UDC 637.18:663.15

Anna Novik, Nadiia Lapytska, Tamara Lystopad, Polina Boychenko, Alina Savchenko

DEVELOPMENT OF THE TECHNOLOGY OF A HIGH-PROTEIN FERMENTED DRINK ON A PLANT BASIS

РОЗРОБКА ТЕХНОЛОГІЇ ВИСОКОБІЛКОВОГО ФЕРМЕНТОВАНОГО НАПОЮ НА РОСЛИННІЙ ОСНОВІ

DOI: 10.58407/bht.2.22.7

ABSTRACT

The article presents the results of the study of plant-based substitutes for dairy products. For this purpose, it is proposed to use chickpeas and flax seeds.

The optimal amount of water for soaking chickpea grains has been experimentally established, which is 3.3 parts per 1 part of grain raw material. It was established that the optimal ratio of chickpeas : water for the purpose of grinding raw materials is 1: 8. The optimal ratio of chickpea and flax liquid base was also established, which is 3:1, respectively.

The bacterial composition of starters for fermenting a drink has been selected. It has been proven that the studied drinks are almost not inferior in the amount of essential amino acids to cow's milk and can act as a worthy alternative to it. In addition, it was established that the proteins of the proposed chickpea-flax drink are well absorbed by the human body.

According to research, the developed chickpea-flax fermented drink is dominated by polyunsaturated fatty acids (3.51 %), among which 2.63 % is linolenic acid. The drink also contains oleic acid in the amount of 1.26 %, which belongs to monounsaturated fatty acids. According to the ratio of fatty acids $C_{18:2}$:$C_{18:1}$ and $C_{18:2}$:$C_{18:3}$, the drink corresponds to the ideal lipid.

It is shown that yogurts based on these starters have higher sensory indicators compared to traditional drinks.

The purpose of the article is the scientific substantiation and development of the optimal formulation and production technology of a high-protein fermented beverage based on chickpeas and flax protein.

Methodology. Microbiological, physicochemical and sensorial research methods were used. Processing of the results was carried out using MS Excel databases.

The scientific novelty is that during the development of the concept of creating technologies for new fermented drinks, in which the protein content is increased and the amino acid composition is improved by adding chickpeas and flax protein.

Conclusions. The prospect of using fermented beverages made on a plant basis has been proven. It was established that the developed drink samples were based on a set of indicators (amino acid composition and soon, potential biological value of protein, utilitarian coefficient of amino acid composition of protein, indicator of “excess content” of essential amino acids, ratio of fatty acids $C_{18:2}$:$C_{18:1}$ and $C_{18:2}$:$C_{18:3}$) are characterized by high biological value of proteins and lipids. The recipe composition of a high-protein fermented chickpea-linseed drink is substantiated and the optimal ratio of water: vegetable protein preparations in the recipe composition is determined.

Key words: fermented drinks, plant-based substitutes for dairy products, vegan yogurts, chickpea and flax protein

АНОТАЦІЯ

В роботі наведено результати дослідження замінників молочних продуктів виготовлених на рослинній основі. З цією метою запропоновано використовувати зерна нуту і насіння льону.

Дослідним шляхом встановлена оптимальна кількість води для замочування зерен нуту, що складає 3,3 частини на 1 частину зернової сировини. Встановлено, що оптимальним співвідношенням нут : вода за метою подрібнення сировини є 1 : 8. Також підібрано оптимальне співвідношення нутової і лляної рідкої основи, що становить 3 : 1 відповідно.

Підібрано бактеріальний склад заквасок для сквашування напою. Доведено, що досліджувані напої майже не поступаються у кількості незамінних амінокислот коров'ячому молоку і можуть виступати йому гідною альтернативою. Крім того встановлено, що білки запропонованого нутово-лляного напою добре засвоюються організмом людини.

Згідно з дослідженнями в розробленому нутово-лляному ферментованому напої переважають поліненасичені жирні кислоти (3,51 %), серед яких 2,63 % – це ліноленова кислота. Також напій містить олеїну кислоту в кількості 1,26 %, що належить до мононенасичених жирних кислот. За показниками співвідношення жирних кислот $C_{18:2}$:$C_{18:1}$ і $C_{18:2}$:$C_{18:3}$ напій відповідає ідеальному жиру.

Показано, що йогурти на цих заквасках мають вищі органолептичні показники в порівнянні з традиційними напоями.

Мета статті полягає у науковому обґрунтуванні і розробці оптимальної рецептури та технології виробництва високобілкового ферментованого напою на рослинній основі нуту і лляного протеїну.

Методологія. Під час проведення роботи використовували мікробіологічні, фізико-хімічні та органолептичні методи досліджень. Опрацювання результатів здійснювали за допомогою баз даних MC Exel.

