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DETERMINING BIOLOGICAL VALUE AND QUALITY INDICATORS OF BEVERAGES OF THE DRINK-BREAKFAST TYPE

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Розроблені рецептури та технології виробництва напоїв типу «drink-breakfast» з підвищеним вмістом білка та вираженими антиоксидантними властивостями. Компонентами композицій напоїв стали: сир кисломолочний, молоко коров'яче знежирене, насіння канюти, ядра волоських горіхів, мед, шпинат, банан, псиліум, гідролізат коллагена (глютин). Напої є джерелами легкозасвоюваного білка, вітамінів-антиоксидантів (С, РР, Е) і харчових волокон.

За рахунок введення в композицію глютина, одна порція розроблених напоїв «Шпинатний» і «Банановый» задовольняє потребу в білках на 7,6 % і 7,2 % відповідно. Введення в склад напоїв шпинату і банану сприяє їх збагаченню фолатами. Аналіз мінерального складу розроблених напоїв дає можливість стверджувати, що напої є джерелами основних макро- та мікронутриентов і на високому рівні задовольняють потреби в них.

Використання як активних інгредієнтів псиліуму та глютину підвищує антиоксидантну активність у 50–60 разів, що пояснюється синергізмом всіх компонентів.

Визначено технологічні умови гідратації псиліуму. Встановлено, що середній розмір сухих частинок псиліуму складає 1,79 мм, а гідратованого 2,28 мм (5 хв., 20 °С). На поверхні часточок утворюється шар слизи – розчинних харчових волокон, що сприяє стабілізації харчової системи. Використання глютину в якості піноутворювача в напоях забезпечує утворення стабільної аерованої структури. Розміри комірок піни в напої «Шпинатний» коливається в діапазоні 0,05–0,15 мм, а в напої «Банановий» від 0,001 до 0,15 мм.

Моделювання умов зберігання за допомогою ALST тесту за оцінкою зміни мікробіологічних та органолептичних показників дає можливість стверджувати, що напої будуть конкурентоспроможними на споживчому ринку України. При зберіганні протягом 36 годин при температурі (4 ± 2) °С влажністю не більше 75 % в герметичній тарі вміст санітарно-показових мікроорганізмів відповідає санітарно-гігієнічним вимогам до напоїв на молочній основі.

Розроблені напої «drink-breakfast» можуть бути рекомендовані для дитячого харчування, а також у харчування вагітних жінок і жінок, що знаходяться в періоді лактації

Ключові слова: комплексна оцінка якості, білковий напій, антиоксидантна активність, харчова цінність, строк зберігання

1. Introduction

The modern nutrition structure of the world population is not consistent with the principles of rational nutrition [1]. Improvement of the structure of nutrition involves, first of all, an increase in food production due to improvement of existing technologies and development of new technologies for food products of a functional purpose. Such products should have a balanced chemical composition, low energy value, low content of carbohydrates and fats, high content of healthy nutrients with functional and health-preventive properties; they should be absolutely safe for humans. It is possible to implement the mentioned measures in organized nutrition effectively through the system of facilities of the restaurant industry.

Development of new technological approaches, methods for analysis and a system of product quality management are important in the nutrition system. Therefore, nowadays, food industry scientists, as well as restaurateurs, are trying to make dishes (drinks) not only good-looking and tasty, but also useful due to introduction of various biologically active ingredients.

Balanced nutrition of pregnant women is the most important problem for a modern woman. A large amount of protein in the diet of a pregnant woman is necessary for the full development of a child in a womb and formation of new cells. The optimum ratio of animal proteins and vegetable proteins is 3:2. However, the diet of pregnant women does not contain enough protein, which can lead to disruption of synthesis of enzymes, dysfunction of glands, formation of negative nitrogen balance, muscle atony and reduce of body resistance to viral diseases. In this regard, the development of a composition, production technology and quality assessment of new beverages with increased nutritional and biological value is relevant.

Special-purpose nutrition is the most convenient and natural form for enrichment of a human body with essential nutrients. Sources of them are plant raw materials (fruits, vegetables, berries, medicinal plants) [2–4].

2. Literature review and problem statement

Creation of special drinks is especially necessary for children and adolescents [5–7]. Products in the form of drinks have a number of advantages, which give possibility to introduce various components into their compositions and to obtain a system with desired functional properties. A lot of beverages have plant raw materials in their base. The current trends in the development of production of functional beverages for children and adolescents are fruit-vegetable and fruit juices, milk and cultured milk drinks, tonic extracts and decoctions [8].

The aim of creation of beverages, which contain a significant amount of micronutrients (vitamins and minerals) and provide vital body functions, is primarily reproduction of a healthy gene pool.

Beverages contain ballast substances and pectin substances, plant fibers, which increase resistance of a body to diseases and strengthen the immune system. They reduce the level of cholesterol in blood and remove heavy metals and free radicals [9].

In recent decades, a new line of beverages appeared. These are drinks-breakfasts, which are both a drink and a quick breakfast.

