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USING OF PLANT RAW MATERIALS IN THE PRODUCTION OF PROPHYLACTIC YOGURTS

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Abstract. Sour milk products, especially yogurts, are very popular not only in Ukraine but also around the world, so improving the composition of this category of products is quite important. Using plant raw materials in yogurt will not only broaden the range of this product, but will also allow using it in various diets, including those to prevent certain diseases, to improve the function of the digestive tract and physiological processes in the body, and to prevent premature ageing. The purpose of the study is to create prophylactic products using powders of plant raw materials (Jerusalem artichoke, celery, pumpkin seed meal) and determine their effect on the organoleptic, physicochemical, structural and mechanical properties of yogurt. Plant raw materials can enrich yogurts with plant proteins, complex polysaccharides, vitamins, and minerals. Experimental samples of yogurts with plant powders added in different concentrations have been obtained in the laboratory. According to the results of organoleptic studies, using the point rating method, the optimal amount of plant raw materials added is 5%. According to the results of structural and mechanical studies, the dependence of the effective viscosity of yogurts on the concentration of the introduced plant powder is not linear. This is explained by the interaction among the particles in yogurt and the formation of a structured food system. The change of the acidity of the yogurt samples (which is an important quality parameter) has been studied, according to the results of titrimetric and potentiometric analyses. It has been determined that powders from plant raw materials increase the titrated and decrease the active acidity of yogurt. To study the probiotic properties of the yogurt samples, the viability of probiotic microorganisms has been calculated in vitro, under conditions simulating the process of human digestion. The results show that the probiotic capacity of the product increases by 1–2 orders of magnitude. It has been experimentally confirmed that using plant raw materials to produce yogurts is practical.

Key words: yogurt, plant raw materials, quality indicators, probiotic properties.

Introduction. Formulation of the problem

Today in Ukraine, as in the rest of the world, the demand for the consumption of foods enriched with nutrients of natural origin is increasing. Special attention is paid to fermented milk products, which have high nutritional, dietary and therapeutic and prophylactic properties, contain "living" beneficial microflora.

It is known that the systematic consumption of dairy products improves human health, increases resistance to infections and endurance of the body, slows down the ageing process [1,2].

Yogurt is a popular fermented milk product that is widely used in the human diet [3-5]. It contains nutrients in easily digestible form, vitamins, enzymes,

minerals and others. Due to the fact that yogurts are versatile, they can be added to a variety of flavouring and aromatic fillers that increase the nutritional value of the finished product [6-12].

Analysis of recent research and publications

Ways of formation of functional and preventive properties of yogurts are covered in works of many domestic and foreign scientists. Thus, microbiological characteristics and basic biochemical mechanisms of yogurt production are given in [1,4], the importance of probiotic properties of yogurts on the human body is highlighted in [1,8,9], potential synergistic health benefits from combined consumption of fruit and yogurt are studied in [2], innovative technologies in the production of low-fat yogurts without the use of

hydrocolloid stabilisers are given in [5,6], prospects for the use of medicinal plant raw materials in the form of extracts and phytosyrups in the production of yogurts are covered in [6-12].

The market of yogurts with fillers and food additives is expanding for the most part due to the use of imported food additives, including those of synthetic origin. However, given the desire of most consumers to consume products on a natural basis with high nutritional value, it is advisable to develop new types of yogurt with the addition of plant raw materials: pumpkin seed meal, powders of Jerusalem artichoke and celery. Such a lively interest in the use of products on a natural basis indicates the timeliness and relevance of this work.

Enrichment of yogurts with plant raw materials will provide the product with plant proteins, complex polysaccharides, vitamins and minerals. Thus, Jerusalem artichoke contains quite a lot of dry matter, including up to 80% – a polymer homologue of fructose – inulin, the hydrolysis of which leads to a harmless sugar for diabetics fructose [13]. In addition, inulin has probiotic properties, promotes the growth of the natural intestinal microflora in various diseases associated with dysbacteriosis. Jerusalem artichoke contains fibre and a rich set of mineral elements: iron, manganese, calcium, magnesium, potassium, sodium and others. Jerusalem artichoke tubers also contain proteins, vitamins, pectin, amino acids, organic and fatty acids. Jerusalem artichoke acts as a detoxifier and can become a worthy competitor to foreign food additives [10-15].