Наукова новизна полягає в тому, що під час розробки концепції створення технологій нових ферментованих напоїв, в яких збільшено білковий вміст і удосконалено амінокислотний склад шляхом додавання нуту і лляного протеїну.

Висновки: Показано перспективність використання ферментованих напоїв на рослинній основі. Встановлено, що розроблені зразки напою за комплексом показників (амінокислотним складом та скором, потенційною біологічною цінністю білка, коефіцієнтом утилітарності амінокислотного складу білка, показником «надлишкового вмісту» незамінних амінокислот, співвідношення жирних кислот $C_{18:2}$:$C_{18:1}$ і $C_{18:2}$:$C_{18:3}$) характеризуються високою біологічною цінністю білків і ліпідів. Обґрунтовано рецептурний склад високобілкового ферментованого нутово-лляного напою і визначено оптимальне співвідношення вода : рослинні білкові препарати у рецептурному складі.

Ключові слова: ферментовані напої, рослинні замінники молочних продуктів, йогурти веганські, протеїн нутовий та лляний

Formulation of the problem

Relevance of work. Interest in alternative food products is constantly growing. With the need to feed a growing global population, new sources of nutrients are a constant concern for both companies and consumers. While consumers prefer products that are made from natural raw materials, without artificial additives, have increased nutritional value and have certain properties for providing the body with food nutrients.

Every year, the number of consumers who choose a plant-based diet (vegetarianism and veganism), which completely or partially excludes products of animal origin from the diet, is increasing. This is due to the desire to avoid the common "diseases of civilization" in our time – cardiovascular diseases, atherosclerosis, hypertension, allergies, various neoplasms, etc.

Special attention needs to be paid to the nutrition of people who suffer from an allergy to cow's milk casein, as well as from such a hereditary disease as hypolactasia, i.e., the inability of the body to absorb milk sugar – lactose. In the body of sick people, there is an insufficient amount of protein, vitamins, and minerals, which leads to a functional disorder of the body. In order to provide adequate nutrition for such people, it is necessary to create and constantly expand the range of products, the composition of which should be as close as possible to the composition of cow's milk.

Although plant-based substitutes for dairy products (PSDP) have existed for centuries as a traditional part of various cultures, interest in them is now growing and the market for such products is expanding rapidly.

Today, the most popular alternative to cow's milk is still soy milk, as well as almond and rice milk substitutes.

The PSDP market is driven by many interests and is influenced by different opinions. At the present time, most consumers choose PSDP not because of need, but because they prefer this product category.

The market for alternatives from plant substitutes is developing especially rapidly in Western countries. On store shelves, there are various options for plant substitutes for dairy products, which have a pleasant taste profile and high nutritional value [9]. A good example of such products are fermented plant-based yogurts, which have recently challenged dairy-based yogurts. The attitude of consumers to new products was previously studied using a specific scale of their innovativeness, which involves the willingness to try and use new developments in food [4].

Fermented foods and beverages of plant origin have attracted increasing attention in recent years due to their beneficial effects on health and increased stability during production and storage, which is desirable from a technological point of view [13].

Analysis of recent research and publications.

Plant-based substitutes for dairy products are aqueous extracts of crushed plant material. Nowadays, there are many types of raw materials from which such drinks are made. However, due to the relative novelty of the product, there is currently no classification of such drinks in the literature. In some scientific works, an attempt is made at a general classification of these products, according to which five categories of drinks are distinguished, namely on the basis of [6]:

– cereals (oats, rice, corn);

– legumes (soybeans, peanuts, lupins);

– nuts (almonds, coconut, pistachios, hazelnuts, walnuts);

– seeds (sesame, sunflower, flax, hemp);

– pseudocereals (quinoa, amaranth, teff) [10].

There is a method for the production of vegetable drinks, which involves the homogenization of vegetable oils (corn, linseed, soybean or sunflower oil) with water in the presence of plant-based proteins (pea, legume or soy proteins), polysaccharides (gum arabic or beet pectin), phospholipids (soy or sunflower lecithin) or saponins (quilays) to form an oil-in-water emulsion [1; 12].

During the production of plant drinks, several stages of processing can be applied. However, the general scheme of the modern process on an industrial scale is mostly the same: the plant material is either soaked and subjected to wet grinding, or the raw material is subjected to dry grinding, after which the flour is extracted in water. Often this slurry is filtered or strained to remove grinding waste and insoluble plant material. Standardization and addition of other ingredients such as oil, flavoring, sugar and consistency stabilizers may be applied afterwards depending on the desired consistency and quality of the finished product [5].

