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Наведені результати розробки синбіотичного комплексу, який складається з іммобілізованих форм біфідобактерій та інуліну. Досліджено вплив даної добавки на структурно-механічні властивості жирової начинки і органолептичні показники вафельних виробів. Встановлено збільшення ефективної вязкості і пластичної міцності начинки. Комбіноване застосування інуліну та іммобілізованих біфідобактерій дозволить покращити консистенцію і смак готових виробів

Ключові слова: іммобілізовані біфідобактерії, інулін, синбіотичний комплекс, структурно-механічні властивості, вафельні вироби

Приведены результаты разработки синбиотического комплекса, который состоит из иммобилизованных форм бифидобактерий и инулина. Исследовано влияние данной добавки на структурно-механические свойства жировой начинки и органолептические показатели вафельных изделий. Установлено увеличение эффективной вязкости и пластической прочности начинки. Комбинированное применение инулина и иммобилизованных бифидобактерий позволит улучшить консистенцию и вкус готовых изделий

Ключевые слова: иммобилизованные бифидобактерии, инулин, синбиотический комплекс, структурно-механические свойства, вафельные изделия

RESEARCH INTO EFFECT OF THE SYNBIOTIC COMPLEX ON THE QUALITY OF A FAT FILLING FOR WAFFLES

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1. Introduction

A growing number of Ukrainians are changing their preferences in food, showing increased interest in the products that are most beneficial for health, basing their choice not on the amount of food consumed but rather its quality.

Food and nutrition occupies a leading place in enabling normal growth and development of the body, protecting it from diseases and harmful influences, maintaining physical and psycho-emotional activity and active longevity.

There is a close relationship between a human's health and composition of his intestinal microflora. Microflora of the intestine is involved in the symbiotic digestion, inactivation of excessive digestive secretions and enzymes, and in the processes of synthesis of the most important nutrients and endogenous regulatory factors [1].

The most important function of the microflora is the transformation, activation, digestion, circulation, inactivation, discharge (Fig. 1).

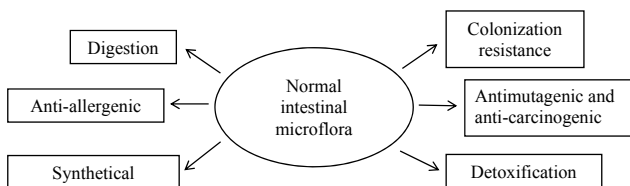


Fig. 1. Functions of normobiocenosis of GIT

Economic development of the planet is accompanied by the introduction into life of ever-growing number of chemical compounds with potential toxic effect on the microbial population. These include organic and inorganic compounds, medical preparations, pesticides, food additives. Ukraine, due to a significant depreciation of production funds of enterprises, constantly faces conditions for the occurrence of various technogenic disasters. This is accompanied by the penetration of harmful compounds into the environment. At present, most of the country's population breathe atmospheric air that contains xenobiotics.

Many household-drinking water supply pipelines lack systems for water pre-treatment and decontamination. All these conditions, as well as antibiotic therapy, the intake of hormonal, immunosuppressive, laxative, choleric and other medicines, irrational nutrition, stresses, intestinal infections, adverse exoecological conditions, lead to the development of dysbiotic disorders of the intestine (Table 1) [2].

It is estimated by physicians that from 75 to 90 % of our fellow citizens in one way or another are prone to intestinal dysbacteriosis, that is, it is possible to argue about a pandemic of dysbacteriosis. That is why the products of functional designation, containing in their composition special ingredients that correct disturbance of intestinal microflora, take one of the top places in comprehensive prevention of diseases, at which the dysbiosis is registered. Functional ingredients contained in the product's composition include synbiotics [3].

Table 1

Causes and factors underlying the development of dysbacteriosis

Exogenous:
Professional (industrial contamination)
sanitation
physical and chemical
climatic-geographical
Endogenous:
immune disturbance
stress conditions
somatic diseases (diseases of the intestine, ulcer of stomach and duodenum, resection of the stomach, disease of gall bladder and biliary tract, liver and pancreas)
infectious diseases
intestinal ischemia
diabetes mellitus
old age
irrational nutrition
hunger
medical impact (antibiotics, preparations, locally anesthetizing, adsorbent substances and other means can change the motor of mucous, break the formation of mucin)

Synbiotics are a combination of the pro- and prebiotic through which they exert a mutually reinforcing influence on the physiological functions and metabolic processes in the human body. Designing confectionery products with a rationally chosen composition of probiotic microorganisms, prebiotics as functionally active ingredients whose deficit is a consequence of the dysbiosis, is a reasonable approach to solving this important problem.