Celery roots are rich in such valuable components as vitamins (ascorbic acid, provitamins A, B₁ and B₂, PP, etc.), macro- and microelements (phosphorus, potassium, magnesium, etc.). In addition to starch, celery roots are rich in other carbohydrates (mannitol, raffinose, maltose, etc.), which increase the nutritional value of the product. Particular emphasis should be placed on the presence of amino acids (about ten species), including essential ones. Consumption of products enriched with celery root will help cleanse the blood and strengthen the hematopoietic function of the body [16].

Pumpkin seed meal is a source of complete, well-digested protein, as well as an additional source of bioflavonoids, fibre, vitamins of group B (B₁, B₂, B₆, B₁₂), vitamin C, carotenoids, microfolate, macroaloin, zinc), essential food fibres [17]. Adding pumpkin seed meal to yogurt will help normalise metabolism, normalise the gastrointestinal tract and increase the overall resistance of the human body.

The purpose of the work is to enrich the classic yogurt with selected plant raw materials (pumpkin seed meal, powders of Jerusalem artichoke and celery) and to study its influence on the organoleptic, physicochemical, structural-mechanical and probiotic properties of yogurts. The main **objectives** were:

- to study organoleptic quality indicators of enriched yogurts on a scale taking into account the weighting factors;

- to determine the synergetic properties of experimental samples; to establish the dependence of the viscosity of yogurt samples on the concentration of plant powder;

- to determine the change in the volume of powder suspensions due to restoration in milk raw material by microscopy; to study active and titrated acidity;

- to determine viable probiotic microorganisms in vitro.

Research materials and methods

Experimental samples of yogurts with the introduction of plant powders in different concentrations were made in the laboratory. For their production ultrapasteurised milk with a fat content of 2.5%, sourdough was used, which contains pure cultures of *Acetobacter aceti*, *Bifidobacterium bifidum*, *Bifidobacterium adolescentis*, *Bifidobacterium longum*, *Bifidobacterium animalis*, *Lactobacillus acidophilus*, *Lactococcus lactis subsp. cremoris*, *Propionibacterium freudenreichii*, and also powders of industrial production from plant raw materials: Jerusalem artichoke, made according to Technical specifications of Ukraine (TS U) 10.8-22503701-001:2012 “Jerusalem artichoke products. Specifications”; pumpkin seed meal – according to TS U 10.4-38667335-002:2014 “Products of processing from oilseeds. Technical conditions” and celery – according to TS U 19125454.001-97 “Dry seasonings for dishes.” Powders have a light yellow colour, sweet taste, which corresponds to a certain type of raw material. The moisture content of plant powders ranges from 7–9%, and the dispersion is about 50–70 nm.

For the preparation of experimental samples, ultra-pasteurised milk with a fat content of 2.5% was heated to a temperature of 38–45°C, sourdough and plant additive were added. The introduction of plant additives at the stage of fermentation causes better growth of microorganisms. The fermentation process lasted 4–10 h before the formation of a clot having a pH of 4.4–4.7. The finished clot was stirred and cooled to a temperature of 4–6°C and stored at this temperature.

According to the research results, the following prescription composition of yogurts is proposed: normalised milk 88.0–96.0%, sourdough on pure cultures 1.0–2.0%, vegetable powder (celery, Jerusalem artichoke, pumpkin seed meal) 3.0–10.0%. Evaluation of yogurt quality was performed according to [18].

Substantiation of the rational amount of plant components introduced into yogurt and assessment of nutritional benefits of new types of yogurt included the use of the method of scoring with the definition of a complex indicator of quality. During the development of the scoring scale, a 5-scoring system with weight coefficients was chosen, which fully meets the current requirements [19,20]. Microscopy of powder suspensions was performed using a microscope brand Mikmed-1.

The synergetic properties of yogurts were determined by the degree of syneresis – the volume of whey filtrate, which was released during a certain time of filtering the sample of fermented milk clot at a certain temperature [8,21].