For example, in Switzerland, the popular drinks-breakfasts contain 20 % of nonfat sour milk and 52 % of fruit juice (TM Coop Betty Bossi).

In the Netherlands, drinks-breakfasts based on low-fat yogurt with a small amount of sugar and 60 % of natural lime or peach juice (TM Sisi Frutmania) are common. In the UK, products with soya extract and high content of fruit pieces (TM Tom Soya) with natural carrot juice (TM Innocent) are popular. In Ireland, there are beverages with more than 50 % content of fruit pieces combined with low-fat yogurt (TM Tropicana Smoothies) produced [10–12].

In recent years, there is a growing popularity of multivitamin beverages produced using natural vitamin concentrates and synthetic vitamin substitutes, because consumption of antioxidant vitamin complexes in doses, which exceed the minimum level, benefits human health [13].

Producers position a well-known functional drink based on Chinese magnolia vine juice, concentrated grape juice, snowdon rose extract and sugar not as a tonic drink only, but also as an immune stimulating one [14]. They used fruits of Chinese magnolia vine, root extract of snowdon rose and Hura as adaptogenic plant materials. However, when developing formulations, they took into account only organoleptic indicators for development of a formulation. They did not carried out optimization in terms of the ratio of basic nutrients.

The formulation of an energy-balanced product consists of plant and dairy raw materials and succinic acid [15]. The ratio of proteins and carbohydrates in the developed drink complies with the principles of healthy nutrition and makes 1:4.

Cranberry and lingonberry extracts can serve also as a source of biologically active components [16]. Authors of [16] used water in the ratio water:plant raw materials =4:1 for extracts. They treated raw materials with “Fruktotsim Kolor”, “Fruktotsim P6L” and “Biocellulose” enzymes to speed up the process of extraction. The obtained extracts contained 1.5 and 1.6 % of dry matter for cranberry and lingonberry, respectively. When optimizing the extraction process, they took into account a yield of dry substances, however, they did not investigate the quantitative yield of individual water-soluble substances such as rutin, phenolic substances, ascorbic acid and leuco-antacyanes.

There were protein sour milk drinks developed [17]. They contained isolates of soy protein and peas, wheat glutin and rice protein. Researchers revealed that introduction of vegetable materials affects physical-chemical and rheological indicators of the quality of beverages produced: pH, titratable acidity, syneresis, viscosity and color. However, there are no studies on an effect of plant proteins on lactic acid microorganisms and their biomass accumulation. Analysis of the amino acid composition of beverages showed that lysine, leucine, methionine and threonine are the most abundant amino acids.

In [18], authors considered the technology of cultured milk drinks with a use of wild plants. They formulated principles of creation of drinks and basic requirements for wild-growing raw materials. They used herbal-based “Tavolga” syrup as an adaptogenic component. Base herbs were *Bergénia crassifólia, Filipéndula ulmária, Mntha piperíta,* as well as the serum extract and syrup based on “Melissa officinalis” balm. They revealed main regularities of formation of sensory, physical-chemical, rheological and probiotic properties of cultured milk drinks with a use of aqueous and serum extracts and syrups based on wild-growing raw materials. However, the use of extracts of plant materials leads to destruction of the homogeneous structure of beverages during storage. The authors did not investigate possibility of introduction of stabilization systems or plant materials capable of stabilization of a nutrition system in their work.

Authors of paper [19] studied the structure and adaptation properties of arabinogalactan of Dahuriya leaves, as well as its influence on formation of cultured milk products. They determined the optimal rate of use of arabinogalactan in a composite mixture.

Work [20] presents the results of the research on development of the technology of the milk drink enriched with natural plant supplements. It investigates the use of plant fillers, in particular, haw puree and stevia syrup, in production of biokefir based on nonfat milk. The work substantiates expediency of introduction of haw puree in the amount of 20 % of weight of milk and stevia syrup in the amount of 3 % of weight of ferment. The developed technology gives possibility to increase the biological value of finished drinks due to introduction of biologically active substances of plant raw materials and to increase the shelf life. This work does not disclose kinetics of acid formation during souring of beverages with introduction of plant raw materials, however, it gives data on its effect on titrated acidity. Authors developed the formulation taking into account the maximum content of bifidobacteria and yeasts, therefore, it would be advisable to take into account a change in the microbial mass during storage.