2. Literature review and problem statement

Under conditions of tough competition, manufacturers of confectionery products realize that survival in the market environment is impossible without the creation of products of high quality and functional designation.

Up to now, however, Ukrainian confectionery industry has failed to manufacture products using pro-, prebiotics, and synbiotics. At the same time, the Russian company “Art Life” developed a series of candies, enriched with the probiotic cultures of microorganisms. They are recommended for consumption as an affordable preventive means. The result of consumption is maintaining intestinal microflora, normal digestion and renewed microflora after a course of antibiotic use, dysbacteriosis of different etiologies, at intestinal infections [4].

A fat filling for flour pastry was also developed with a full replacement of sugar with palatinoza and the introduction of Jerusalem artichoke powder in the range of 7 % as it possesses prebiotic properties. The studies conducted have shown that the introduction of palatinoza and the Jerusalem artichoke powder affected physical-chemical properties of the fat filling, as well as on rheological and organoleptic characteristics. The devised technological techniques made it possible to obtain the filling with a reduced fat content and with improved physiological value [5].

Paper [6] reported studies into reducing energy value and sugar content by replacing sugar and part of fat with the sweet agent Beneo™ Synergy1, consisting of the powder

of inulin and oligofructose. The introduction to the formulation of this supplement as a sweet agent makes it possible to obtain a confectionary product with dietary and prebiotic properties.

A possibility of using the dietary fibers (DF) Citri-Fi was investigated for producing fat fillings in order to reduce fat content of the product. The obtained results show that DF, in addition to functionality, have high moisture-binding and fat-binding capacity, they produce a positive effect on the structure of fat and can be employed in the composition of a fat formulation [7].

Researchers studied the possibility of obtaining wafers with the use of the prebiotic fiber inulin. They investigated samples of a fat filling with the introduction of various mass fraction of the prebiotic. The obtained experimental data on determining the impact of inulin on the rheological properties of a semi-finished product and organoleptic indicators of the finished products indicate the prospects for introducing the given additive to the formulation of a fat filling [8].

The moisture-resistant waffles are proposed, which contain a small amount of sugar. The composition of waffles includes 0...8 % of sucrose, starch hydrolysate, inulin hydrolysate, and a mixture. The waffle composition is additionally added with proteinase and/or xylanase. In addition, the liquid batter is supplemented with 0.0005–1.0 % of heat-resistant α -amylase. Fat content in waffles is <4 % [9].

There have been developed new types of fat filling with introduction to the formulation of bifidobacteria and lactobacillus as probiotics. Conducted experiments have shown that the introduction of probiotic microorganisms provides consistent quality of finished products and makes it possible to effectively regulate duration of the technological process [10].

It was proposed to use in the formulation of a fat filling the probiotics – Bifilakt A and Bifilakt D, as well as the prebiotic Beneo™ Synergy1. The paper investigated the effect of additive on the rheological properties of the model system and determined optimum amount of the additive in order to obtain a high-quality filling [11].

In article [12], authors conducted a study on the introduction of pro-, prebiotics, and synbiotics to the formulation of chocolate. They explored the positive and negative aspects of the designed functional products in comparison with the standard products. It was concluded that the obtained results had to be confirmed by *in vitro* and *in vivo* studies.

Scientists have developed a synbiotic based on the microorganisms *B. indicus* HU36 and food fibers (FF) – maltodextrin and lemon fiber. The influence of the additive on the organoleptic properties of dark chocolate was examined. Authors studied the survival of microorganisms when introduced to the formulation of chocolate. They proved the impact of FF on the sensory properties of the finished product: sweetness and firmness [13].

In paper [14], milk chocolate was prepared by introducing free or encapsulated *Lactobacillus casei* NCDC 298 and inulin. The number of *Lactobacillus* remained above 10⁸ cfu/g over the period of storage of 60 days. It was discovered that the introduction of these ingredients helps to improve microbiological properties of the finished product during storage. A sensory analysis has confirmed good taste indicators of chocolate with synbiotic properties.