Studies of rheological properties were performed on a rotary viscometer Reotest 2. By potentiometric and titrimetric methods was determined the active and titrated acidity, respectively. The probiotic properties of microorganisms in the product were determined by the number of living microorganisms in vitro, simulating the process of human digestion [1,2,8,9]. The colonies of probiotic microorganisms grown on a dense nutrient medium in Petri dishes were counted after 48 hours of incubation at a temperature of 37°C. The number of living microorganisms in one dose, which is 1 ml of sourdough preparation of pure cultures, and also after 4 hours in an acidic model medium with the enzyme acidin-pension (pH 2.5) and after 12 hours in an alkaline model medium with the enzyme panzinorm forte 20000 (pH 7.0) was determined, simulating the composition of gastric juice and the secretion of the pancreas.

Results of the research and their discussion

In order to determine the rational dosage of plant raw materials in the prescription composition of yogurt, experimental studies of its effect on the organoleptic characteristics of yogurt.

To determine the required amount of plant material, it was introduced into the experimental samples in the amount 3-10% and the quality indicators were determined with the help of the senses using the method of scoring. The results of organoleptic evaluation yogurts with different dosages of plant powder, are presented in the form of a profilogram, which allows to clearly demonstrate the change in the consumption characteristics of yogurts (Fig. 1-3)

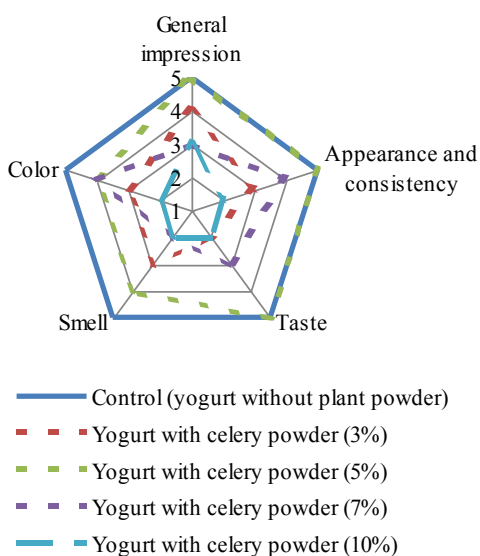


Fig. 1. Profilogram of yogurt with different doses of celery powder

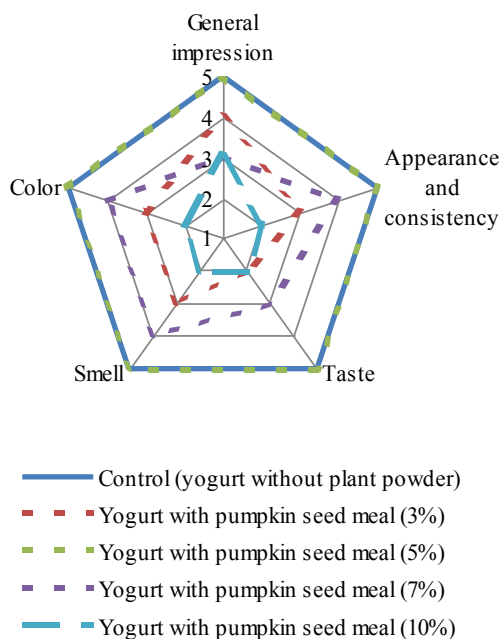


Fig. 2. Profilogram of yogurt with different doses of Jerusalem artichoke powder

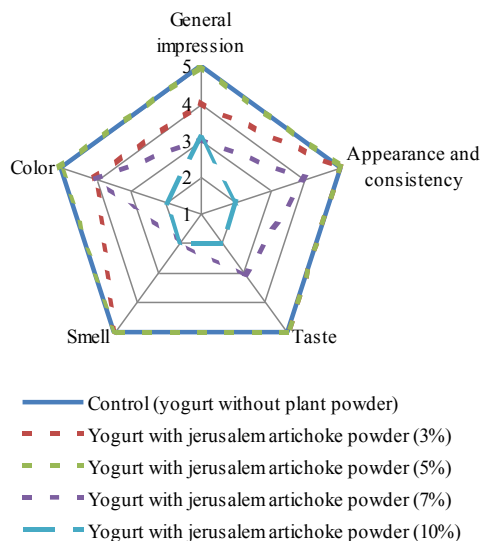


Fig. 3. Profilogram of yogurt with different doses of pumpkin seed meal

Based on the results of expert evaluations, it can be concluded that the best organoleptic characteristics were observed in yogurt samples with the addition of 5% plant powder, so the rational dosage is selected 5% of plant raw materials to the prescription mass.