Initially, the oil-soluble ingredients are dissolved in the oil phase, while the water-soluble ingredients (including the hydrophilic emulsifier) are dissolved in the aqueous phase. Next, a preliminary emulsion mixture is obtained by mixing the oil phase and the water phase. A finely dispersed emulsion is formed by passing a preliminary emulsion mixture through a mechanical device ("homogenizer") that further splits the oil droplets. Different types of homogenizers can be used to achieve the desired oil droplet sizes (eg, colloid mills, high-pressure valve homogenizers, microfluidizers, and sonicators). Next, the plant drinks usually undergo some form of heat treatment to deactivate any enzymes or microbes that could cause spoilage or health problems, while maintaining the high quality of the product [5].

In some cases, new technological techniques such as ultrasound, pulsed electric field treatment, ohmic heating, and homogenization at high and ultrahigh pressure are used to increase stability without the use of additives. As a rule, the application of the above technologies is aimed at inactivating microorganisms and enzymes, reducing the size of particles and reducing viscosity to increase the physical stability of a plant-based drink [1].

In the field of "plant milk" production, several areas of innovation are being explored. One of them is the possibility of producing mixtures of "plant milk". Mixes such as almond-oat and almond-coffee drinks are becoming fashionable and increasingly popular with consumers. It is also expected that the market and types of fermented plant-based drinks will grow in the future. Also, in the coming years, the commercial application of advanced non-thermal technologies for the production of "plant milk" is expected [1].

Purpose of work: to scientifically justify and develop the production technology of fermented chickpea-flax drink;

Methodology. During the research were used: organic chickpeas of the "Ahimsa" brand (Certificate "Organic Standard" UA-BIO-108 №21-0306-07-01; ETKO UA-3254-101-2020.NOP); flax protein of the "Organic Oils" brand (Technical Conditions of Ukraine 10.4-39764614-003:2019); drinking water (Sanitary rules and regulations 2.2.4–171–10 and State Standard of Ukraine 7525–2014).

Sampling for sensory, physicochemical and microbiological studies was carried out in accordance with State Standards 26809 and IDF 122B.

During the research, the titrated acidity of drinks was determined by the titrimetric method according to State Standard 3624–92 (method using the phenolphthalein indicator).

The conditional viscosity of the product was determined by the time it took for the drink to flow out of a 100 ml pipette with an outlet diameter of 5.0 mm at a temperature of 20°C in seconds.

The mass fraction of dry substances (based on sucrose) in the drink was determined by the refractometric method according to the State Standard of Ukraine 4855:2007.

The nutritional value was determined by calculation with the help of data taken from reference literature, regarding the composition of raw materials [10].

The amino acid score was calculated according to a well-known method relative to the ideal protein [2].

The warranty expiration date was established based on the dynamics of changes in a complex of sensory, physicochemical and microbiological indicators under conditions of proper storage.

During the research, the recipe composition of high-protein fermented chickpea-flax drink was developed; the optimal ratio of water: vegetable protein preparations in the prescription composition is determined.

Scientific novelty is that the concept of creating technologies for new fermented drinks based on chickpeas and flax protein with previously predicted health properties has been developed, the protein content has been increased and the amino acid composition of plant-based drinks has been improved by adding flax protein to the chickpea liquid base.

Research results

Based on the study of the properties of raw material components of PSDP, as well as existing production technologies, technology, technological scheme of manufacture and recipe for fermented drink on a plant-based – chickpeas and flax protein were developed.

In the Table 1 shows the draft recipe composition of samples of high-protein fermented chickpea-flax drink with and without additives.

Table 1

Project recipe composition of high-protein fermented chickpea-flax drink

№	Name of raw materials	Required amount of raw materials (per 100 l), %		
		Sample №1 (without additives)	Sample №2 (with sugar)	Sample №3 (with additives)
1	2	3	4	5
1	Chickpeas (grains)	15.8	15.8	15.8
2	Drinking water	79.7	74.7	73.2
3	Food salt	1	1	1
4	Flax protein	4.5	4.5	4.5

Continuation of Table 1

1	2	3	4	5
5	Sugar-sand	–	5	5
6	Agar-agar	–	–	1.5
7	Citric acid	–	1	1
8	Vanillin	–	–	0.05
9	Leaven	0.5	0.5	0.5
	Output	100	100	100

Chickpea drink is the basis for the preparation of chickpea-flax fermented drink; therefore it was important to choose the optimal amount of raw materials and water at all stages of production of the liquid base. It was found experimentally that 3.3 parts of water are needed to soak 1 part of chickpeas. For crushing swollen chickpeas, the optimal ratio of chickpeas:water is 1:8, respectively.