The developed "Tar", "Ot uerete" and "Unnuula" medicinal beverages of the new generation [21] made it possible to improve the quality of products based on secondary dairy raw materials. "Tar" cultured milk product is produced of nonfat and whole milk. Introduction of wild-growing plants increases the energy value of a drink, so it is from 29 to 49 kcal in 100 g in "Tar fat free" drink, from 38.40 to 72 ... 76 kcal in "Tar Low Fat" (1.5 % fat), while the carbohydrate content increases from 3.8...4.5 to 7.9...12.7 %. Compared to kefir with a fat content of 3.2 %, the content of replaceable amino acids is higher in 1.6 times in "Tar" drink, and in irreplaceable ones by 1.8 times. The base of the "Ot Uerete" cultured milk product is buttermilk or kefir with addition of wormwood leaves, which enriches the product with protein, calcium, iron, copper, carotene and C, E, B_1, B_3, B_4, B_6, PP vitamins. "Vot uerete" cultured milk product is made of buttermilk and has a high protein content (3.33 %) and carbohydrates (4.9 %), but it has low energy value (40.9 kcal/100 g) due to the low concentration of fat in raw materials. "Unnuula" drink is made with addition of rhizomes of umbellatus. The addition of rhizomes of unmellatus enriches the cultured milk product with carbohydrates, proteins, potassium, calcium, copper, iron, magnesium, zinc, iodine selenium, C vitamin and group B vitamins. The problem of this study may be the kinetics of acid formation during fermentation of beverages. There are no concentrations of wild-growing plants given. Therefore, there is the question about how they affect accumulation of microbiota taking into account their chemical composition and bitterness.

Insoluble dietary fibers include psyllium. Psyllium flour is made of seed coats of *Plantago ovata* (oval plantain, Indian plantain). Psyllium is a plant fiber obtained from the dried and grinded shells of plantain seeds. The seeds of psyllium planus contain soluble dietary fiber – the amount reaches 70 % of the total. The seeds of common plantain contain soluble dietary fiber. Their number reaches 70 % of the total volume. For comparison, the amount of dietary fiber is only 5 % of the total mass [22] in oat bran. There are practically no digestible carbohydrates in psyllium [23, 24]. Psyllium almost does not have its own flavor and consists of 80–85 % of soluble dietary fiber such as gums, mucus, hemicellulose. The main active component is the mucous hydrocolloid, which is arabinoxylan. It has a high hydration rate and water-holding capacity [25]. Currently, psyllium is used as a food additive [25–28] and as an effective entero-sorbent [29].

Study [30] made it possible to identify mechanisms of action of psyllium at intestinal infections, such as a pronounced decrease in pH, due to the content of uronic acids [25] in the intestinal lumen, which leads to a decrease in the biomass of pathogenic microorganisms. As for the chemical composition of seeds of plantain, it includes mineral salts of iron, magnesium, zinc, potassium, and calcium in addition to proteins, glycosides, and fats. Therefore, seeds also act as a medicine, although not as often as its shells. Nutritional value per 100 g of the product: energy value – 17.7 kcal, fat – 0.6 g, carbohydrates – 1.46 g, protein – 3–4 g.

Based on the needs of pregnant women, we can consider collagen-containing raw materials as a source of protein. Secondary fish raw materials draw special attention. The main properties of fish collagen are hypoallergenity and identity to human collagen. They contribute to its maximum absorption. The presence of oxidized forms of lysine and proline accelerates formation of collagen fibers and connective tissue of a fetus. Paper [31] proves the ability of glutin (collagen hydrolysate) to form colloidal solutions. This ability gives us possibility to recommend it for a use not only as a source of digestible protein, but also as a structuring agent in the production of a number of products.

Thus, it is important to develop drinks like "drink-breakfast" ones with a balanced nutrient composition. The introduction of new unconventional raw materials – psyllium – to the composition of beverages makes possible to obtain a product enriched with soluble dietary fiber and to adjust technological processes to obtain biologically valuable products. We can use dietary fibers of psyllium and collagen hydrolysate as structuring agents replacing modern expensive drugs with them.

3. The aim and objectives of the study

The objective of the study was the analysis of the biological value and quality indicators of beverages of the "drink-breakfast" type.

We set the following tasks to achieve the objective:

– investigation of the hydration ability of psyllium;

– determination of the biological value of protein drinks with a maximum content of protein and folic acid;

– determination of storage conditions using ALST method.

4. Materials and methods for the development of drinks for pregnant women

We used the following equipment for research:

– for preparation of beverages: a blender (PHILIPS HR-1633/80, China), a refrigerated cabinet (ShH-0.4 MS, Republic of Mari El, Russia), a bathtub and an electric scale (Rotex RSK 10-P, China);

– for determination of the antioxidant activity – KFK-2MP photo colorimeter (Russia).

We microscoped samples using the Biolam P15 microscope (Lomo, Russia) with the ScopeTek DCM-130 E 1.3 Mp digital eyepiece camera (Hangzhou Scopetek Opto-Electric Co., China) [31].

We performed optimization of the drinks formulation based on basic indicators of the chemical composition, which correspond to the needs of a pregnant woman, by mathematical modeling. [32]. We implemented the mathematical modeling of the composition of protein drinks using linear programming in MS Excel editor [32].

We determined the antioxidant activity with a use of $NAD{\cdot}H_2 – K_3[Fe(CN)_6]$ electron transport model [33].

We applied ASLT test to forecast duration of the actual shelf life of beverages. In the test, we examined the dependence of the process of changing merchandising indicators and beverage safety indicators on time and temperature of storage. The main quality indicators were organoleptic indicators and microbiological indicators. We divided the produced beverages into samples of 50 cm^3 each. We subjected them to temperature changes from 5 °C to 15 °C with 5 °C steps and a shelf life from 12 to 72 hours with 12 hours steps during storage.