In order to determine the change in technological properties, a study was carried out on synergetic parameters of yogurts with addition of selected plant raw materials in comparison with the control sample (Fig. 4).

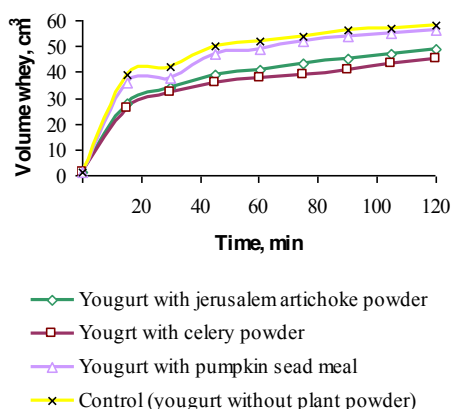


Fig. 4. Syneresis curves of yogurts enriched with plant raw materials

Fig. 4 shows that the introduction of plant raw materials into the yogurt caused a decrease in the ability to syneresis of the experimental samples. The separation of whey during storage is reduced due to the formation of a spatial network of hydrogen bonds from plant raw materials, which allows to improve the consistency during storage of the finished product. These properties are especially pronounced in samples with the addition of Jerusalem artichoke and celery powders, because this raw material has a high content of dietary fibre, which has a moisture-retaining ability. The data obtained correlate well with the results of microscopy presented on the example of a sample with celery powder (Fig. 5).

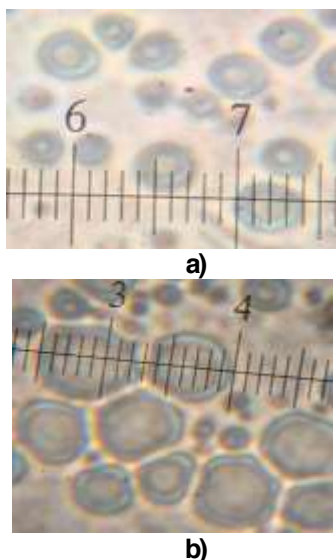


Fig. 5. Photomicrographs of suspensions of celery powder before swelling (a) and after 3 hours of swelling (b) (magnification x 400)

Thus, in the analysis of microphotographs, there is an active increase in the particle size of the powder in the suspension. For 3 hours, the hydration process of dried plant material is characterised by intense swelling, due to the high hydrophilicity of polysaccharides [14], and formed during drying by the capillary-porous structure of plant raw materials [20].

According to the results of rheological studies of all samples of yogurt, the dependence of the effective viscosity of the food system on the dosage of powder is constructed (Fig. 6). The resulting dependence can be divided into three areas. The first is with a low concentration of the dispersed phase (up to 2%), where there is a rarefaction and a decrease in the viscosity of the system compared to the control sample. In the second area, with a concentration of the dispersed phase (plant powder) from 3 to 5%, there is a more intense increase in viscosity, which can be explained by the moisture-absorbing and gelling abilities of the powder. In the third area, at a concentration of 6% and above, the viscosity increases significantly, which impairs the organoleptic properties of the finished product. Thus, viscosity is an important property of the food polydisperse system, which describes the equilibrium state between the processes of restoration and destruction of the structure.

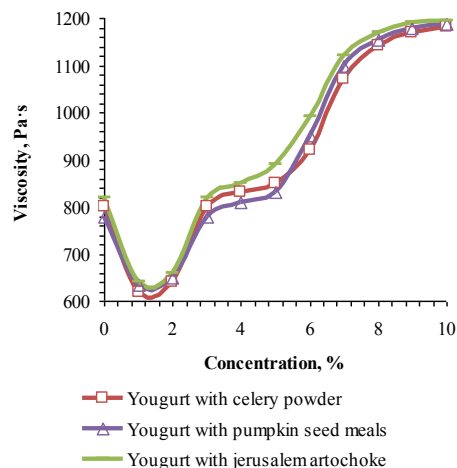


Fig. 6. Dependence of the yogurt viscosity on powder dosage

The study of changes in the indicators of active and titrated acidity of experimental samples of yogurt during 7 days of storage is presented in Fig. 7, 8.