Paper [15] presented various possibilities for enriching bakery and confectionery products with probiotic microorganisms. In particular, a confectionary cream, enriched with six kinds of microorganisms. It was examined that they

retain their viability after storing at a temperature of 20 °C. The probiotic confectionary cream has a pleasant slightly sour taste.

Article [16] reports studies on using synbiotics in the technology of nougat. Synbiotic complex was developed based on a probiotic – microorganisms of the *Bacillus coagulans* family and a prebiotic – the low-calorie sweeteners isomalt and sorbitol. The authors investigated the survival of bacteria at high temperature and after a long period of storage of the finished product. The influence of prebiotic on the texture of nougat was examined. They also studied the survival of bacteria over the entire period of shelf life of the finished product. It was established that in 6 months the number of living cells of the microorganisms was 10⁶ cfu/g.

Thus, the above works considered the introduction to the formulation of various confectionery products of pro- and prebiotics. It should be noted that there are practically no studies aimed at developing the synbiotics and exploring their impact on the quality of finished products. The papers report results on the introduction of probiotics to the formulations of confectionary products, but fail to take into account the effect of technological factors on their survival. There is no research into techniques that “protect” microorganisms from the unfavorable factors.

We developed at Odessa National Academy of Food Technologies (Ukraine) the symbiotic complex, which consists of the immobilized forms of bifidobacteria and inulin. Employing it in the technology of waffle products opens up new pathways to create products with functional properties. That is why it is advisable to examine the influence of synbiotic on the structural-mechanical and organoleptic quality indicators of a fat filling.

3. The aim and objectives of the study

The aim of present work is the scientific substantiation of creating a symbiotic complex and experimental confirmation of the feasibility of using it in the technology of a fat filling.

To achieve the set aim, the following tasks have been solved:

- to develop a synbiotic complex based on the immobilized bifidobacteria *Bifidobacterium bifidum* and the prebiotic inulin;
- to determine effect of the synbiotic complex on the structural-mechanical and organoleptic properties of a filling for waffles;
- to assess consumer properties of the obtained waffle products.

4. Materials, objects, and methods of research

The object of research is the organoleptic, physical-chemical properties of the fat filling. The subject of research is a fat filling with the synbiotic complex – we used microencapsulated bifidobacteria as the probiotic, and inulin as the prebiotic. The samples differed by the mass fraction of inulin (10, 20 and 30 % of inulin). We used the wafers “Artek” as a control.

The examined materials and research methods are described in detail in [17].

5. Results of research into organoleptic, physical-chemical properties of a fat filling with the synbiotic complex

5.1. Design of the synbiotic complex for a fat filling

One of the most important groups of symbiotic microflora of the human is the genus *Bifidobacterium*. Representatives of this genus are the natural inhabitants of the large intestine of children and adults. In this case, many species exert a considerable number of positive effects on the owner's body [18]. Bifidobacteria, which are constantly present in the gastrointestinal tract and mucous of the human, participate in the morphogenesis and functions of different systems of the host's organism – digestive, immune, cardiovascular, endocrine, etc. This happens due to the participation of bifidobacteria in the metabolism of proteins, lipids, carbohydrates, as well as due to the large number of produced biologically active substances: enzymes, extracellular proteins, polysaccharides [19–21].

It was found that bifidobacteria perform the following functions:

- they carry out physiological protection of the intestinal barrier against penetration of germs and toxins inside the internal environment of the body by associating with the bowel's mucous membrane;
- they possess high antagonistic activity against pathogenic and conditionally pathogenic microorganisms due to the generation of organic fatty acids;
- they take part in the recycling of food substrates and activation of parietal digestion;
- they synthesize amino acids and proteins, vitamin K, pantothenic acid, the B group vitamins: B₁ – thiamine, B₂ – riboflavin, B₃ – nicotinic acid, B₆ – pyridoxine [22].

Until recently, in order to prevent and treat dysbacteriosis, the pharmacopoeia preparations and/or functional food products were consumed, which include probiotic microorganisms in their composition. It is generally known, however, that bifidobacteria are the anaerobic microorganisms, that is, the bacteria that live in the oxygen-free environment. They are also very sensitive to acidic environment and temperature impacts. In addition, bifidobacteria occupy a very specific ecological niche in the biocenosis of the “owner's” bowel. That is why the designers of products with functional properties face the following problems in terms of survival and delivery of bifidobacteria to the large intestine (Fig. 2).