According to GOST ISO 6658:2005, we carried out the organoleptic analysis using an analytical assessment by a descriptive method (profiling method) and a method of scales and categories use (assessment with a point scale) [34].

We determined microbiological indicators of beverages according to the regulatory document DSP 4.4.5.078-2001:

– bacteria of the group of intestinal bacilli (GOST 30712);

– mesophilic anaerobic microorganisms and facultative-anaerobic microorganisms (GOST 1044.15);

– pathogenic microorganisms, including Salmonella (DSTU IDF 93A);

– a number of mold fungi and yeast (GOST 10444.12).

5. Results of study into indicators of beverages quality

5. 1. Study of the hydration capacity of psyllium

Homogeneity of beverages in production and storage depends on the intermolecular interaction of all components. Glutin (collagen hydrolysate) and psyllium serve as hydrocolloids in drinks for pregnant women. Each of them has unique functional characteristics, chemical structure, shape and size of a molecule. Selected hydrochlorides can adsorb on a surface of solid particles or droplets of the dispersed phase of a nutrition system and reduce their aggregation due to steric and electrostatic effects.

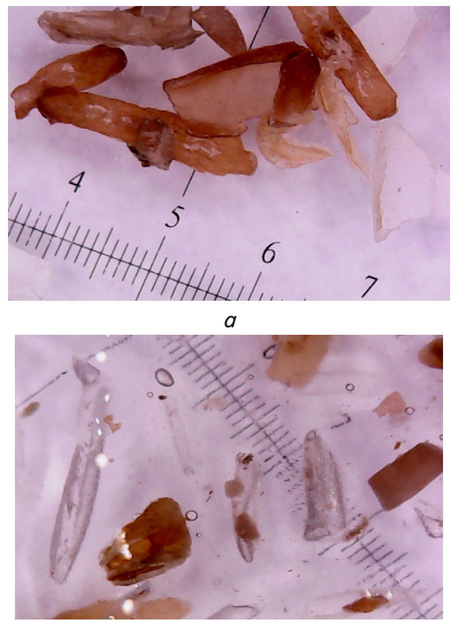
Therefore, we determined the influence of technological parameters on the ability of psyllium to hydration (pH and temperature) to predict the behavior of psyllium in the nutrition system as a structuring agent.

We carried out the study of the hydration of psyllium at physiological pH values (2; 6.5; 9) and different temperatures (20 °C, 40 °C, 60 °C). We observed the lowest degree of swelling at all temperatures at pH=6.5, because of extraction of B fraction (gel-forming one) and the release of mucus. At pH=2, the degree of hydration of psyllium reached 714, 967, 1,167 % at temperatures of 20 °C, 40 °C, 60 °C, respectively, after 10 minutes of incubation. At all temperatures studied, the degree of swelling was the highest at pH=9, while A fraction was the most extracted. Due to A fraction, binding of water molecules and an increase in the amount of psyllium occurred.

At a temperature of 20 °C, the degree of swelling of psyllium was 343 %, 114 %, 429 % at pH 2, 6.5, and 9, respectively, after 5 minutes of incubation. At a temperature of 40 °C, the degree of swelling of psyllium reached 467 %, 167 %, 600 % at pH 2, 6.5 and 9, respectively, after 5 minutes of incubation. At 60 °C, the degree of swelling of psyllium was 567 %, 200 %, 700 % at pH 2, 6.5 and 9, respectively, after 5 minutes of incubation. After 10 minutes of incubation at different temperatures, the degree of swelling increased almost by 1.9–2.1 times.

Since a drink is a liquid medium, it was necessary to study a change in the rigid structure of psyllium particles to predict their sedimentation and formation of a colloidal structure. Fig. 1 shows microphotographs of dry and swollen psyllium.

We established (Fig. 1) that the average size of dry psyllium particles is 1.79 mm, and of swollen ones (5 min., 20 °C) is 2.28 mm. That is, psyllium particles increase by 1.3 times in average. As we can see in Fig. 1, dry particles have clear contours. The contours soften when swelling (Fig. 1), due to the swelling of the structure of psyllium and the release of soluble dietary fiber.



a

b

Fig. 1. Microphotographs of psyllium: *a* – dry psyllium, *b* – swollen psyllium

Thus, psyllium is capable of forming a gel structure, preventing delamination and sedimentation in the nutrition system.

5. 2. Determination of the biological value of protein drinks with a maximum content of protein and folic acid

We applied linear programming in MS Excel editor to simulate the formulations of drinks. The main task was construction of an appropriate mathematical model that included the following steps: definition of the research objective; selection of optimality criteria; identification of major constraints; mathematical formalization.