Next, the optimal indicators of temperature and time of heat treatment of the obtained suspension were determined. Based on literary sources, the following technological parameters were chosen: 15-20 min at a temperature of 100°C [7-8; 16]. During heat treatment, the suspension must be periodically stirred so that the chickpea starch does not form a dense clot and is evenly distributed throughout the volume. At a temperature of 50-70ºC, denaturation of the protein with its dehydration is observed, in particular, absorption of water from the environment by pasteurized starch. Pasted starch forms a strong jelly in the cells, which affects the consistency of the drink. Gelation of starch is accompanied by the dissolution of starch polysaccharides during heat treatment, which leads to the accumulation of water-soluble substances, and the partial hydrolysis of oligosaccharides and starch leads to an increase in the total amount of sugars. During cooling to room temperature, the chickpea base thickens and acquires the consistency of liquid jelly.

Chickpea protein was extracted in a water-salt solution for 45-60 minutes, followed by filtration through a double-layer cheesecloth to separate insoluble residues. The ratio of water:protein is 10:1, respectively. Extraction is carried out with the aim of extracting water- and salt-soluble proteins, as well as to prevent "flouriness" in taste.

The optimal ratio of chickpea and flax liquid base was chosen experimentally, which is 3:1, respectively.

At the next stage of the research, starter cultures of starter culture were introduced into the obtained liquid chickpea-linen base.

After thorough mixing, the chickpea-linseed drink was divided into three equal parts:

– only starter cultures were introduced into sample №1;

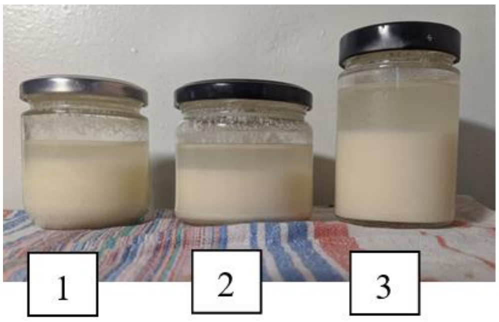
– a sweetener in the form of granulated sugar and an acidity regulator citric acid were added to sample №2;

– sweetener (sugar-sand), acidity regulator (citric acid), consistency stabilizer (agar-agar) and flavoring (vanillin) were added to sample №3.

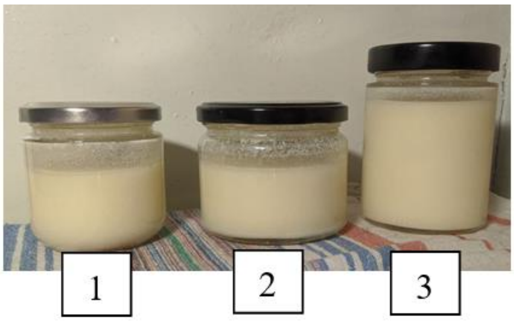
As a control, there was already commercially available yogurt, made by using "plant milk" as a substitute for dairy raw materials, namely "Alpro Soy Vanilla Yogurt".

Samples of new fermented drinks are shown in Fig. 1.

Different types of sourdough starters, which contain fermentation polycultures of bacteria, were experimentally selected for the study (Table 2).



A – immediately after fermentation



A – after mixing

B – immediately after fermentation

Fig. 1. Samples of fermented chickpea-flax drink fermented with sourdough A – "Probio yogurt" (Vivo) and B – "Vegan yogurt" (Vivo): 1 – with sugar; 2 – with additives; 3 – without additives

Table 2

Bacterial composition of starter cultures used to ferment samples of chickpea-flax drink [11]

Name of the leaven	Bacterial composition	Characteristics of leaven
Vegan yogurt (Vivo)	*Streptococcus thermophiles*; *Lactobacillus delbrueckii* ssp. *Bulgaricus*	Does not contain components of animal origin and lactose. Suitable for making vegan yogurt based on soy milk or lactose-free yogurt based on lactose-free cow's milk. 1 bag of sourdough is designed to prepare from 1 to 2 liters of yogurt
Probio yogurt (Vivo)	*Streptococcus thermophiles*; *Lactobacillus delbrueckii* ssp. *Bulgaricus*; *Lactobacillus acidophilus* (2 strains); *Bifidobacterium lactis* (2 strains); *Lactobacillus casei*; *Lactobacillus rhamnosus*; *Lactobacillus paracasei*; *Bifidobacterium infantis*	It can be used in the form of a fermented milk product, and in its pure form, without fermentation. The number of bacteria in the bag is enough for the guaranteed fermentation of 3 liters of animal milk (at the end of the shelf life of the starter)

Samples were fermented in a multicooker "Mirta" (MC-2209) using the "yogurt" mode for 16 hours at a temperature of 40°C. The obtained samples were cooled and stored at a temperature of 4 ºC for 24 hours. During cooling, the texture of fermented beverages thickened.

The nutritional value reflects the full range of useful properties of a food product and is characterized, first of all, by its chemical composition. The chemical composition and energy value of chickpea-flax fermented drinks are given in the Table 3.