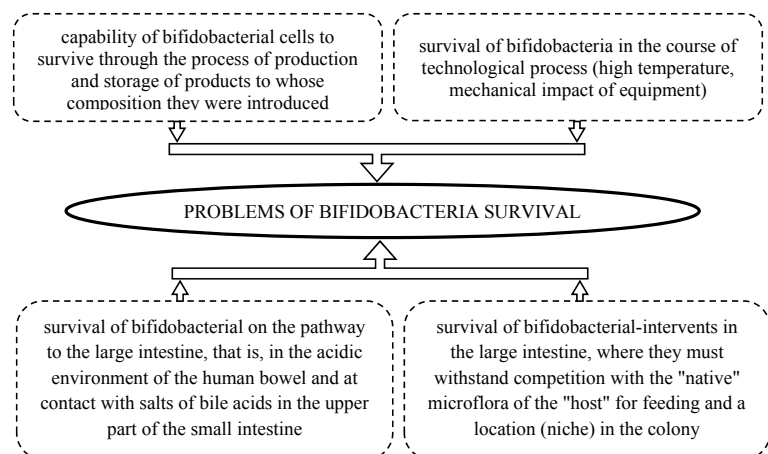


Fig. 2. Problems of the bifidobacteria survival

The decision was made to “protect” the cells of bifidobacteria from the effects of adverse conditions. To do this, authors of [23, 24] employed the process of immobilization and obtained the microcapsules with bifidobacteria coated with a protective sheath.

There was also another technique to influence the intestinal microflora. It is based on the properties of certain food materials to reach, unchanged, the large intestine, where they serve as the breeding medium for bifidoflora. These substances are called bifidogenic or prebiotic.

Inulin was applied as a prebiotic in the studies on designing the synbiotic complex. Inulin is the organic matter of polysaccharides, which is received as a result of processing roots and tubers of some plants. One of the most important properties of inulin is that it withstands the effect of digestive enzymes that are found in our stomach. Inulin has a slightly sweet taste, a neutral color and smell, it improves the volume, texture and taste of the product. It forms a white opaque soft cream-like gel that mimics the texture of fat. It possesses high solubility and thermal stability, has moisture-retaining properties, increases stability of the emulsion, improves the organoleptic and physical-chemical characteristics of the finished product.

The molecules of inulin, while entering the digestive tract, under the influence of hydrochloric acid, are split into fructose and other elements that penetrate the bloodstream. The unsplit part of inulin is associated with glucose in the blood, reducing thereby the concentration. The unsplit inulin is also bound with ketones, acetones, various toxins, fatty acids and cholesterol, removing them from the human body, providing a beneficial effect on the general health condition [22].

In the large intestine inulin is processed by bifidobacteria. Thus, bifidobacteria receive an exclusive feed supply that provides active growth. Numerous clinical studies, conducted in various countries, showed that in all cases the introduction of inulin led to a substantial increase in the population of bifidobacteria, while suppressing at the same time the pathogenic organisms [25].

Thus, inulin possesses important dietary properties, which make it possible to position the finished food products as the dietary, functional and enriched products. It also has a reduced calorie content of 1 Kcal/g; suitable for the diabetic diet; it possesses important technological properties, which make it possible to obtain products with a reduced fat and sugar content, to improve texture, stability, and taste.

Given the above, we decided to create the synbiotic complex whose composition includes immobilized cells of bifidobacteria as the probiotic, and inulin as the prebiotic.

5. 2. Effect of the synbiotic complex on the structural-mechanical properties of a filler for waffles

Within the framework of present study, we determined the mass fraction of inulin introduced to the formulation of a fat filling. The mass fraction ranged from 10 to 40 %, replacing the equivalent amount of fat. The number of bifidobacteria, which were added to all samples, was determined taking into account that the physiologically-active level of microorganisms in the functional food products should equal 10^6 – 10^7 cfu/g of the contents of the intestines.

The samples prepared with 40 % of fat replaced with inulin possessed higher density and viscosity, which prevented uniform applying the filling on wafer. The organoleptic indicators – a dense consistency – also indicated the impossibility of using such an amount of inulin. That is why we de-

termined that the mass fraction of inulin, which is introduced to the formulation of the filling for waffles, is 10, 20, and 30 %.

