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TECHNOLOGY OF BEVERAGE EMULSION BASED ON PLANT RAW MATERIALS FOR SPORTS NUTRITION

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Abstract. The article presents the development of a special-purpose beverage emulsion technology based on natural plant raw materials for use in sports nutrition. The recipe ingredients were selected considering the optimal ratio of the main nutrients that an athlete's body needs after intense physical exertion for recovery. A comparative analysis of the characteristics of the main types of emulsifiers was carried out, and soy lecithin was selected as the emulsifier. Production technology for a beverage emulsion for athletes was developed, and its functional diagram was presented, indicating the modes and parameters of technological operations. It was found that a beverage emulsion made from quinoa broth, banana puree, pea protein isolate, flaxseed mucilage, and stabilized with lecithin, exhibits typical pseudoplastic behavior, indicating the effective structural organization of the colloidal system and its adaptability to mechanical influences. It was determined that the dynamic viscosity values ranged from 235 mPa·s (at 5 s^{-1}) to 65 mPa·s (at 200 s^{-1}) immediately after preparation, indicating a dense but drinkable consistency with good organoleptic properties. It was found that after one day of storage in a cooled state (4 °C), there was a slight decrease in dynamic viscosity within 5-10 % at all shear rates, which did not lead to a loss of homogeneity and functional characteristics of the beverage emulsion. The organoleptic quality indicators of the beverage emulsion were assessed 10 minutes after its preparation and after storage for 24 hours at a temperature of 4 °C, and it was proven that such storage does not significantly affect appearance, aroma, taste, consistency, drinkability, homogeneity, and overall impression. Both samples of the beverage were characterized by excellent organoleptic qualities. Recommendations were made regarding the use of the developed «Revive» beverage with the possibility of its short-term storage. The beverage is developed as specialized sports nutrition consumed after training or competitions. It is recommended for sale in restaurants as a functional beverage with high nutritional value and stable rheological structure.

Keywords: beverage emulsion, technology, plant ingredients, stabilizer, dispersion, dynamic viscosity, quality indicators.

Introduction. Formulation of the problem

Ukraine's public policy concept [1] includes steps to keep people healthy and able to work, and to help them live longer and better lives. The main things that affect how healthy people are, how they feel, and how well they work are what they eat, how much physical and mental stress they have, how fast they can share information, etc.

Food products for special sports consumption are developed to meet the specific needs of people who lead an active lifestyle. The composition of such products differs significantly from that of conventional food products [2]. The difference is that they are not produced by food industry enterprises, but by specialized catering establishments, and they are also sold in specialized departments of retail chains.

The category of special food products includes: natural food products containing the necessary amount of functional ingredients or combination of such ingredients; natural products additionally enriched with any functional ingredient or combination of ingredients; natural products with an extracted component which might prevent the physiological activity other ingredients; natural products with ingredients modified to ignite their physiological activity or to increase this activity; products modified to increase the absorption of the original active ingredients; natural or artificial products in which, as a result of a combination of technological techniques, the ability to maintain and improve human physical or mental health and/or reduce the risk of disease arises [3,4].

In today's world of sports, where every second and any increase in productivity percentage of performance

is crucial, scientific research is constantly focused on finding innovative approaches to optimize athletes' physical capabilities. One such promising area is the development and use of beverage emulsions. Traditionally, beverages made for athletes focus on quick restoration of water and electrolyte balance and easy provision of accessible carbohydrates. However, growing interest in the role of fats as an important source of energy, especially during prolonged and intense exercise, and antioxidants offer new perspectives for the creation of functional beverages for athletes.

Beverages are the most technologically advanced products to create new types of special-purpose foods due to the easy addition of any functional ingredients to their composition. The selection of dietary micronutrients or natural sources of biologically active substances should be based on the basic criteria developed by the WHO and approved by the Cabinet of Ministers of Ukraine [5,6].

Today, there are several technological methods to enrich food products with micronutrients. They include dry mixing, dissolution in water or other liquids, dissolution in fats and oils, etc.

Recently, the interest in special food products, the composition of which was developed with the aim of replenishing the diet with nutrients, has increased dramatically. An important role in this is given to vitamins, which have been used more often over the past ten years.

The developed production technologies [7,8,9] are associated with the enrichment of vitamins A, D, and E, which are added separately in the form of oil substances or in the form of a premix – a mixture of these vitamins in sunflower oil solution. β-carotene is used rather intensively to color various groups of products.

