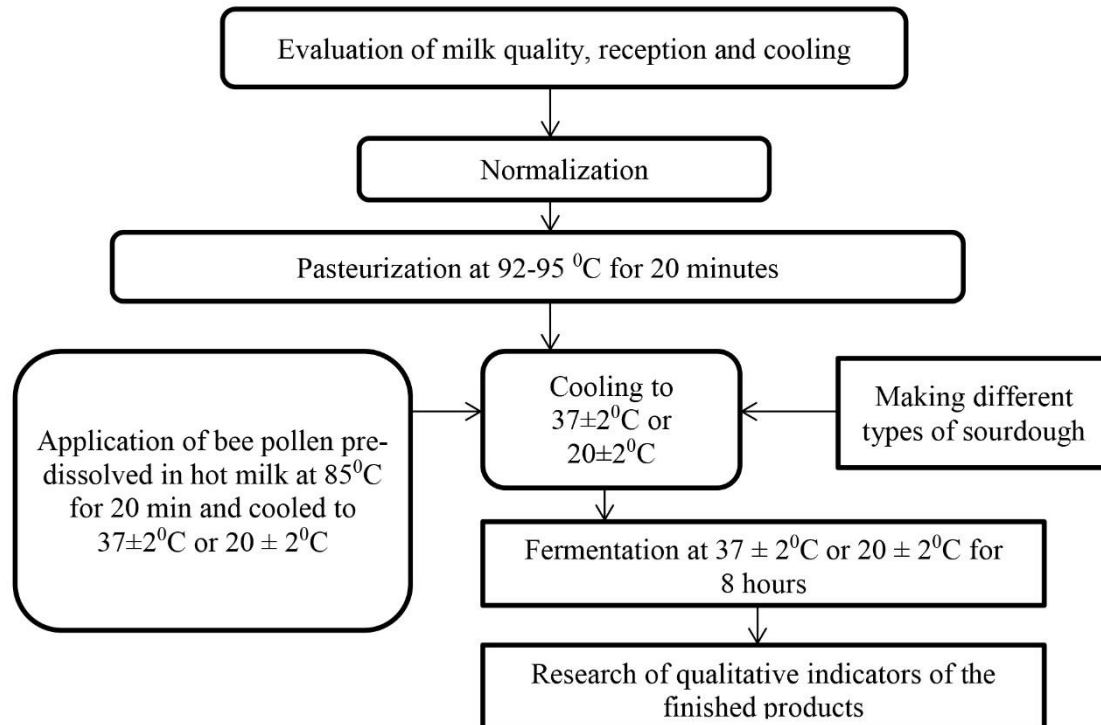


Figure 2. Technological process of sour-milk products production

Dry sourdough was introduced directly from the package into the prepared, normalized, pasteurized and cooled to the fermentation temperature milk mixture with bee pollen.

Then, the mixture was thoroughly mixed and left for fermentation, the duration of which depends on the type of bacteria and their activity.

Sourdough quality was checked before it using.

Good quality sourdough should ferment milk quickly, have a clean taste and smell. The clot should be homogeneous, dense, free of gas and serum. As is known, the initial quality of the sourdough determines the taste and smell of the finished product.

Two sourdoughs were taken for further research, i.e.

- combined sourdough *Lactobacillus acidophilus*

+ *Bifidobacterium longum* + Milk yeast (№1), Italy is a manufacturer;

- combined sourdough *Lactobacillus acidophilus* + *Bifidobacterium complex* (№2), Bulgaria is a manufacturer.

Fig. 3. includes research of organoleptic indicators in the enriched products fermented by different types of sourdough.