We can represent conditions for mathematical programming of beverage formulations by the following formulas:

$$F = f(x_1,...x_i,...x_n) \to \text{const}, \quad i = \overline{1,n},$$

$$x_i \le (=,\ge) b_i, \quad i = \overline{1,n},$$

$$d_k \le x_k \le D_k, \quad k = \overline{1,n},$$

where F is the objective function of the linear model; x_i is the formulation component of the product, %; b_i are the restrictions of i-th component by the content in the formulation, %; x_k is the content of k nutrient in the formulation, %; d_k, D_k are the lower limit and the upper limit for x_k nutrient content, %; n is the number of formulation components and nutrients.

The objective function answered the maximum content of folic acid in modeling of drinks formulations.

$$Z(x_i) = \max,$$

where $Z(x_i)$is the objective function that displays the mass fraction of folic acid in the formulation, mg/100 ml; x_i is a formulation component, %.

We sought for a solution by the simplex method. We considered the search for a generalized quality criterion as fuzzy non-linear programming with n incompatible criteria, m control variables and k non-linear constraints:

$$\text{Optimize } K[K_1(X), K_2(X), \ldots K_n(X)],$$

if

$$C_i \equiv G_{Li} \leq G_i(X) \leq G_{Ui}, \quad i = 1,2,\ldots k,$$

$$x_{Li} \leq x_i \leq x_{Ui}, \quad i = 1,2,\ldots m,$$

where $K_1(x)$ represent fuzzy local product quality criteria; $X(x_1, x_2,..., x_m)$ is the vector of control variables that we define; G_{Li}, G_{Ui} are the lower limit and the upper limit of restrictions, respectively; $x_{Li} \leq x_i \leq x_{Ui}$ are the lower and upper limits for control variables that we define.

We set the content of glutin in the range of 1...5 %, we regulated the content of psyllium in the range of 1...3 %. The drink portion was 200 cm^3. We obtained the formulations of "Banana" and "Spinach" drinks as a result of construction in MS Excel using "Search for a Solution" add-on (Table 1).

Table 1

Formulations of drinks with increased antioxidant effect

Raw materials	Content of components, g	
	"Spinach"	"Banana"
Nonfat curd cheese	20	20
Sesame	4	3
Honey	7	7
Non-fat cow's milk	121	125
English walnut	12	10
Spinach	30	0
Banana	0	29
Psyllium	1	1
Glutin	5	5
Yield	200	200

Fig. 2 shows the functional diagram of the developed technology of "Spinach" and "Banana" drinks.

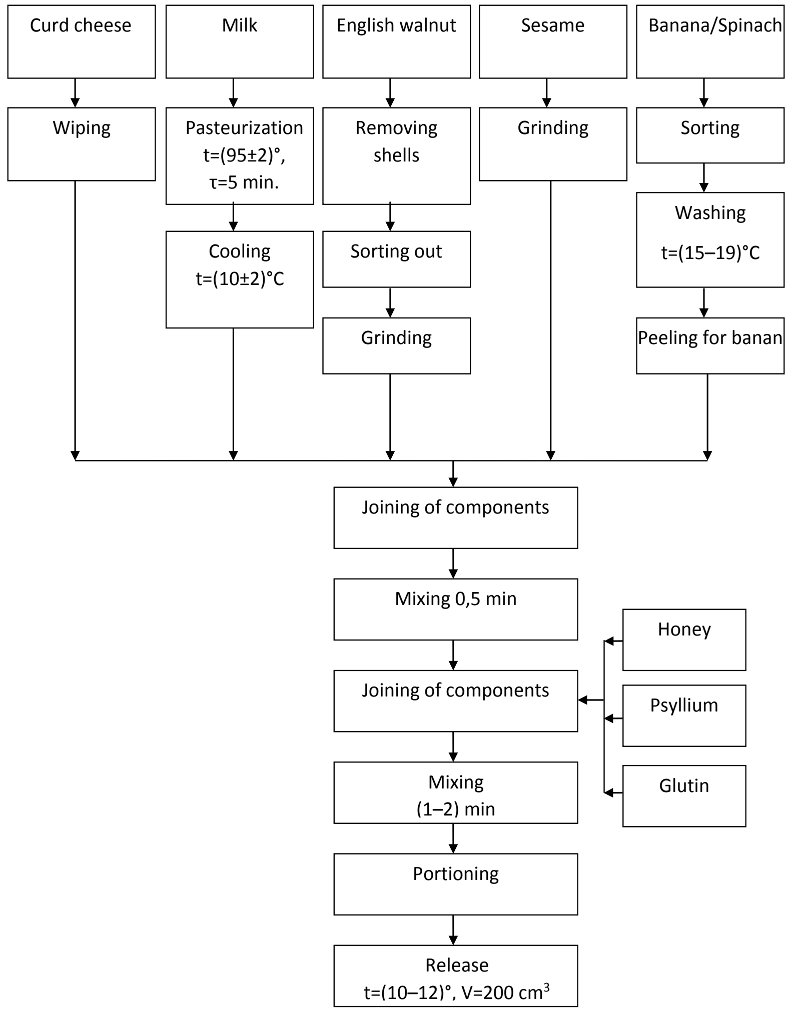


Fig. 2. General functional diagram of the production of beverages

We examined the microstructure of the resulting beverages (Fig. 3) with the electron microscope. The research results give an idea of a certain homogeneity and swelling of plant raw materials and its behavior in the nutrition system. The study of the microstructure of beverages with an increase in 5 times made it possible to detect fragments of components of the beverage components in the form of particles up to 0.01 mm in size (1 DIV=0.1 mm). The microrelief of particles confirms that most of particles have characteristic depressions on a surface, a number and size of which confirm the mechanical integrity of a product surface and its high degree of homogeneity.