The content of vitamins, especially fat-soluble vitamins, in fortified foods is calculated in a way as to eliminate their deficiency, but not to create the problem of hypervitaminosis.

The simultaneous presence of polar and fat solvents in beverages allows for an increased range of enrichment ingredients. In addition, polyunsaturated fatty acids in the fat component also have a functional effect participating in the construction of cell membranes, the formation of the nervous system and visual apparatus, reducing the risk of cardiovascular disease and atherosclerosis, and influencing mental and intellectual development.

Functional products based on grain (pseudocereal) crops are becoming increasingly widespread. Their functional effect is due to the presence of a whole complex of biologically active substances. The nutritional value of pseudo-cereal products (quinoa) is 2.3 times higher than that of conventional cereals due to their higher content of vitamins B and E, as well as essential amino acids such as lysine and tryptophan [10,11,12].

For people who are heavily involved in sports it is very important to ensure sufficient protein intake, including plant protein. In this respect, legumes, which have been used by humans for more than five millennia, are a promising raw material among cultivated plants. For example, soybeans contain 35-48 % protein, peas 23-27 %, beans 21 %, while wheat has only 12-15 %, corn 10-12 %, oats 12-14 %, beef 20,0 %, and cottage cheese 18,0 %.

With reference to the above, it's worth developing new types of beverage emulsions containing fat and water to search for improvers and technological techniques that enhance the functional properties of the finished product.

Analysis of recent research and publications

Emulsions which are stable dispersions of two or more liquids that do not normally mix have the unique ability to combine the benefits of hydration with the effective delivery of lipids and other fat-soluble biologically active compounds. This form improves fat absorption, provides prolonged energy release, and enriches beverages with essential vitamins and antioxidants, which are critical to support recovery and overall health of athletes.

In this respect, the development of new beverage emulsion formulations represents the creation of products with certain predefined properties.

In addition to combining ingredients of different chemical compositions in order to give the product the desired functional properties, special attention is paid to the physical stability of the emulsion during and immediately after emulsification. This stability is called short-term stability and shows how well the emulsion droplets are protected from coalescence. Mechanical methods of producing an emulsion should ensure not only a reduction in the size of the droplets, but also their stabilization immediately after formation.

In the case of deformation and destruction of the original emulsion droplets, their transformation is possible, depending on the processing conditions. Droplets that are sufficiently protected from sticking together remain small and create the necessary finely dispersed structure. If clumping cannot be prevented, the droplets merge and increase in size that completely negate the previous treatment [13]. Accordingly, this process can lead to emulsion separation, which must be prevented.

There is a well-known technology for producing a stable carotene-containing emulsion of the oil-in-water type [13]. At the beginning of the process, a suspension of carotene crystals in oil is created. After that, a fat phase is mixed with a water phase and cooled. This form is an unstable intermediate emulsion, which is homogenized, so that the droplets become smaller, and a stable finely dispersed system is formed, which contains carotenoids in the form of a supersaturated oil solution.

When considering the stability of beverage emulsions, physical and chemical stability should be distinguished. Emulsions formed by high-pressure homogenization have a finely dispersed texture and the likelihood of their stratification is not significant. The use of multi-cycle processing allows for a narrower distribution of droplets and increased physical stability. To increase the chemical stability of carotenoids, antioxidants can be added to slow down possible transformations.

Emulsions are unstable systems. Since there is no affinity between oil and water particles, they tend to break down [14,15]. To create food emulsions that are kinetically stable over a long period of time, emulsifiers and thickeners must be used.

The emulsifier exhibits the properties of a surface-active substance that adsorbs onto the surface of the dispersed phase particles and forms a protective film without causing droplet aggregation (Fig. 1).

Certain classes of substances are used as emulsifiers: ionogenic (anionic or cationic), surface-active substances (salt cations); non-ionic (cellulose and its derivatives, such as methylcellulose, sodium carboxymethylcellulose in the form of a 1-2 % solution) amphoteric (gelatin, proteins, microbial polysaccharides). The most commonly used are proteins, polysaccharides, phospholipids, and low-molecular-weight surfactants [13]. The characteristics of the most common natural surfactants are shown in Tab. 1.