Table 3

Chemical composition and energy value of chickpea-flax fermented drink

Name of sample	Content, g/100 g				Energy value, kcal/100 g
	Proteins	Lipids	Carbohydrates	Food fibers	
1	2	3	4	5	6
Control	3.2	1.9	13.6	–	85
Sample №1	4.8	1.1	8	2.1	61.1

Continuation of Table 2

1	2	3	4	5	6
Sample №2	4.8	1.1	13	2.1	83.2
Sample №3	4.8	1.1	13	2.1	84.1

The analysis of research results shows that experimental samples of chickpea-flax fermented drink are characterized by increased nutritional value due to the content of proteins and carbohydrates. The relatively high content of the latter in samples № 2 and № 3 is explained by the specificity of the raw material and added sugar. Compared to the control "Alpro Soy Vanilla Yogurt", the developed drinks differ in higher protein content and lower lipid content, as well as the presence of dietary fibers.

An important indicator of the biological value of a protein is its closeness to the ideal. Taking into account the fact that the fermented chickpea-flax drink is offered to replace dairy products, a comparison of the content of essential amino acids in the proteins of the drink with a similar indicator in cow's milk and with the reference protein was carried out, as well as the calculated amino acid rate (Table 4).

Table 4

Comparison of the content of essential amino acids of the developed drink with cow's milk and reference protein

Name of amino acid	Content, g/100 g of protein				
	Reference protein according to FAO/WHO	Cow's milk protein	Amino acid rate, %	Chickpea-flax protein drink	Amino acid rate, %
Threonine	25	44	176	45	180
Lysine	48	78	163	61	127
Methionine + cystine	23	33	144	36	157
Phenylalanine + tyrosine	41	102	249	84	205
Histidine	16	27	169	30	186
Isoleucine	30	47	157	52	173
Leucine	61	95	156	76	125
Tryptophan	6,6	14	212	16	242
Valin	40	64	160	58	145
Total essential amino acids	290.6	504		458	

From the Table 4 shows that the protein of the fermented chickpea-flax drink has a high nutritional value, as it contains all essential amino acids in quantities exceeding the values established by FAO/WHO experts for the reference protein. Comparing with cow's milk, we can conclude that the chickpea-flax drink is almost not inferior in the amount of essential amino acids and can be a worthy alternative.

The biological value of proteins depends primarily on the balanced amino acid composition of essential ones. All 20 amino acids are necessary for the construction of the vast majority of proteins in the human body, and in certain ratios that are as close as possible to those in the proteins of the human body. Violation of the balance of the amino acid composition of the protein leads to a violation of the synthesis of its own proteins, destroying the dynamic balance of protein anabolism and catabolism towards the predominance of the breakdown of its own proteins, in particular enzyme proteins. Lack of one or another essential amino acid limits the use of other amino acids in the process of protein biosynthesis. Proteins can have one or more limiting amino acids.

The analysis of these values of amino acid rate indicates an excess of all essential amino acids in chickpea-flax fermented drink. Amino acids with an amino acid rate of less than 100% are not included, i.e. the content of each essential amino acid meets the requirements of human needs in reference protein according to the requirements of FAO/WHO (2013) [2].

It should be noted that tryptophan and methionine + cystine have the lowest content among protein amino acids of chickpea-flax fermented drink. The amino acid index, which shows the completeness of the protein, exceeds the recommended values.

The utilitarian coefficient reflects the balance of essential amino acids in relation to the standard, but a more informative indicator of the balance of the composition of essential amino acids is the indicator of comparative redundancy.

The coefficient of comparative redundancy characterizes the total mass of essential amino acids, which is not used for anabolic needs in such a quantity of product protein, which is equivalent to the potentially utilized content of 100 g of reference protein. The smaller the value of the coefficient of comparative redundancy, the better balanced essential amino acids and therefore more rationally can be used by the body [14].

The potential biological value of the fermented chickpea-flax drink is 90%, which indicates a high level of amino acid balance (Table 5).

Table 5

Indicators of biological value of proteins of fermented chickpea-flax drink

Indicator	The value of the biological value of proteins in the drink	Recommended values
Potential biological value of protein, %	90	100
Amino acid rate difference coefficient, %	10	0
U, units	0.74	U → 1.0
σc, g/100 g of protein	0.13	σc, → 0
The ratio of essential amino acids / total amino acids	0.77	0.4

The utilitarian coefficient of the amino acid composition (U) indicates a high possibility of utilization of amino acids by the body, and a low indicator of comparative redundancy (σc,) means that proteins are well absorbed by the body. The ratio of essential amino acids to total ones slightly exceeds the norm.

The functional features and biological value of food lipids are determined by their fatty acid composition (Table 6).