A mixer used in production of beverages saturates the nutrition system with air to form bubbles. The size of bubbles varies in the range of 0.05–0.15 mm in "Spinach" drink, the average diameter is 0.1 mm (Fig. 3). The size of bubbles varies from 0.001 to 0.15 mm in "Banana" drink, but more than 80 % of bubbles do not exceed 0.06 mm in diameter and 10 % of bubbles have a diameter close to 0.5 mm (Fig. 4).

The developed drinks have homogeneous colloidal structure with a solids content of 22.7 % for "Spinach" drink and 23.9 % for "Banana" drink.

Table 2 presents the sensory analysis of indicators of drinks. The data in the table indicate rather pleasant appearance of drinks, pleasant taste and color.

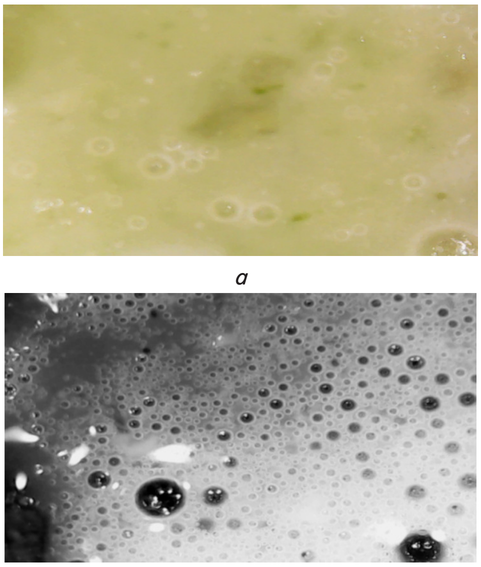


Fig. 3. Microstructure of beverages ×5: *a* – "Spinach" drink, *b* – "Banana" drink

Table 2

Organoleptic indicators of drinks

Name of indicator	Characteristic of drink	
	"Spinach"	"Banana"
Appearance	Homogenous, without unnecessary impurities, without lumps	Homogenous, without unnecessary impurities, without lumps
Consistency	Particles of plant raw materials are evenly distributed throughout the volume; the consistency is weakly viscous	Particles of plant raw materials are evenly distributed throughout the volume; the consistency is viscous
Color	From light lime green to light green, with visible spinach and psyllium particles	From light milky to light beige, with visible psyllium particles
Aroma	Milky with a slight fresh smell of spinach, no foreign odors	Milky with a pronounced smell of banana, no foreign odors
Taste	Sweet, milky, mild spinach, without foreign flavors	Sweet, milky-banana, pronounced banana, without foreign flavors

According to modern nutritional principles, products should contain a wide range of ingredients that are necessary for a human body; and be balanced on nutritional and biological value. Therefore, we conducted a study on the chemical composition of beverages. Table 3 presents the data of the study.

The results presented in Table 3 indicate that drinks have a high content of proteins, which is very important to meet the needs of a body of a pregnant woman for proteins. Based on recommendations of nutritionists and obstetricians, it is recommended for pregnant women to consume about 100 grams of protein per day. Thus, the developed "Spinach" and "Banana" "drinks" satisfy the need for proteins by 7.6 % and 7.2 %, respectively, if a consumed portion is 200 cm^3.

Table 3

Chemical composition of beverages

Name of nutrient	Content, %	
	"Spinach"	"Banana"
Humidity	77.3	76.1
Protein	7.6	7.2
Fat	4.8	3.9
Carbohydrates	7.3	10
Dietary fiber	1.1	1.06
Ash	1.1	0.9

We should note that the developed drinks have rather high content of all other essential nutrients, namely calcium, potassium, phosphorus, and iron, which are essential for a human body (Fig. 4).

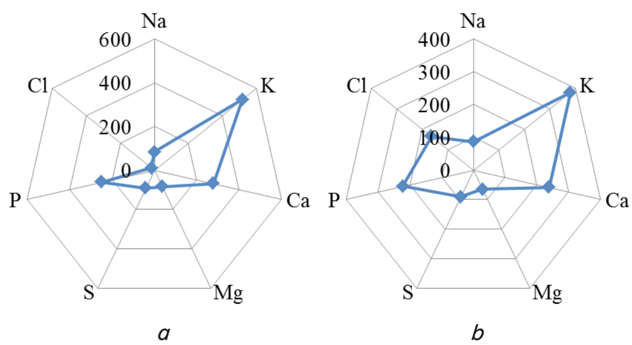


Fig. 4. Mineral composition of drinks, mg/serving: *a* — "Spinach" drink, *b* — "Banana" drink

Fig. 5 presents analysis of the vitamin composition of drinks. The results obtained indicate that the developed drinks are sources of B vitamins, which are especially necessary for pregnant women and children, and they are also rich in antioxidant vitamins, such as: tocopherol, nicotinic and ascorbic acid.