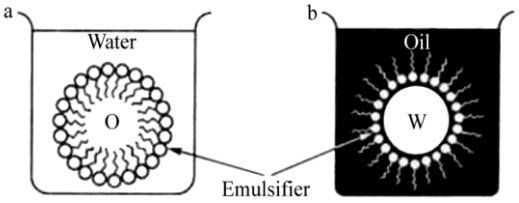

Fig. 1. Scheme of emulsion stabilization using surfactants:
a) emulsion type I oil/water (o/w); b) emulsion type II water/oil (w/o)

The development of beverage emulsion technology will enable the production of a product enriched with water-soluble and fat-soluble components.

Beverage emulsions are an important component of human nutrition. The biological effectiveness of fats is determined, on the one hand, by the structural characteristics of fatty acids and, on the other hand, by their ratio. Essential polyunsaturated fatty acids play a special role in the composition of fats.

They are represented in food products by two main classes: the ω-3 and ω-6 families. According to the recommendations of nutritionists, the human body's need for PUFAs is 11 g/day, and 1-1.5 g/day for omega-3 fatty acids and no more than 10 g/day for omega-6 fatty acids.

Table 1 – Characteristics of some surfactants

Name of surfactant	Characteristics
Arabian gum (Gummi arabicum)	is one of the first imported emulsifiers for the preparation of pharmaceutical emulsions for extemporaneous manufacture. It is obtained from several species of African acacia. When mixed with water in a 1:2 ratio, it forms a thick glue-like liquid. Highly dispersed emulsions are obtained from the best varieties of Arabian gum. For every 10 parts of oil, take 5 parts of Arabian gum.
Apricot gum (Gummi armeniaca)	is formed from cuts and cracks in the trunks and branches of apricot trees. It dissolves well in water. For every 10 parts of oil, take 3-4 parts of apricot gum.
Plant mucus (Mucilagines)	are polysaccharide substances formed as a result of the «mucous» degeneration of plant cells (mucus from flax seeds, orchis root, marshmallow root, algae). When swollen in water, they form viscous solutions that have the ability to form emulsions.
Pectin (Pectinum)	is used to reduce gelatinization; it is advisable to use it in combination with apricot gum in a 1:1 ratio.
Starch paste (Mucilago Amyli)	is a non-ionic surfactant emulsifier for extemporaneous emulsions. For every 10 parts of oil, take 5 parts of starch solution in the form of paste.
Cellulose and its derivatives	methylcellulose is a non-ionic surfactant. It is used as an emulsifier in the form of a 5% solution. Sodium carboxymethylcellulose is a non-ionic surfactant. It is used as an emulsifier in the form of a 1-2 % solution.
Emulsion waxes	a complex emulsifier with predominantly non-ionic properties. It is for producing direct type viscoelastic emulsions.
Gelatosa	an ampholytic (amphoteric) surfactant has a high emulsifying capacity. However, emulsions with its use are a favorable environment for the development of microorganisms and require the introduction of a preservative. The recommended concentration is 5 g per 10 g of vegetable oil.
Lecithin	an ampholytic surfactant is an emulsifier to produce direct emulsions. It is recommended for stabilizing parenteral emulsions of the oil-in-water type.

Thus, most scientists believe that the optimal biological formula for the balance of polyunsaturated fatty acids is the ratio of the ω-3: ω-6 family as 1:10 in the diet of a healthy person, and for therapeutic and prophylactic nutrition – from 1:3 to 1:5 [16].

In today's environment of heightened interest in functional nutrition, especially among athletes and people who lead active lives, beverage emulsion which has high biological value are attracting particular attention. Such products should not only provide energy support, but also have stable physical and chemical abilities, in particular, optimal consistency and structural homogeneity [17].

Purpose and objectives of the study. The purpose of this article is to analyze the conditions for creating beverage emulsions for athletes, justify the choice of raw materials, and develop a technology for manufacturing drinks in specialized restaurant establishments. To do this, the following tasks must be completed:

1. Consider the water- and fat-soluble food ingredients necessary for athletes to achieve high results.
2. Select the fat component of the drink, find a type of emulsifier, and test its effectiveness.
3. Determine the dynamic viscosity of the developed beverage emulsion for further evaluation of its rheological behavior, structural stability, and organoleptic characteristics.
4. Determine the modes and parameters of technological operations and develop a technology for a beverage emulsion based on raw materials of plant origin.
5. Develop recommendations for the consumption of the beverage for athletes.