Table 6

Evaluation of compliance of the fatty acid composition of the lipids of chickpea-flax fermented drink with the recommended norms of their consumption

Name of fatty acids	Mass fraction of fatty acids, % of the total amount of fatty acids	Recommended amount, g/day [3]
Saturated, including	0.63	25
Miristynova (C14:0)	0.40	
Palmytynova (C16:0)	0.23	
Monounsaturated, including	1.26	30
Oleinova (C18:1)	1.26	
Oleinova, including	3.51	11
Linoleic (C18:2) ω6	1.15	
Linolenic (C18:3) ω3	2.36	

Analysis of the composition of fatty acids showed that polyunsaturated fatty acids (3.51 %) predominate in the developed chickpea-flax fermented drink. The developed drink contains oleic acid (the monounsaturated fatty acid), the content of which is 1.26 %. The dominant fraction among polyunsaturated fatty acids is irreplaceable linolenic acid, the content of which is 2.63 %. Among saturated fatty acids, myristic acid prevails (0.40 %).

The digestibility of lipids depends not only on the content of individual groups of fatty acids, but also on their ratio, which characterizes the biological effectiveness of the product's lipids (Table 7).

Table 7

Indicators of biological efficiency of lipids of chickpea-flax fermented drink

Ratio	Lipids	
	Ideal lipid [15]	Lipids of chickpea-flax fermented drink
SFA:MUFA:PUFA	1:1:1	1:2:5.57
PUFA:SFA	0.2-0.4	5.57
$C_{18:2}$:$C_{18:1}$	> 0.25	0.91
$C_{18:2}$:$C_{18:3}$	> 7.0	0.19

The ratio of SFA:MUFA:PUFA does not meet the requirements for ideal lipid : content of MUFA is twice and PUFA is 5.5 times higher than the recommended ratio of ideal lipid, respectively. According to the ratios of $C_{18:2}$:$C_{18:1}$ and $C_{18:2}$:$C_{18:3}$ fatty acids, the drink corresponds to ideal lipid.

Product quality is determined not only by sensory properties, but also by the product's nutritional and energy value.

Ready-made plant-based drinks do not reach the acidity recommended by the State Standard of Ukraine for ordinary milk yogurts (norm – 80-140). The highest acidity was found in sample (34 °T).

In terms of sucrose content, only sample № 1 (4.0) is inferior to milk yogurt (the norm is at least 5.0). The low sucrose content in this case is explained by the fact that there is no added sugar in chickpea-flax drink №1.

The process of whey separation in chickpea-flax drink is not very different from yogurt based on cow's milk. Indicators indicate less serum release from the plant drink, as its ability to retain serum is less.

The analysis of research results shows that experimental samples of chickpea-flax fermented drink are characterized by increased nutritional value due to the content of protein and carbohydrates. The relatively high content of carbohydrates in samples № 2 and № 3 is explained by the specificity of raw materials and added sugar. Compared to control ("Alpro Soy Vanilla Yogurt"), the developed drinks differ in higher protein content and lower lipid content, as well as the presence of dietary fiber.

The protein quality indicator is the biological value, which is determined by the qualitative and quantitative content of amino acids and a set of coefficients characterizing the degree of protein assimilation by the body.

Based on the results of the sensory evaluation, a profilogram of the sensory indicators of the quality of the experimental samples of the chickpea-flax fermented drink was created (Fig. 2).

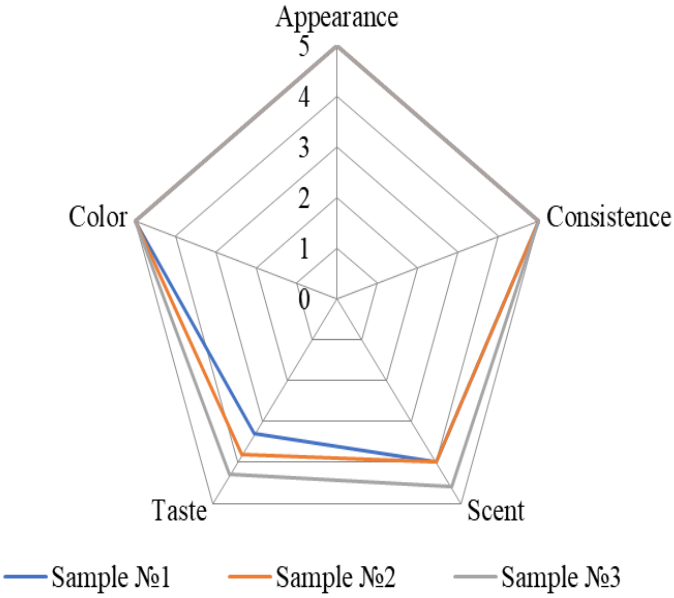


Fig. 2. Profilogram of sensory quality indicators of experimental samples of chickpea-flax fermented drink

The results of sensory evaluation of chickpea-flax fermented drink show that the developed samples are characterized by high sensory indicators. Thus, sample №3 with additives received the highest total score of 18.9 points out of a possible 20. The color of the drinks is mainly white and creamy, uniform throughout the mass. The samples had a pleasant, moderately intense smell and taste, characteristic of this type of product and raw material. The consistency of the test samples was homogeneous, viscous, without gas formation. Before tasting, the drinks were mixed, because during the storage process, whey separated, which is typical for this type of product.