The effect of the introduced components of the synbiotic complex on the rheological characteristics of a semi-finished product – a fat filler – is the factor that enables production of quality products. It is important that the filler has the required properties for the uniform application on a wafer and stabilization in the process of maturing.

The basic rheological characteristics of fat masses include: boundary effective viscosity; shear stress at which the destruction of structure starts, and plastic strength. Strength describes the capability of shaped products to withstand subsequent mechanical action (glazing, wrapping, etc.). Viscosity characterizes ability of the masses to be shaped in one way or another.

Viscosity depends largely on the temperature of the examined mixture. Prepared filler, before being delivered for applying on the wafer sheets, is stored in a tempering machine with its temperature equal to 35 °C.

The experiments were carried out on the rotary viscometer “Reotest-2” with a change in the shear rate within 0.1667–72.9 s⁻¹, temperature of the filler was 35 °C. Results of the experiments were processed in accordance with the instructions to the device.

With the introduction of different mass fraction of inulin and the microencapsulated bifidobacteria to the filler, effective viscosity at a shear rate of 0.1667 s⁻¹ in the control sample was 0.7 kPa·s; and in the examined samples with 10, 20, and 30 % of inulin and capsules is, respectively, 0.8; 0.9, and 1.3 kPa·s (Fig. 3).

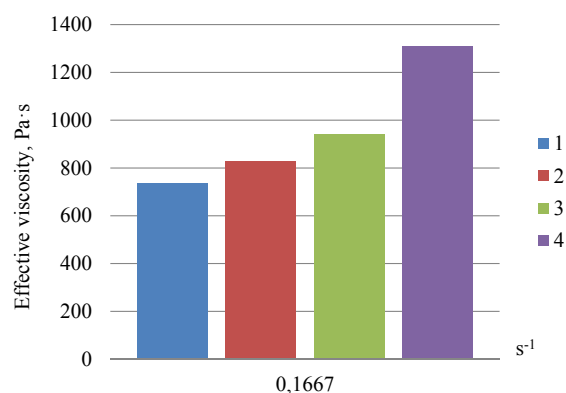


Fig. 3. Effect of the synbiotic complex on a change of effective viscosity with undamaged structure at a shear rate of 0.1667 s⁻¹: 1 – control; 2 – 10 % of inulin and microencapsulated bifidobacteria; 3 – 20 % of inulin and microencapsulated bifidobacteria; 4 – 30 % of inulin and microencapsulate dbifidobacteria

Based on the experimental data, we determined that adding to the filler a synbiotic additive results in the increasing effective viscosity (Fig. 4).

Fat filling in the process or preparation is related to the compact two-phase highly dispersed systems of the coagulation type; after cooling and crystallization of the fat – to the coagulation-condensation structures.

An important technological process when obtaining the filling is the cooling of wafer layers. A long period of the filling hardening indicates the need for a longer time to cool a wafer layer or a lower temperature of cooling. A long period of cooling can lead to moisturizing because that the relative humidity of air in the cooling chamber is not less than 92 %.

Therefore, it was important to explore the process of structure formation of a wafflefiller.

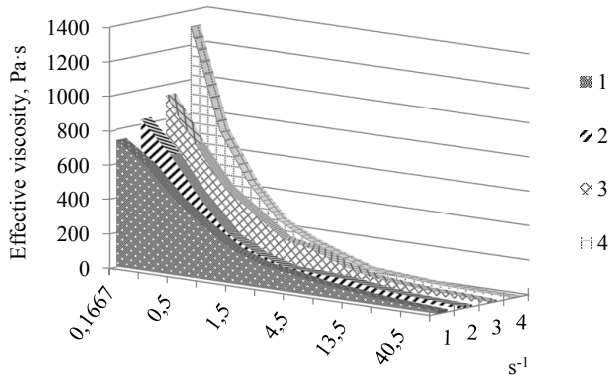


Fig. 4. Dependence of effective viscosity η of the filler on the shear rate gradient D with a different content of inulin, %: 1 – 0; 2 – 10; 3 – 20; 4 – 30, and the according number of microencapsulated bifidobacteria

Physical-mechanical properties of the filler for waffles are characterized by the magnitude of boundary shear stress when the penetrometer cone penetrates the bulk of the filler and is an objective indicator that reflects resistance of the material to shift and displacement. That is why the penetration properties of the material are related to its structural strength, which may be estimated quantitatively by the boundary shear stress – τ_0 .