Research materials and methods

It is advisable to provide the protein component in beverages by using pea protein as a concentrated protein mixture. The purity of pea protein isolate, depending on the production technology, ranges from 80 to 90 % [18]. The isolate contains nine essential amino acids, and its total amino acid content is 34.4 g per 100 g [19]. Plant-based pea protein naturally contains no lactose or gluten and is more easily digested than proteins from dairy products. Compared to other common protein concentrates, peas are more environmentally friendly and more economically to grow. Pea protein as an ingredient has many advantages over other plant-based proteins: it is a functional ingredient as it has moisture- and fat-binding abilities, a neutral taste, and its digestibility is about 98 % [20].

Coconut water is used as a natural source of electrolytes, which play a key role in maintaining the water-salt balance in the athlete's body. Due to its isotonic composition coconut water promotes rapid restoration of hydration and energy potential and is a promising ingredient for functional recovery beverages. Coconut water contains minerals, vitamins, and amino acids. Consumption of this liquid helps improve metabolism, lower blood pressure, and normalize gastrointestinal function. Coconut water contains five essential electrolytes that help regulate body temperature [21,22]. It is a clear liquid found inside green (unripe) coconuts. It differs from coconut milk, which is made from the flesh of ripe coconuts. This liquid is famous for its freshness and natural taste, as well as its numerous beneficial properties. It is a unique drink rich in various nutrients, containing a complex of vitamins, minerals, and other important components that have a positive effect on human health.

Flax seeds are a source of healthy fat containing α-linolenic acid, which can remain unoxidized for a long time in the seeds. Used in beverages, flax seeds require pre-treatment and a reduced critical preparation time for the components in order to prevent oxidative transformations [23,24].

Quinoa is a superfood renowned in the culinary world. Quinoa seeds belong to the category of pseudocereals or cereal-like crops, rich in protein, fiber, various minerals, and vitamins [25,26]. The high protein and fiber content in quinoa keeps you feeling full for a long time after the meal. The protein that humans get, when eating pseudocereals, is complete as it contains nine essential amino acids necessary for being healthy. The high fiber content helps maintain the health of the intestines and the entire digestive system in general.

Emulsifiers are used in the production of emulsion drinks to prevent the mixture from separating and to create a homogeneous consistency of the finished product. Lecithin is chosen as the emulsifier.

A complex multi-component composition of beverage emulsions for athletes requires certain manufacturing conditions. Nowadays, among other modern equipment, the use of a thermomixer, which is an inexpensive and widely available device, is popular in restaurants. A German production TM5 thermomixer was used to make emulsion drinks. To improve organoleptic properties, flavor and aroma additives were used.

Produced beverage emulsions were tested for stability before and after storage and for organoleptic properties depending on the ratio of the component composition.

The rheological characteristics of the beverage were determined using a Brookfield rotary viscometer at a temperature of 20±1 °C in accordance with the standard ISO 3219:1993 [27].

Results of the research and their discussion

As our previous studies have shown, increasing the performance of athletes and accelerating recovery processes in their body after prolonged and excessive physical exertion is not possible without adequate supplementation of the diet with biologically active substances. Some of the ingredients important for the

athletes' body are water-soluble, and some are fat-soluble. For the simultaneous intake of these substances, it is advisable to develop a beverage emulsion technology based on such superfoods as quinoa and pea protein isolate with the addition of banana puree, coconut water, crushed flax seeds, honey, cinnamon and lecithin. Special products for athletes are a complex of nutrients that purposefully affect the metabolism in the athlete's body both during and after training. The purpose of using these foods is to expand the limits of adaptation to systematic muscular activity of varying intensity and duration [2]. This is a category of food products designed to meet the specific needs of the body of people who are regularly involved in intense physical activity. Such products differ from conventional ones in the increased content of certain nutrients, such as proteins, carbohydrates, vitamins, minerals and other functional ingredients. The main purpose of these products is to provide energy, recovery potential, hydration and maintain a functional state: optimizing metabolic processes and overall health. Considering the significant physiological changes that occur in athletes during their physical activity, it is beverages that play a critically important role by ensuring the hydration of their body, replenishing it with electrolytes, providing energy and recovering potential after exercise.

Recovery beverage emulsions are specialized nutritional products designed to optimize the recovery process of athletes after intense physical activity. The key feature of these drinks is the use of emulsification technology, which involves creating a stable combination of liquids that normally do not mix. This allows you to combine a variety of nutrients important for recovery in one product in an easily digestible form.