Conclusions

The obtained results confirm the experimentally selected different types of starters, which contain fermentation polycultures of bacteria. A batch of samples fermented with "Probio Yogurt" (Vivo) starter, had worse sensory indicators than the samples fermented with "Vegan Yogurt" (Vivo) starter. Therefore, control samples for tasting were prepared using the second starter. According to the results of the sensory evaluation of the chickpea-flax fermented drink, sample № 3 with additives (sugar, citric acid, agar-agar, vanillin) received the highest overall score. In terms of flavor profile, this sample is more like a traditional dairy yogurt flavor.

Developed samples of chickpea-flax fermented drink are characterized by increased nutritional value due to the content of protein and carbohydrates. Compared to the control (Alpro Soy Vanilla Yogurt), the developed drinks differ in higher protein content and lower lipid content, as well as the presence of dietary fiber.

The biological value of the developed drinks is characterized by the content of all essential amino acids. According to a complex of indicators (amino acid composition and speed, potential biological value of protein, utilitarian coefficient of amino acid composition of protein, indicator of "excess content" of essential amino acids), developed samples of chickpea-flax fermented drink are characterized by high biological value of proteins.

The ratio of SFA:MUFA:PUFA does not meet the requirements for ideal lipid. The content of MUFA is twice as high, and PUFA is 5.5 times higher than the recommended ratio of ideal lipid, respectively. According to the ratios of $C_{18:2}$:$C_{18:1}$ and $C_{18:2}$:$C_{18:3}$ fatty acids, the drink corresponds to ideal lipid.

References

1. Aydar, E.F., Tutuncu, S., & Ozcelik, B. (2020). Plant-based milk substitutes Bioactive compounds, conventional and novel processes, bioavailability studies, and health effects. *Journal of Functional Foods*, 70. DOI: 10.1016/j.jff.2020.103975.

2. Dietary protein quality evaluation in human nutrition: Report of an FAO Expert Consultation. Rome (Italy): FAO, 2013. 66 p. URL: http://www.fao.org/3/a-i3124e.pdf.

3. Dudenko, N. V. (2013). Nutrytsiolohiia: navch. posib. [Nutritionology: manual]. Kharkiv: Svit Knyh.
Дуденко Н. В. Нутриціологія: навч. посіб. Харків: Світ Книг, 2013. 560 с.

4. Huotilainen, A., Pirttilä-Backman, A.-M., & Tuorila, H. (2006). How innovativeness relates to social representation of new foods and to the willingness to try and use such foods. *Journal of Food Quality Preference*, 17 (5), 353–361. DOI:10.1016/j.foodqual.2005.04.005.

5. Jeske, S., Zannini, E., & Arendt, E. (2018). Past, present and future: The strength of plant-based dairy substitutes based on gluten-free raw materials. *Food Research International*, 110, 42–51. DOI: 10.1016/j.foodres.2017.03.045.

6. Lapytska, N. V. (2021). Tekhnolohiia napoiv, ekstraktiv ta kontsentrativ: navch. posibnyk [Technology of drinks, extracts and concentrates: manual]. Chernihiv: T.H. Shevchenko National University "Chernihiv Colehium".
Лапицька Н. В. Технологія напоїв, екстрактів та концентратів: навч. посібник. Чернігів: НУЧК імені Т. Г. Шевченка, 2021. 217 с.

7. Li, W., Wei, M., Wu, J., Rui, X., & Dong, M. (2016). Novel fermented chickpea milk with enhanced level of γ-aminobutyric acid and neuroprotective effect on PC12 cells. *PeerJ*. DOI: 10.7717/peerj.2292.

8. Luana, R., & Rodrigues de Alencar, E. (2020). Development of novel plant-based milk based on chickpea and coconut. *LWT-food Science and Technology,* 128, 96–106. DOI: 10.1016/j.lwt.2020.109479.

9. Mäkinen, O.E. et al. (2016). Foods for Special Dietary Needs: Non-dairy Plant-based Milk Substitutes and Fermented Dairy-type Products. *Critical reviews in food science and nutrition,* 56(3), 339–349. DOI: 10.1080/10408398.2012.761950.

10. Motuzka, Yu., & Koshelnyk, A. (2019). Rynok analohiv molochnykh produktiv roslynnoho pokhodzhennia: svitovi trendy [The market of analogues of plant-based dairy products: global trends]. *Tovary i rynky - Goods and markets*, 3, 38–49. DOI: 10.31617/tr.knute.2019(31)04.