We investigated effect of the synbiotic on strength of the filling depending on the mass fraction of inulin and bifidobacteria.

An important factor for the successful production of waffles is the process of filling stabilization during maturing of the products. In this connection, we discovered and mapped on the chart the dependence of a change in the boundary shear stress of the filler during maturing. A change in the boundary shear stress was determined over the duration of structure formation from 0 to 14 minutes every 2 minutes. The received results are shown in Fig. 5.

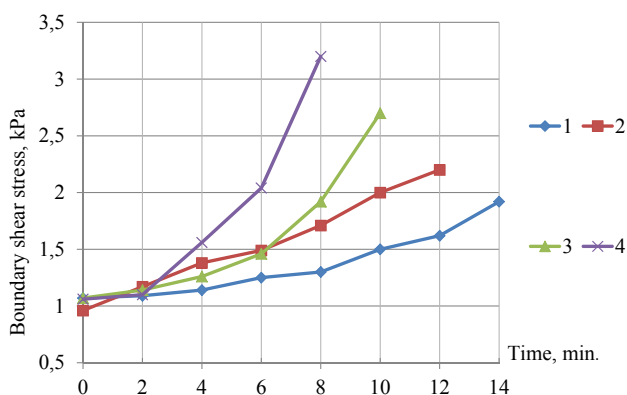


Fig. 5. Change in the boundary shear stress, τ_0 , with a different content of inulin, %: 1 – 0; 2 – 10; 3 – 20; 4 – 30, and the corresponding number of microencapsulated bifidobacteria

In the manufacture of a fat filling, of great importance is the degree of its sticking to the surface of production equipment and a close fit of the wafer layer to the filling.

The formation of adhesive bond between the filling and the surface of a wafer sheet is crucially affected by the rheological properties of the filling, duration and tension of the previous contact, a waffle sheet temperature, the temperature of the filling, the technique and rate of tear. Adhesion is the phenomenon that occurs during a contact between two dissimilar materials.

Results of the study into a change in specific tear force T of the plate on mass of the filling with a synbiotic complex are shown in Fig. 6.

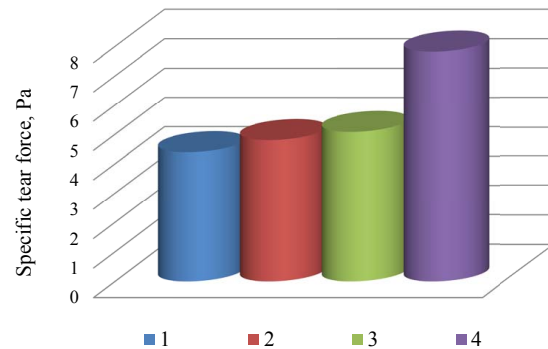


Fig. 6. Dependence of specific tear force T, samples of the filling with a content of inulin, %: 1 – 0; 2 – 10; 3 – 20; 4 – 30, and the corresponding number of microencapsulated bifidobacteria

In the present work, we examined a change in the density of a waffle filling introduced with the synbiotic complex. Experimental results of the study into dependence of density of the filling on the mass fraction of inulin and the corresponding number of immobilized bifidobacteria are shown in Fig. 7.

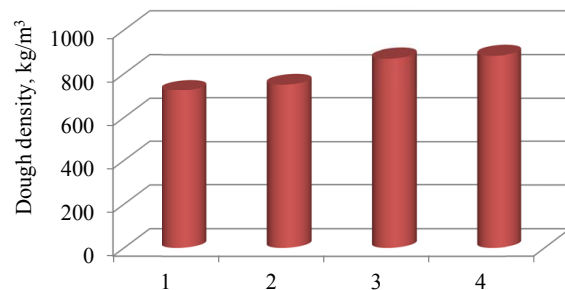


Fig. 7. Change in density of the filling introduced with the synbiotic complex: 1 – control; 2 – 10 % of inulin and microencapsulated bifidobacteria; 3 – 20 % of inulin and microencapsulated bifidobacteria; 4 – 30 % of inulin and microencapsulated bifidobacteria

In the examined samples of the filling introduced with the synbiotic complex, there occurs a reduction in the mass fraction of fat, which contributes to the saturation of the mass with air. That is why there is an increase in the density of the examined samples of the filling compared to the control. A fat filling is the multiphase structured dispersed system whose composition includes the solid, liquid and gaseous phase. The latter is formed in the process of stirring the mass and due to the capturing and holding the bubbles of air.