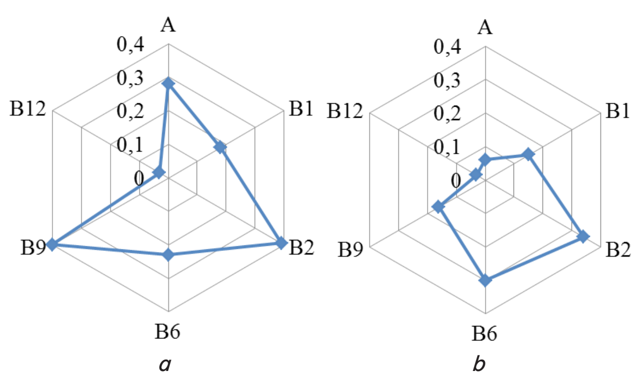


Fig. 5. Vitamin composition of drinks, mg/serving: *a* — "Spinach" drink, *b* — "Banana" drink

Fig. 6 shows comparative content of the main antioxidant vitamins in the developed drinks.

"Spinach" drink has antioxidant activity (AOA) of 7,500 s. u., and "Banana" – 5,000 s. u. The indicator of antioxidant activity of beverages increases in 50–60 times with the introduction of psyllium (AOA=2,750 s. u.) and glutin

(AOA=700 s. u.) to formulations, because of the synergism of all components of drinks, as well as the presence of amino acids with high antioxidant properties (methionine, tyrosine, cysteine).

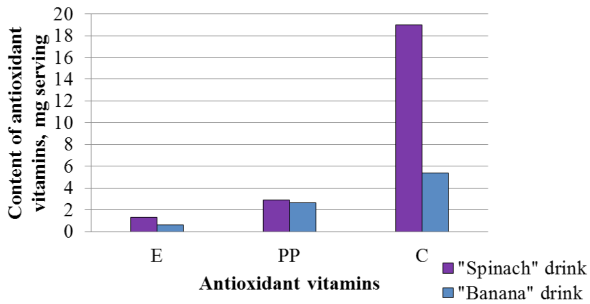


Fig. 6. Comparative content of antioxidant vitamins in drinks

Since drinks contain protein, it was necessary to conduct a study of the amino acid composition. We took beverages without glutin but with increased psyllium content by an appropriate mass of glutin as control ones. The research results showed that there were nineteen amino acids, including all essential ones, identified in the protein of drinks. We studied the biological value of the developed drinks by calculation of the amino acid score of proteins (Table 4).

Comparison of the amino acid score of the control samples with the developed drinks revealed an increase in the amino acid score of all essential amino acids by 14.53 % on average for "Spinach" drink, by 15.37 % for "Banana" drink. The data obtained showed that phenylalanine is the first limiting amino acid in beverages. The difference in amino acid score (CDAS) shows the average excess of amino acid score of essential amino acids compared to the lowest level of phenylalanine score. The score increases by 10.85 % and 11.32 % with the introduction of glutin to the composition of "Spinach" and "Banana" drinks, and CDAS – by 15.81 % and 16.6 %, respectively.

The results of microbiological studies show that indicators of microbiota do not exceed the permissible sanitary and hygienic conditions and meet the requirements of the current DSP 4.4.5.078-2001. The data obtained proves the high quality of the developed drinks and possibility of introduction of them in restaurant facilities.

5. 3. Determination of storage conditions using ALST method

Various physical-chemical changes may occur during storage of beverages. They can affect the quality of a finished product. We stored samples in sealed glass bottles. There was no change in organoleptic characteristics during storage for 48 hours. Tables 5, 6 present data on studies of physical-chemical and microbiological indicators of beverages during storage.

Analysis of the indicators given in Tables 5, 6 showed that there were no sanitary indicative, conditionally pathogenic and pathogenic microorganisms detected under the condition of compliance with sanitary and hygienic requirements in the developed drinks.