Such beverages usually contain water for rehydration, carbohydrates to replenish glycogen stores, proteins to repair muscle fibers, and sometimes small amounts of fat, which, due to emulsification, become more accessible to the body. Other important components are electrolytes that help restore water-salt balance, vitamins, minerals to support metabolic processes, and antioxidants.

The advantages of beverage emulsions, which increase the recovery abilities, may include improved digestibility of some fat-soluble components due to their increased surface area, as well as a more pleasant and uniform texture, which may increase the athlete's desire to consume such a drink after an intense workout routine. In addition, they provide a comprehensive supply of essential nutrients in one convenient formula. Although scientific research into the unique benefits of emulsion formulas is still ongoing, the use of emulsification technology is promising in sports nutrition to optimize the characteristics of recovery products.

In order to find a stabilizer for the structure of the drink, we analyzed the main types of emulsifiers (Table 2).

Considering the data presented in Table 2, it was decided to use soy lecithin as a stabilizer for the structure of the beverage the main characteristics of which are presented in Table 3.

Table 2 – Classification and comparative analysis of the characteristics of the main types of emulsifiers

Characteristics	Surfactants	Biopolymers (proteins, polysaccharides)	Finely dispersed solid particles
Basic mechanism of action	Reduction of interfacial tension due to adsorption at the interface. Can provide electrostatic or steric repulsion	Steric repulsion (polysaccharides), film formation and viscosity increase (both types). Some proteins also reduce interfacial tension	Formation of a stable layer of solid particles at the phase interface (Pickering emulsions)
Types	Ionic (anionic, cationic), non-ionic (polyol esters, sucrose esters), amphoteric (rarely used in beverages)	Proteins (casein, gelatin, whey proteins), polysaccharides (gum arabic, pectins, starches)	Mineral substances (silicon dioxide), organic (rarely used in beverages)
Used in beverages	Lecithin, polysorbates (E432-E436), esters of glycerol and resin acids (E445), mono- and diglycerides of fatty acids (E471)	Gum Arabic (E414), Pectins (E440) (in some fruit beverages), Casein (in dairy beverages)	Rarely found in traditional drinks, but can be used in new developments
Advantages	Effective reduction of interfacial tension, wide range of available molecules with different properties	Often of natural origin, may provide additional functional properties (e.g. thickening)	Can create very stable emulsions that are resistant to coalescence
Disadvantages	Some may be sensitive to pH and ionic strength, may affect taste or cause foaming	Emulsifying ability may be lower compared to some surfactants; effectiveness depends on pH and other conditions	Can change the texture of the drink, more difficult to control particle size

Table 3 – Characteristics of soy lecithin

Parameter	Meaning / Description
Origin	Natural, defatted soybean meal
Composition	Phospholipids (phosphatidylcholine, phosphatidylethanolamine, etc.) – up to 70 %, fatty acids, triglycerides
Form	Granules or liquid (liquid, dispersed in coconut water)
Color	From light brown to amber
Solubility	Insoluble in water, but forms stable emulsions when dispersed (especially in warm liquid)
Optimal concentration	0,3 % – 1,5 % (in our case 1.5 % was used)
Activation temperature	It works best at 30-60°C, so preliminary dispersion was carried out in a warm environment (50 cm³ of coconut water)
pH stability	Stable within pH range 3.0-8.0
Food function	Emulsifier, antioxidant, source of phospholipids for the nervous system and cellular nutrition

Soy lecithin has good emulsifying ability even water, proteins, fats and dietary fibers are grouped together as a multicomponent. It is compatible with protein isolates and with such plant raw materials as bananas and flax seeds. In addition, the use of this stabilizer has a positive effect on the organoleptic, creating a silky structure of the beverage. It is also important that soy lecithin is commercially available, which is important for specialized catering establishments such as sports cafes, sports bistros, sports bars, etc.

To make a beverage emulsion (Fig. 2), quinoa was used, which was previously washed and boiled in water for 15 min, infused for 10 min and filtered. Banana puree and flax seeds were added to the resulting broth, which were infused in water at temperatures of 80-90 °C for 5 minutes to release mucous substances [28]. Next, 1.5 % lecithin, pre-dispersed in coconut water [29], pea protein isolate, cinnamon, honey and coconut water were added. All components were mixed in two stages using a blender (9000 rpm – 60 sec and 500 rpm – 15 sec) respectively. The resulting beverage was cooled to 20 °C before studying.