Thus, in the studied samples, the level of active acidity decreases and the level of titratable acidity increases, which is explained by the fermentation of a part of lactose, as contained in the finished product to acetic and lactic acids. All samples on the seventh day of storage have critical values of acidity, therefore, taking into account the reserve coefficient, the finished product is suitable for consumption no more than 5 days from the date of production.

To study the probiotic properties of yogurt samples (for example, yogurt with pumpkin seed meal), the viability of probiotic microorganisms in vitro was calculated, simulating the process of human digestion. Counting colonies of probiotic lactic acid microorganisms was performed on a dense nutrient medium MRS, counting colonies of bifidobacteria – on a liquid nutrient medium Blaurock. Data on the initial number of viable bacteria in one dose of sourdough, which is 1 ml (Table 1).

Table 1 – Content of viable probiotic microorganisms in vitro

Product	Microorganisms	The total number of bacteria is 1 ml of sourdough	The content of live bacteria in the sample at the time of the experiment, CFU ml ⁻¹		
			0 h	4 h	12 h
Yogurt with pumpkin seed meal powder	<i>Bifidobacteria</i>	6·10 ⁹	5·10 ⁹	8·10 ⁸	8·10 ¹⁰
	<i>Lactic acid</i>	7·10 ⁹	6·10 ⁹	1·10 ⁸	2·10 ¹⁰
Sourdough (control)	<i>Bifidobacteria</i>	6·10 ⁹	5·10 ⁹	3·10 ⁷	2·10 ⁶
	<i>Lactic acid</i>	7·10 ⁹	6·10 ⁹	5·10 ⁷	1·10 ⁶

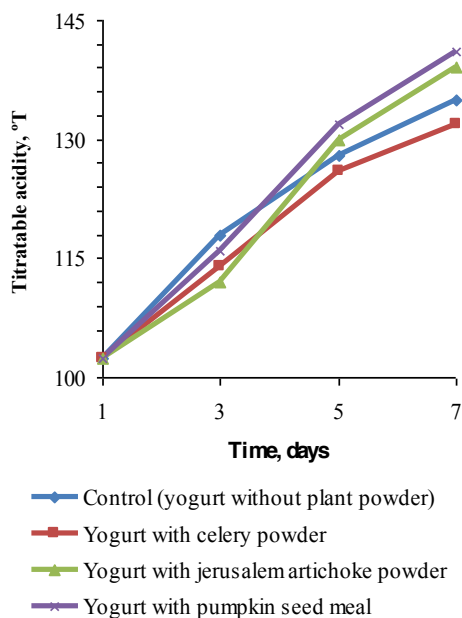


Fig. 7. Dynamics of the change of yogurts titratable acidity, with plant raw materials added in the amount 5%

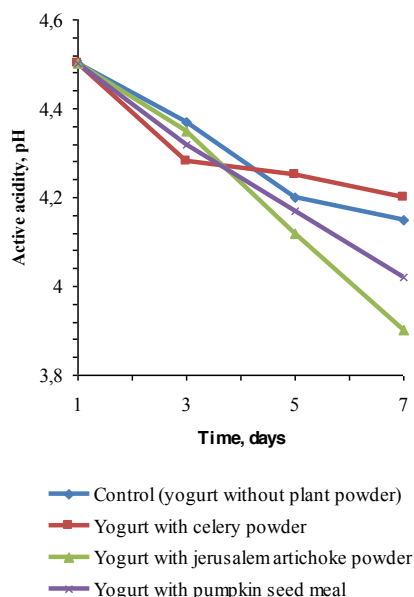


Fig. 8. Dynamics of the change of yogurts active acidity, with plant raw materials added in the amount 5%

From the above data it is seen that the introduction of pumpkin seed meal powder in yogurt improves the

probiotic properties of the product, which can be explained by the enriched composition of yogurt, namely the high content of bioflavonoids, complete protein, macro- and microelements, water-soluble vitamins, food fibres – substances that are not absorbed and have a positive physiological effect, which selectively stimulates growth and enhances the metabolic processes of the normal intestinal microflora (primarily bifidobacteria and lactobacilli), which act as a prebiotic. Therefore, yogurt with pumpkin seed meal has synbiotic properties, as it contains prebiotics and probiotics.