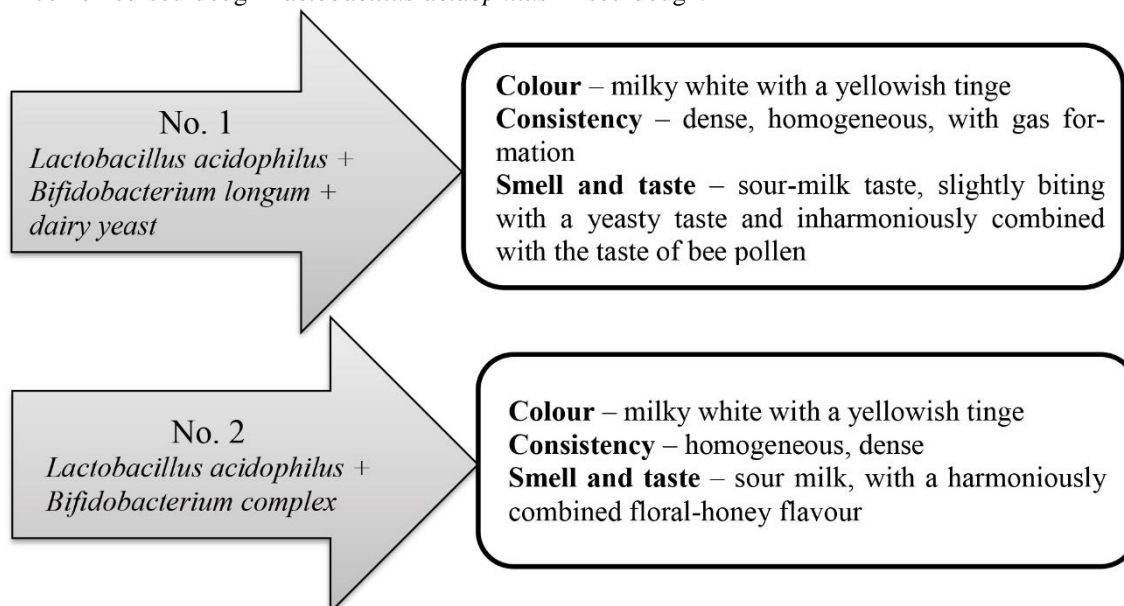


Fig. 3. Organoleptic evaluation of fermented milk drinks fermented by different types of sourdoughs

According to organoleptic evaluation, first sample of fermented milk product fermented with lactic yeast and *Lactobacillus acidophilus* + *Bifidobacterium longum*, is characterized by fermented milk taste with a slightly biting yeasty taste, which is inharmoniously combined with bee pollen.

The sample with a combined sourdough of acidophilic and bifidobacteria (*Lactobacillus acidophilus*

+ *Bifidobacterium complex*) was the best one, because it has a harmoniously combined floral-honey taste and aroma.

Samples were produced to determine the efficiency of acid formation of enriched products, and the titrated acidity of figs was investigated every 2 hours (Fig. 4).

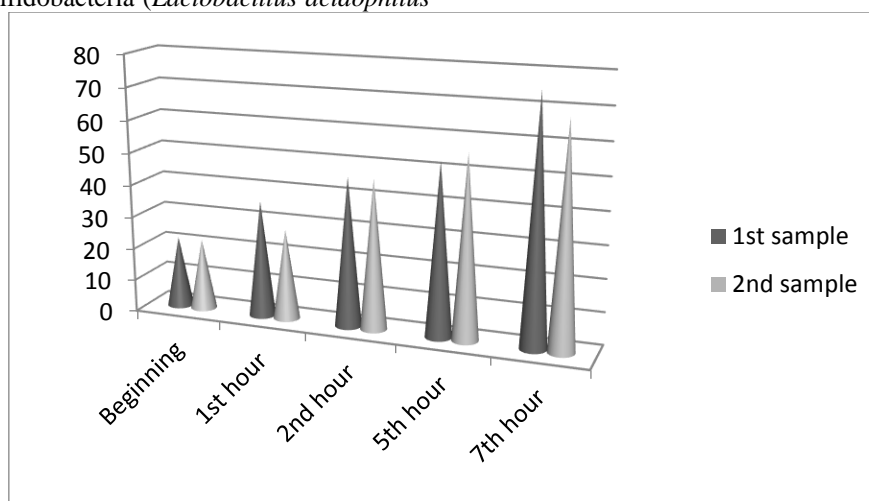


Fig. 4. Efficiency of acid formation of products by various sourdoughs (No. 1 *Lactobacillus acidophilus* + *Bifidobacterium longum* + Dairy yeast; No. 2 *Lactobacillus acidophilus* + *Bifidobacterium complex*)

Thus, the acid formation process is more efficient in the sample with acidophilic bacteria and dairy yeast (No. 1). It should be noted that the sample with the combined sourdough of acidophilic and bifidobacteria (No. 2), *Lactobacillus acidophilus* + *Bifidobacterium complex* differs slightly from the sample No. 1 (less

than 10⁰T). However, it was much better but organoleptic parameters. We can conclude that the combined sourdough of acidophilic and bifidobacteria (*Lactobacillus acidophilus* + *Bifidobacterium complex*) has the highest consumer properties and will be selected as a working sourdough for further researches.

Further researches were conducted in order to select the dose of bee pollen for the production of acidophilic fermented milk product. The dry sourdough of lactic acid bacteria *Lactobacillus acidophilus* and *Bifidobacterium complex* and, pre-dissolved in milk

bee pollen in the amount of 1%, 1.5% and 2%, were added in pasteurized and cooled to $37 \pm 2^{\circ}\text{C}$ milk, it was mixed and left to ferment until the formation of a dense clot and achieve a titratable acidity of 65-70 °T. The results obtained are presented in table 3.