5.3. Evaluation of consumer properties of the obtained waffles

At the next stage of research, we conducted a comprehensive assessment of consumer properties of the designed waffles.

Effectiveness of the designed formulations and technological modes of manufacture of waffles with fat fillings for functional purposes were confirmed by the experimental and industrial tests at the facilities of Ltd. “Agrobusiness” and Ltd. “Charivny karavay” (Ukraine).

Organoleptic indicators of the developed type of waffles with the synbiotic complex are given in Table 2.

Table 2

Organoleptic indicators of waffle quality

Indicator name	Control	“Perlynka”
Taste	Sweet, without foreign flavor	Less sweet, no fat taste, crisp
Aroma	Peculiar to this type of product, no foreign smell and flavor	Peculiar to this type of product, no foreign smell and flavor. Waffles are distinguished by pleasant aroma
Color	Color of the sheet is light yellow, in the section – combined. Color of the filling is uniform, white	
Structure when broken	Wafer sheets are evenly baked, with well-developed porosity, with crispy properties, the filling is evenly distributed	
Physical appearance, surface	Surface with a clear pattern, with an even cut, no leaks. The filling in waffles is not over the edge.	
Filling’s consistency	The filling has uneven consistency without lumps, though they sometimes appear, buttery, does not shift wafer layers	The filling has homogeneous soft consistency, it melts easily, no lumps or grains. In the finished product, it is dense, does not shift wafer layers

Conditions for the development of market economy in Ukraine dictate the necessity to consider in the course of research not only physiological needs of the population but also competitiveness of the proposed products. And since the consumer, when choosing the products, is guided primarily by the organoleptic indicators, it is appropriate to a priori rank the factors that determine the organoleptic indicators of consumer appeal of the finished goods. Experts unanimously assigned the first place by importance to the taste of flour confectionary products, with the second place taken by aroma. That is why, judging by the distribution of ranks, the most important criterion for evaluating flour confectionary products is the taste of the product.

In order to define organoleptic parameters that characterize consumer’s appeal of the product, we applied a systems approach to the finished products. The attributes (descriptors), based on which the products were evaluated, were devised in line with the results of discussion by members of the tasting board. The taste of the product was accepted to be the object of study.

Based on the results of tasting, we constructed a diagram of the products’ taste.

Fig. 8 shows profilogram of taste of waffles (control and the one introduced with the synbiotic complex “Perlynka”).

Results of the organoleptic analysis showed that the examined samples of waffles positively differed from the control. They possess the filling with a more tender consistency, no lumps, no fat taste.

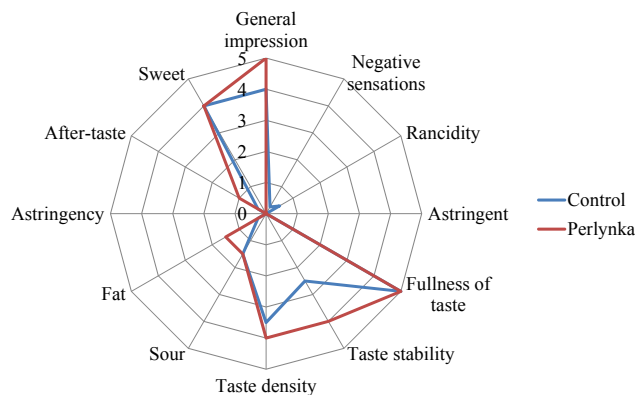


Fig. 8. Profilogram of waffle taste

6. Discussion of results of examining effect of the synbiotic complex on quality of a fat filling

As shown by the results of experimental data (Fig. 4), with an increase in the gradient of shear rate effective viscosity of the filler decreases, with the process that occurs especially intensively in the range of relatively low shear rates, to approximately 8.1 s^{-1} . With a further increase in the shear rate, the effective viscosity varies slightly. Horizontal sections of the curves correspond to the viscosity of the bulk whose structure is completely destroyed. In this regard, it follows that obtaining a filling needs to be carried out at such shear rates, at which the structure of the bulk is not destroyed. The maximum shear rate, at which it is possible to receive a good-quality filling, matches the beginning of the section of smooth transition to the region of the destroyed structure. In the given case, this rate amounted to 8.1 s^{-1} .