The beverage was put aside for 10 minutes in order to get stabilized before its further studies. The sample volume contained 150 cm^3 of emulsion drink.

Dynamic viscosity was measured at shear rates from 5 to 200 s^{-1}, immediately after preparation and after 48 hours of refrigerated storage at 2-6 °C [30, 31].

The results of the study of the dynamic viscosity of the developed emulsion drink 10 min after preparation and 24 hours after storage at 4 °C are shown in Fig. 3.

As stated in Table 4, the beverage exhibits typical pseudoplastic behavior: the viscosity decreases with an increasing shear rate, which is typical for emulsions containing proteins, pectins and lecithin [32].

The dependence of dynamic viscosity on shear rate before and after storage of the developed emulsion drink is presented in Fig. 3.

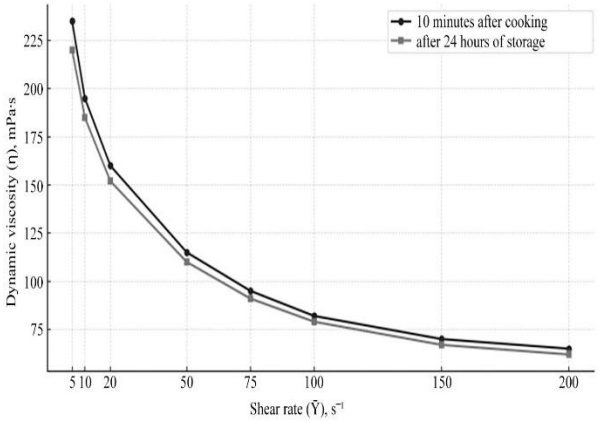

Fig. 3. Graph of dynamic viscosity versus shear rate for a beverage emulsion stabilized with lecithin

Considering the data presented in Fig. 1, it is obvious that the beverage exhibits typical pseudoplastic behavior: the viscosity decreases with increasing shear rate, which is typical for emulsion systems with proteins, pectins and lecithin [32].

After 24 hours of storage at 4 °C, a slight (5-7 %) decrease in viscosity is evident, more at low shear rates, which may be associated with partial sedimentation of the suspension, structural relaxation of proteins or a slow change in the hydration of the emulsifier. It should be noted that such a decrease is natural and does not lead to a loss of homogeneity or functional characteristics of the product. In general, we can speak of a stable rheological structure of the beverage after cooling and settling, which indicates the stability of the emulsion, even considering the presence of a light suspension of proteins and polysaccharides [31].

So, soy lecithin in the amount of 1.5 % of the total mass of the beverage effectively stabilizes the multicomponent emulsion, preventing stratification during storage.