Table 3

Organoleptic parameters of acidophilic drinks with different bee pollen concentrations

Indicator	Bee pollen concentrations		
	1%	1.5%	2%
Taste and smell	Sour milk with a harmonious pleasant honey-floral taste and aroma	Sour milk with a pronounced honey-floral taste and aroma	Weakly sour milk with excessively expressed taste of bee pollen
Appearance and consistency	Dense, homogeneous with undamaged clot and little sediment	Dense, homogeneous with undamaged clot, a thin yellow film on the surface, and a well-marked sediment at the bottom	Dense, homogeneous with undamaged clot, a thin yellow film on the surface, and a well-marked sediment at the bottom
Colour	Light cream with a yellowish tinge throughout the mass	Creamy yellow throughout the mass	Bright yellow throughout the mass

Analysis of the table data shows that a sample of acidophilic fermented milk drink with a concentration of bee pollen of 1% has the most harmonious taste and smell. The efficiency of the acid formation process depending on different concentrations of bee pollen

(1.0%; 1.5%; 2%) was also researched.

Table 4 has got results of ready acidophilic sour-milk products scoring.

Table 4

Organoleptic scoring of a product with bee pollen different concentrations

Sample	Indicator	Taster				
		1	2	3	4	5
1%	Colour	5	5	5	5	5
	Smell	5	4	5	5	5
	Taste	4	4	4	5	5
	Consistency	5	5	4	5	5
	Aftertaste	5	5	5	5	5
Average	4.8	4.8	4.6	4.6	5	5
1.5%	Colour	4	4	4	4	4
	Smell	5	4	5	5	4
	Taste	4	3	4	4	3
	Consistency	4	3	3	4	4
	Aftertaste	5	4	4	4	5
Average	4.0	4.4	3.6	4	4.2	4
2%	Colour	4	4	4	4	4
	Smell	4	3	4	4	3
	Taste	4	3	3	4	3
	Consistency	4	4	4	5	3
	Aftertaste	4	3	4	3	4
Average	3.7	4	3.4	3.8	4	3.4

Fig. 5 contains a graphical representation of the profilogram of organoleptic quality assessment of finished acidophilic products with bee pollen different concentrations.

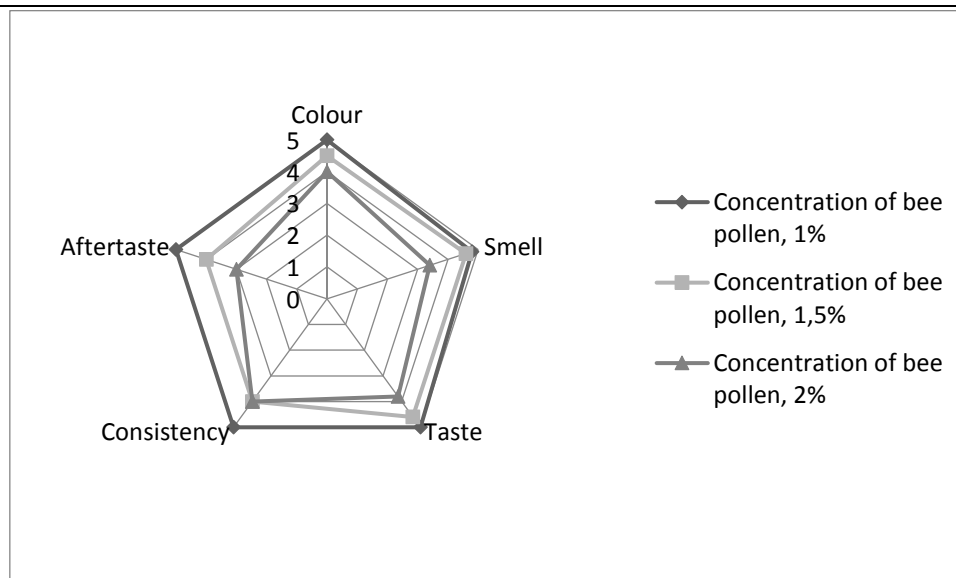


Fig. 5. Profilogram of average acidophilic product organoleptic evaluation

Fermentation was performed until a clot formed and the titratable acidity reached 65-70 °T. Titrated acidity was determined every hour.

According to our research results, the introduction of bee pollen into acidophilic fermented milk products affects the growth of the titrated acidity of the product and its organoleptic characteristics. Thus, the introduction of 1%, 1.5% and 2% of bee pollen caused an increase in titratable acidity compared to control and achieve the required acidity of 70-75 °T after 5 hours, while the control sample of this acidity reaches after 6.5 hours of fermentation.