Table 5

Dynamics of changes in organoleptic, physical-chemical and microbiological indicators of "Banana" drink during storage

Name of indicator	Characteristics of indicators after the end of the technological cycle	Storage duration, hours			
		12	24	36	48
Physical-chemical indicators					
Active acidity, pH	6.1	6.0	5.8	5.4	5.3
Viscosity, sec.	10	12	14	16	22
Microbiological indicators					
Bacteria of the group of intestinal bacilli in 1 g	Not detected	Not detected			
Pathogenic microorganisms. including *Salmonella* in 100 g	Not detected	Not detected			
MAPAnM in 1 g. not more than $\times 10^3$	1.1	1.1	1.1	1.15	1.19
Amount of mold fungi in 1 g not more than	4	4	4	5	5

Table 4

Amino acid score of proteins of beverages

Name of amino acid	Recommended FAO/WHO content, mg/g protein	"Spinach" drink		Control for "Spinach" drink		"Banana" drink		Control for "Banana" drink	
		mg/1 g of protein	AA score	mg/1 g of protein	AA score	mg/1 g of protein	AA score	mg/1 g of protein	AA score
Isoleucine	40	47.36	118.4	40.71	101.78	96.62	241.5	82.55	206.38
Leucine	70	42.38	60.5	37.90	54.15	86.41	123.4	76.94	109.91
Lysine	55	71.46	129.9	62.71	114.01	147.7	268.6	129.25	235.00
Methionine	35	53.03	151.5	44.47	127.06	107.7	307.9	89.67	256.20
Phenylalanine	60	14.05	23.4	12.66	21.11	28.64	47.7	25.71	42.85
Threonine	40	25.58	63.9	19.43	48.57	50.62	126.5	37.60	94.00
Tryptophan	10	8.53	85.3	8.53	85.31	16.80	167.9	16.80	167.96
Valin	50	38.19	76.3	33.88	67.76	77.80	155.6	68.68	137.36

The number of microorganisms of the group of spoilage and MAPAnM does not exceed the permissible levels of content within 48 hours. In addition, organoleptic and physical-chemical indicators did not change significantly during storage of the developed drinks.

Thus, we can recommend the shelf life of the developed drinks for 36 hours at the temperature of (4±2) °C and humidity not more than 75 % in hermetically packed bottles based on the conducted research.

Table 6

Dynamics of changes in organoleptic, physical-chemical and microbiological indicators of "Spinach" drink during storage

Name of indicator	Characteristics of indicators after the end of the technological cycle	Storage duration, hours			
		12	24	36	48
Physical-chemical indicators					
Active acidity, pH	6.0	6.0	5.9	5.7	5.5
Viscosity, sec.	10	12	14	16	22
Microbiological indicators					
Bacteria of the group of intestinal bacilli in 1 g	Not detected	Not detected			
Pathogenic microorganisms. including *Salmonell*a in 100 g	Not detected	Not detected			
MAPAnM in 1 g. not more than $\times 10^3$	1.3	1.3	1.3	1.3	1.37
Amount of mold fungi in 1 g not more than	Not detected	Not detected			

6. Discussion of results of the analysis of indicators of drinks quality

Analysis of quality indicators shows high quality characteristics of the developed protein drinks for pregnant women. The nutrient composition of the developed drinks showed that the use of psyllium and collagen hydrolysate significantly enriches the finished product with both digestible dietary fibers and protein. The high content of protein and folates makes possible to recommend developed drinks in the diet for pregnant women.

The analysis of quality indicators shows high quality characteristics of the developed drink-breakfast protein drinks. The nutrient composition of the developed drinks showed that the use of psyllium and collagen hydrolysate significantly enriches the finished product with both digestible dietary fibers and protein. The high content of protein and folates makes possible to recommend developed drinks in the diet for pregnant women.

The use of mathematical programming in modeling of formulations makes possible to adjust the content of all components based on needs of an individual organism.

The advantage of the study is an integrated approach to selection of raw materials for production of drink-breakfast drinks, simulation of modes of structure formation using psyllium, as well as a comprehensive analysis of the nutrient composition of the resulting drinks.

We used a banana, an allergenic product, as a source of dietary fiber and carbohydrates at development of "Banana" drink. Therefore, we replaced a banana with another plant raw material capable of forming jelly at development of a line of such drinks.

As for microbiological safety, the developed protein drinks comply with the requirements of the current sanitary legislation of Ukraine. Simulation of storage conditions with a use of ALST test makes possible to recommend sales of beverages at restaurant facilities and through retail.

We plan to conduct SWOT-analysis of the beverages obtained and the calculation of an index of competitiveness of new beverages in the Ukrainian market for introduction into production.

7. Conclusions

1. We studied the hydrational ability of psyllium as a component of special-purpose beverages. We observed the lowest degree of swelling at pH = 6.5, because of the release of mucus. At pH=2, the swelling reached 714, 967, 1,167 % at temperatures of 20 °C, 40 °C, 60 °C, respectively, after 10 minutes of incubation. At all temperatures studied, the degree of swelling was highest at pH=9.

2. We studied the chemical composition of the drinks obtained. We proved the high content of proteins and folates in their composition, which made us recommend them for a use by pregnant women. We revealed the synergism between components of drinks. It affected the antioxidant effect. We proved that AOA of drinks increases in 50–60 times with the introduction of psyllium and glutin into compositions of the drinks.

3. We investigated storage conditions by ALST analysis. Thus, the optimal conditions for the storage of beverages are 36 hours at a temperature of (4±2) °C and humidity not more than 75 % in an airtight container.

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