Мотузка Ю., Кошельник А. Ринок аналогів молочних продуктів рослинного походження: світові тренди. *Товари і ринки.* 2019. №3. С. 38–49. DOI: 10.31617/tr.knute.2019(31)04.

11. Produktsiia kompanii VIVO [Products of VIVO company]. URL: https://www.zakvaski.com/products/

Продукція компанії VIVO. URL: https://www.zakvaski.com/products/

12. Sánchez-Zapata, E., Fernández-López, J., & Angel Pérez-Alvarez, J. (2012). Tiger Nut (*Cyperus esculentus*) commercialization: health aspects, composition, properties, and food applications. *Comprehensive Reviews in Food Science and Food Safety,* 11(4), 366–377. DOI: 10.1111/j.1541-4337.2012.00190.x. 3.

13. Sethi, S., Tyagi, S.K., & Anurag, R.K. (2016). Plant-based milk alternatives an emerging segment of functional beverages: a review. *Journal of Food Science and Technology,* 53(9), 3408–3423. DOI: 10.1007/s13197-016-2328-3.

14. Sydorenko, O., Apach, M., & Burkatska, H. (2016). Biolohichna tsinnist bilkiv *Rapana venosa* [Biological value of *Rapana venosa* proteins]. *Tovary i rynky - Goods and markets,* 1, 159–168. URL: http://tr.knute.edu.ua/files/2016/21/18.pdf.

Сидоренко О., Апач М., Буркацька Г. Біологічна цінність білків *Rapana venosa. Товари і ринки*. 2016. № 1. С. 159–168. URL: http://tr.knute.edu.ua/files/2016/21/18.pdf.

15. Tsypriian, V.I. (2007). Hihiiena kharchuvannia z osnovamy nutrytsiolohii: pidruch. u 2-kh kn. [Nutritional hygiene with the basics of nutrition: a textbook in 2 books]. Kyiv: Medytsyna.

Ципріян В.І. Гігієна харчування з основами нутриціології: підруч. у 2-х кн. К.: Медицина, 2007. 544 с.

16. Zhang, X., Zhang, Sh., Xie, B., & Sun, Zh. (2021). Influence of Lactic Acid Bacteria Fermentation on Physicochemical Properties and Antioxidant Activity of Chickpea Yam Milk. *Journal of Food Quality,* 2021, 1-9. DOI: 10.1155/2021/5523356.

Received: 24.11.2022. **Accepted**: 26.12.2022. **Published**: 29.12.2022.

Cite this article in APA Style as:

Novik, A., Lapytska, N., Lystopad, T., Boychenko, P., and Savchenko, A., (2022). Development of the technology of a high-protein fermented drink on a plant basis. *BHT: Biota. Human. Technology*, 2, 93-105. (in English)

Information about the authors:

Anna Novik [*in Ukrainian*: Новік Г.] [1] Ph.D. in Tech. Sc., Assoc. Prof., e-mail: anna.novik.82.2ukr.net
ORCID: 0000-0003-4045-4878, *ResearcherID:* G-8283-2019
Department of food technology, Oles Honchar Dnipro National University,
Gagarina str., 72, Dnipro, Ukraine, 49010, Ukraine

Nadiya Lapytska [*in Ukrainian*: Лапицька Н.] [2], Ph.D. in Tech. Sc., Assoc. Prof., e-mail: nadegda.lapitskaja@gmail.com
ORCID: 0000-0003-2431-4373
Department of Chemistry, Technology and Pharmacy, T.H. Shevchenko National University «Chernihiv Colehium»,
53 Hetmana Polubotka Street, Chernihiv, 14013, Ukraine

Tamara Lystopad [*in Ukrainian*: Листопад Т.] [3]**,** Ph.D. in Tech. Sc., e-mail: lystopad.tamara.88@gmail.com
ORCID: 0000-0002-5669-6778 *ResearcherID:* Q-9734-2017
LLC "AUTOCOM DNIPRO"

Polina Boychenko [*in Ukrainian*: Бойченко П.] [4]**,** master, e-mail: linaboichenko@ukr.net
Department of food technology, Oles Honchar Dnipro National University,
Gagarina str., 72, Dnipro, Ukraine, 49010, Ukraine

Alina Savchenko [*in Ukrainian*: Савченко А.] [5], Assistant, e-mail: savkalka3@gmail.com
ORCID: 0000-0002-2649-8412, *ResearcherID:* ADT-972-2022,
Department of food technology, Oles Honchar Dnipro National University, Dnipro.
Gagarina str., 72, Dnipro, Ukraine, 49010, Ukraine

---

[1] Study design, statistical analysis, manuscript preparation
[2] Data collection, statistical analysis,
[3] Data collection, statistical analysis
[4] Statistical analysis, manuscript preparation
[5] Statistical analysis