The results show a reduction in the fermentation process by 1.5 hours, which will save energy. It should be noted that the taste of samples with bee pollen was pleasant and harmonious, even when the titratable acidity of 90-95 °T.

Thus, taking into account the research results, we will use 1% bee pollen concentration for further researches.

The biological value of the product characterizes the quality of the protein component of the product due to the degree of balance of amino acid composition.

The biological value of proteins depends on the ratio of essential amino acids (lysine, methionine, tryptophan, phenylalanine, leucine, isoleucine, threonine, valine), which cannot be synthesized in the human body and should be consumed with everyday food.

The biological value of acidophilic products and their components was investigated by the content of amino acids (Fig. 6), primarily essential, at the end of the expected shelf life (10 days).

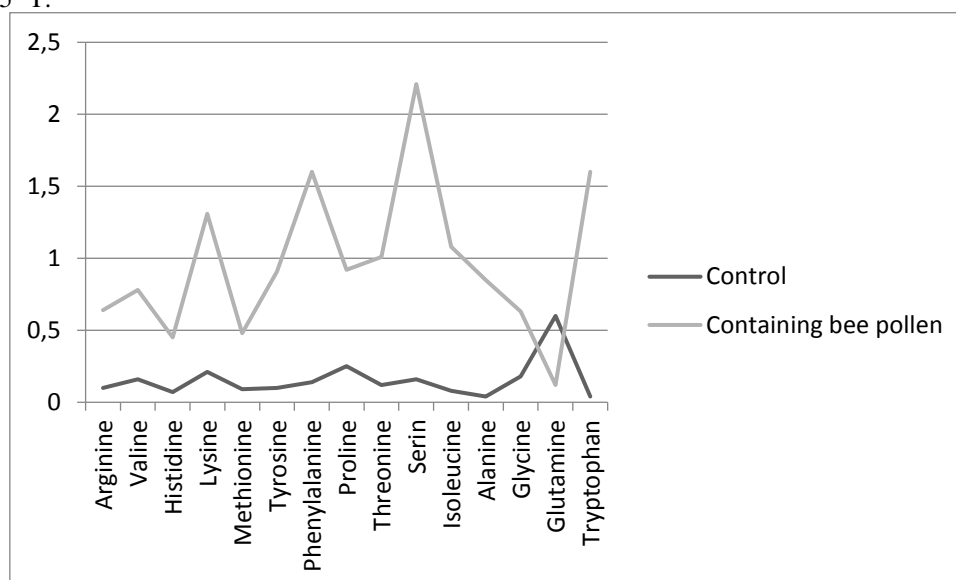


Fig. 6. The content of amino acids in the developed acidophilic product with bee pollen in comparison with the acidophilic drink (control), (g / 100 g).

As a result of the experiment it was found that there was an increase in the content of some amino acids due to the introduction of bee pollen into the recipe.

Lysine is one of the essential amino acids necessary for normal growth, tissue regeneration, production of antibodies, enzymes and hormones. Lysine is involved in muscle building and collagen formation,

forms the connective tissues of the body. Enrichment of the product with bee pollen increased lysine by 1.1 g

Therefore, the qualitative indicators of the acidophilic product were researched. It is established that their nutritional value and consumer properties are higher than traditional drinks. The introduction of bee pollen helps to increase the content of vitamins and minerals, as well as increase the biological value of the developed product; the amount of essential amino acids increased by 20%.

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АЗОТИРОВАНИЕ ИНСТРУМЕНТАЛЬНЫХ СТАЛЕЙ

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NITROGENING TOOL STEELS

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Аннотация

В статье исследованы различные группы инструментальных сталей (быстрорежущие штамповые стали для штампов холодной штамповки, стали для штампов горячей штамповки и менее легированные стали) и влияние состава сталей на процесс азотирования. Установлены оптимальные режимы азотирования высокоуглеродистых инструментальных сталей, рекомендовано азотирование режущих насадных инструментов вместо цианирования.

Abstract

The article investigates various groups of tool steels (high speed die steels for cold stamping dies, steels for hot stamping dies and less alloyed steels) and the effect of the composition of steels on the nitriding process. The optimal modes of nitriding of high-carbon tool steels have been established, nitriding of cutting attachment tools is recommended instead of cyanidation.

Ключевые слова: состава, режимы, азотирование, быстрорежущие, диффузия, сталь, высокоуглеро- дистых.

Keywords: composition, modes, nitriding, high-speed, diffusion, steel, high-carbon.

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