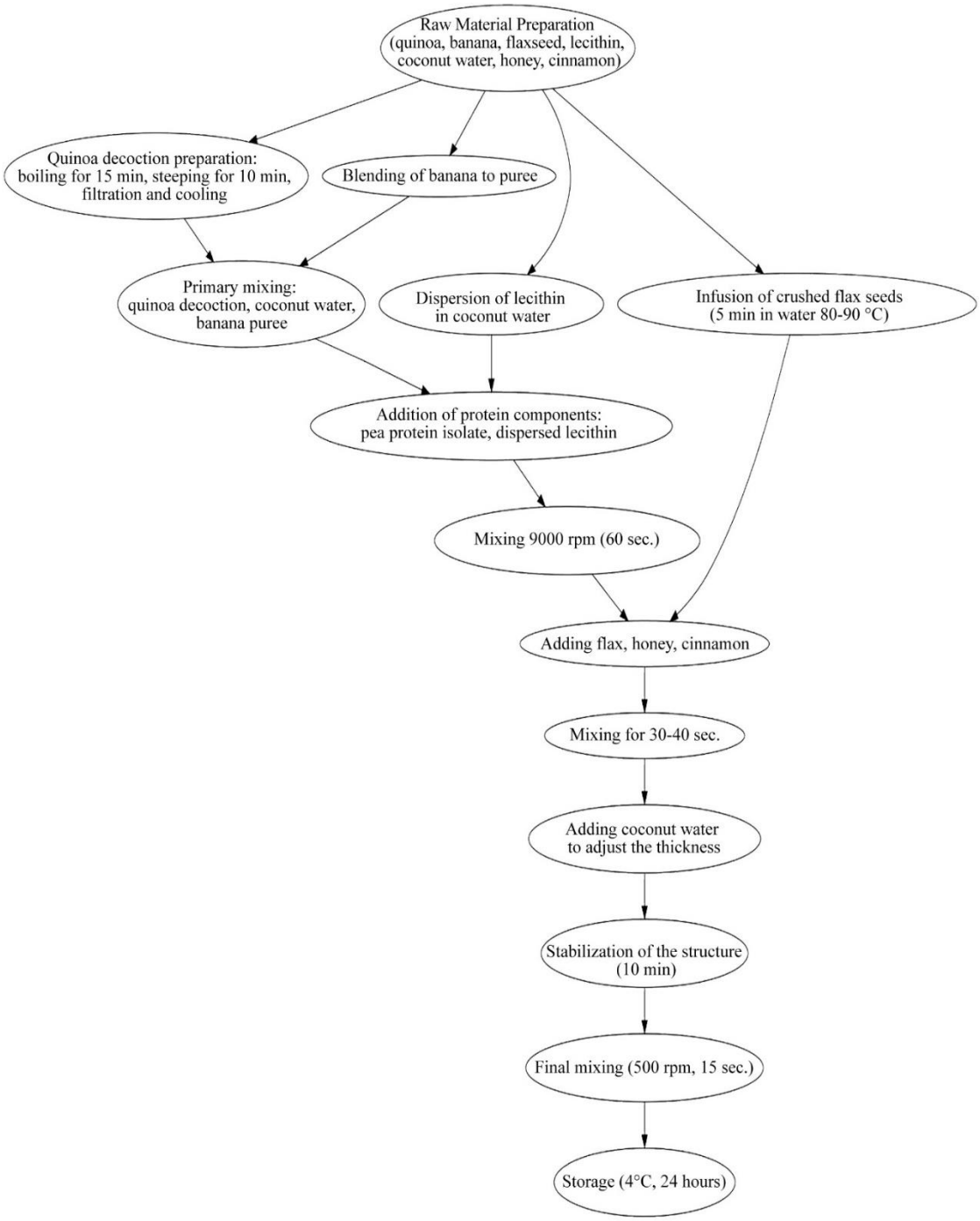

Fig. 2. Functional diagram of a beverage emulsion «Revive» made for athletes

Thus, it can be stated that the developed beverage emulsion has non-Newtonian, pseudoplastic behavior, which is typical for emulsions containing vegetable proteins and pectin-like substances. Due to the dense consistency this beverage should be served chilled to 8-10 °C in glasses with a thick straw or in protein shakers. The organoleptic quality indicators, which are of great importance for beverages, are given in Table 4 to qualify the developed beverage.

The data presented in Table 4 indicate high organoleptic indicators as a consequence of a well-chosen composition of ingredients for the recipe: the softness of the banana, stability due to lecithin, the natural sweetness of honey, the aroma of cinnamon, but the absence of stratification or silky consistency indicate successful emulsification.

Table 4 – Organoleptic characteristics of the beverage emulsion

Indicator	Description
Appearance	Homogeneous liquid with light suspension, without stratification
Color	Creamy beige, slightly cloudy, typical for plant-based raw materials
Aroma	Distinkt natural banana scent with light hints of cinnamon
Taste	Soft, with a slight sweetness of honey, not bitter or impure
Consistence	Soft, gentle, pleasant to swallow
Drinkability	Light, without «stretchiness», convenient to use even through a straw
Homogeneity	High, no lumps, ingredients evenly distributed throughout the volume
Overall impression	A functional, tasteful and a visually pleasing beverage

Since visualization allows you to assess quickly the balance of product perception according to key organoleptic criteria, profilograms of the beverage were constructed. The product was evaluated 10 minutes after preparation and after storage in a refrigerator at a temperature of 4 °C for 24 hours on a 10-point scale. The results of the study are shown in Fig. 4.