In practice, the total duration of receiving a high-quality filling is about 15 minutes. Mixing time depends on the nature of the mixed liquids, the mixing frequency, design of the device, and the temperature. As the obtained data indicate, mixing frequency is limited because the structure of a filling is destroyed at speed above 9 s^{-1} .

An increase of effective viscosity in the examined samples of a filling is probably related to that the coagulation structure, created by a dispersive environment, emerges due to the adhesion between particles of the prebiotic fiber of inulin and powdered sugar through thin layers of dispersive environment (fat). With a decrease in the amount of fat in a filling, the fat layer between particles becomes thinner, resulting in the strengthening of the structure and coagulation contacts. That is why, when introducing the synbiotic complex, effective viscosity of the bulk increases.

It was established that reducing the fat content in the bulk and a simultaneous increase in the solid phase leads to an increase in its strength (Fig. 5). Duration of maturing of the finished waffles is reduced because during introduction to the examined samples of the synbiotic additives the plastic strength of filling at structure-formation increases from 1.9 kPa in the control sample to 3.2 kPa in the sample with the dosage of 30 % inulin and microencapsulated bifidobacteria. The experimental data show that the filling of control samples acquires the required strength in 14 minutes, whereas for the examined samples this period is 8–12 minutes.

Strength of the coagulation structures is determined by the number and strength of the solid particles’ con-

tacts per unit volume. An increase in solid particles and a decrease in the thickness of the fat layer leads to the strengthening of the structure. This can be explained by the increasing strength of the fat mass when a symbiotic complex is introduced.

The obtained experimental data indicate that the application of the synbiotic complex leads to an increase in the force of separation of plate from the samples of filling introduced with an additive (Fig. 6). This is probably explained by an increase in the filling's plasticity. In the course of technological process, there occurs a strong attachment of the filling to the wafer layers. Over the entire period of storage, the finished products will retain their shape and will not stratify.

The obtained experimental results allow us to assert that the introduction of the synbiotic to the formulation of waffles leads to the improvement of structural and mechanical properties of a semi-finished product. It improves plasticity and viscosity of the filling, shortens duration of maturing of the finished products. The waffle fat content reduces. Over the entire period of storage, waffle products will retain their shape and will not stratify. The introduction of the synbiotic complex will provide finished products with physiological orientation, as a result of correction and adjustment of composition and function of the microflora of the digestive tract. This will make it possible to expand the range of flour products for functional purposes intended for people with impaired microecological condition of the body.

Prospects for further research are to determine effect of the synbiotic complex on the state of a fat component of the filling.

7. Conclusions

1. Based on the theoretical generalizations, we substantiated a choice of functional ingredients to be introduced to the formulation of a fat filling, which consists of the probiotic microorganisms *Bifidobacterium bifidum* and the prebiotic – inulin. The symbiotic complex was developed experimentally, which consists of the microencapsulated bifidobacteria and inulin. The given synbiotic complex provides a useful effect on the health of the host organism, improving the survival rate in the intestine of live bacterial additives and selectively stimulating the growth and activation of the bifidobacterial metabolism. This will make it possible to create a new kind of the functional fat filling for waffles, capable of restoring the normal microflora of the organism and preventing at the same time a dysbacteriosis.

2. It was established that the introduction of the additive contributes to an increase in effective viscosity of the mass due to the strengthening of the structure and coagulation contacts. This will help during technological process to better apply and evenly distribute the filling on the surface of a waffle sheet. The introduction of the synbiotic to the formulation of a fat filling also contributes to an increase in plastic strength of the fat filling. The higher the boundary shear stress (structural strength) of a fat filling, the stronger external mechanical impact it takes to cause a boundary destruction of the structure.

3. Results of the tasting assessment showed that the examined samples of waffles are characterized by improved organoleptic characteristics, have advantages in terms of the indicator "taste", and they do not have a fat taste. The filling is smooth, of tender consistency, and contains neither lumps nor grains.

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