Since Jerusalem artichoke and celery powders have the same chemical composition, it can be assumed that samples of yogurt with these additives will have the same probiotic properties. The definition of these indicators is the subject of further research.

Conclusion

Organoleptic quality indicators of enriched yogurts have been investigated and rated on a point scale taking into account weight coefficients and the rational dosage of plant raw materials in the amount 5% to the prescription weight was determined. According to the results of studies of the synergetic properties of the experimental samples, it has been found that the addition of plant raw materials helps to reduce the release of whey, which has a positive effect on the organoleptic properties during storage.

The acidity of yogurts on the 7th day of storage is critical, so taking into account the reserve ratio of the finished product is suitable for consumption no more than 5 days from the date of production.

The viability of probiotic microorganisms in vitro has been determined, simulating the process of human digestion, which helps to establish the effectiveness of the combination of yogurt with other ingredients. The obtained results indicate that the number of probiotic microorganisms is negatively affected by acidic and altering, alkaline model environment, simulating in vitro digestive conditions in humans. In this case, the survival of bacteria in vitro is reduced by 2–3 orders of magnitude (0.1–0.001%) of their original number, and in combination with pumpkin seed meal, which serves as a substrate for bacterial reproduction – the probiotic capacity of the product increases by 1–2 orders.

Thus, the development of yogurts using traditional plant raw materials is a promising direction, as they are commonly used and affordable.

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**ВИКОРИСТАННЯ РОСЛИННОЇ СИРОВИНИ У ВИРОБНИЦТВІ ЙОГУРТІВ
ПРОФІЛАКТИЧНОГО ПРИЗНАЧЕННЯ**

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Анотація. Споживання кисломолочних продуктів, особливо йогуртів, є дуже популярним не лише в Україні, а й в усьому світі, тому поліпшення складу даної категорії продукції є досить актуальним. Внесення рослинної сировини в йогурт дозволить не лише розширити асортимент, а й застосовувати даний продукт у різних харчових раціонах, у тому числі для профілактики певних видів захворювань, для покращення роботи шлунково-кишкового тракту,

фізіологічних процесів в організмі людини та запобігання передчасному старінню організму. Метою дослідження є створення продукції профілактичного призначення з використанням порошків рослинної сировини (топінамбура, селери, шроту із насіння гарбуза) і визначення її впливу на органолептичні, фізико-хімічні та структурно-механічні властивості йогуртів. Збагачення йогуртів рослинною сировиною дозволить забезпечити продукт білками рослинного походження, складними полісахаридами, вітамінами та мінеральними речовинами. Дослідні зразки йогуртів із внесенням порошків рослинної сировини у різних концентраціях отримано в лабораторних умовах. За результатами органолептичних досліджень, з використанням методу бальної оцінки, обрано оптимальне дозування рослинної сировини у кількості 5%. За результатами структурно-механічних досліджень виявлено, що залежність ефективної в'язкості йогуртів від концентрації внесеного рослинного порошку не є лінійною, що пояснюється взаємодією між частинками в йогурті і утворенням структурованої харчової системи. Досліджено зміну кислотності зразків йогуртів, за результатами титриметричного та потенціометричного аналізів, що є важливим показником якості. Порошки з рослинної сировини підвищують титровану і знижують активну кислотність йогурту. Для дослідження пробіотичних властивостей зразків йогуртів підраховано життєздатність пробіотичних мікроорганізмів в умовах *in vitro*, імітуючи процес травлення людини. Отримані результати показують, що пробіотична здатність продукту збільшується на 1–2 порядки. Експериментально підтверджено доцільність використання порошків рослинної сировини у виробництві йогуртів.

Ключові слова: йогурт, рослинна сировина, показники якості, пробіотичні властивості.

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