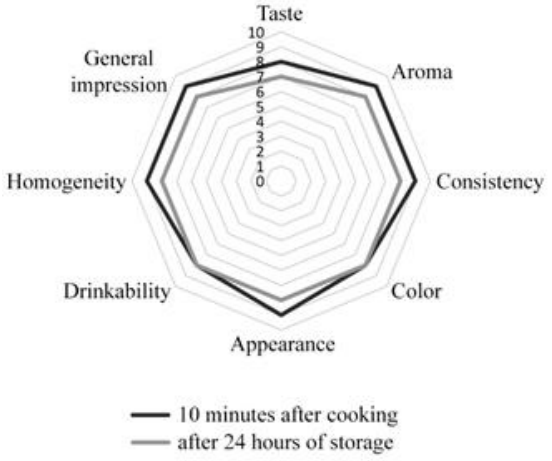

Fig. 4. Comparative profile of organoleptic indicators of the beverage emulsion «Revive»

Figure 4 shows that after a day of storage in chilled condition, the beverage emulsion demonstrates high preservation of organoleptic characteristics. There was a slight change in homogeneity, the color didn't change but stayed natural, and the aroma was less intense. The taste was less distinct, but the consistency remained silky. A slightly less dense homogeneity of the structure was observed. According to the general impression, the beverage retained its functional and organoleptic properties. Such a slight decrease in scores did not affect the consumer appeal of the product. The structure of the beverage remained resistant to delamination, its homogeneity, creamy consistency and mild taste were preserved, which indicates the feasibility of using lecithin as a natural emulsifier in combination with protein and polysaccharide ingredients of plant origin. This result proves the effectiveness of using soy lecithin as a stabilizer in production technology and the possibility of selling the developed beverage emulsion by catering establishments.

Conclusion

A recipe and production technology for a beverage emulsion for athletes based on plant raw materials has been developed. The beverage is of high nutritional and functional value. The developed beverage has pseudoplastic rheological behavior, which contributes to easy drinkability under mechanical influence, and it provides stability during storage. Lecithin in an amount of 1.5% effectively stabilizes the emulsion. After storage at the temperature of 4 °C for 24 hours, the consistency of the beverage does not change significantly and remains homogeneous, stable, without any signs of delamination, which allows us to recommend the product for sale within the established period. The beverage is recommended for use as sports nutrition as well as for sale by specialized catering establishments.

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ТЕХНОЛОГІЯ ЕМУЛЬСІЙНОГО НАПОЮ НА ОСНОВІ РОСЛИННОЇ СИРОВИНИ ДЛЯ СПОРТИВНОГО ХАРЧУВАННЯ

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Анотація. У статті представлено розробку технології емульсійного напою спеціального призначення на основі натуральної рослинної сировини для використання в системі спортивного харчування. Здійснено підбір рецептурних інгредієнтів з огляду на оптимальне співвідношення основних поживних речовин, яких потребує організм спортсмена після інтенсивного фізичного навантаження з метою відновлення. Проведено порівняльний аналіз характеристик основних типів емульгаторів та обрано в якості емульгатора соєвий лецитин. Розроблено технологію емульсійного напою для спортсменів та наведено його функціональну схему з вказанням режимів та параметрів технологічних

операцій. Встановлено, що емульсійний напій, виготовлений на основі відвару кіноа, бананового пюре, ізоляту горохового білка, слизових речовин насіння льону та стабілізований лецитином, демонструє типову псевдопластичну поведінку, що свідчить про ефективну структурну організацію колоїдної системи та її адаптивність до механічних впливів. Визначено, що показники динамічної в'язкості змінювались у діапазоні від 235 мПа·с (при 5 $с^{-1}$) до 65 мПа·с (при 200 $с^{-1}$) одразу після приготування, що вказує на щільну, але питку консистенцію з добрими органолептичними властивостями. Встановлено, що після однієї доби зберігання в охолодженому стані (4 °С) відбулося незначне зниження динамічної в'язкості у межах 5-10% при всіх швидкостях зсуву, що не призвело до втрати однорідності та функціональних характеристик емульсійного напою. Проведено оцінку органолептичних показників якості емульсійного напою через 10 хв після його виготовлення і після зберігання протягом 24 годин при температурі 4 °С та доведено, що таке зберігання не впливає суттєво на зовнішній вигляд, аромат, смак, консистенцію, питкість, однорідність та загальне враження, обидва зразки напою характеризувались відмінними органолептичними якостями. Надано рекомендації щодо використання розробленого напою «Revive» з можливістю короткотермінового зберігання у спеціалізованому спортивному харчуванні після тренувань або змагань, а також для реалізації у закладах ресторанного господарства як функціонального напою з високою харчовою цінністю та стабільною реологічною структурою.

Ключові слова. емульсійний напій, технологія, рослинні інгредієнти, стабілізатор, диспергування, динамічна в'язкість, показники якості.