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# FUNCTIONAL ISOTONIC DRINKS BASED ON THE TISSUE FLUID OF RHOPILEMA JELLYFISH

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***ABSTRACT.*** *A formulation for the preparation of isotonic drinks based on the tissue fluid of the rhopilema jellyfish (Rhizostomeae) Rhopilema Asamushi is proposed. While jellyfish are made up primarily of water (up to 97% of undried weight), the main chemical factors in maintaining the water-salt balance of jellyfish tissues under environmental pressure conditions are free amino acids (up to 10% of dry weight) and various mineral elements (up to 65% of dry weight). The proportion of the latter significantly exceeds the protein component (up to 20% of dry weight), which distinguishes jellyfish from most species of animals. Prevailing tissue elements are sodium, potassium, calcium, magnesium, iron, zinc, copper, chromium and selenium. Known technologies of jellyfish processing are aimed at obtaining a dense and stable structure of the semi-finished product, while the liquid fraction is removed during processing. In so doing, at least 70% of all water content, as well as mineral elements, free amino acids and water-soluble proteins dissolved in it, are lost. Herein, a method is proposed for separating the liquid fraction of jellyfish tissues from high-molecular impurities using the ultrafiltration method. Due to the presence of low molecular weight soluble components, the solution obtained can serve as the basis for the creation of isotonic drinks containing biologically active substances. As a result, a formulation of isotonic drinks is developed, which brings the value of the osmotic pressure of the obtained product to the limits of the established norms (270-330 mOsm/kg). In this regard, the composition of the formulation includes carbohydrates (glucose and fructose) in the amount of 6,5 g per 100 ml of product. Additionally, a preservative, acidity stabilisers and antioxidants (citric and ascorbic acids) are used, as well as the berry extracts in order to impart attractive organoleptic properties to product. In addition to performing the function of restoring the water-salt balance, these drinks can serve as additional sources of such mineral components as iron, chromium and selenium.*
***Keywords:*** *isotonic drinks, osmolality, mineral elements, amino acids, Rhopilema jellyfish*

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# ФУНКЦИОНАЛЬНЫЕ ИЗОТОНИЧЕСКИЕ НАПИТКИ НА ОСНОВЕ ТКАНЕВОЙ ЖИДКОСТИ МЕДУЗЫ РОПИЛЕМЫ

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***РЕКЗЮМЕ.*** *Предложен состав для приготовления изотонических напитков на основе тканевой жидкости медузы ропилемы (корнерота) Rhopilema Asamushi. Преобладающим компонентом тканей медузы является вода (до 97% от массы тела). В удержании структуры обводненного межклеточного матрикса важную роль играют протеогликановые комплексы, стабилизированные ионами двухвалентных металлов. Основными химическими факторами поддержания водно-солевого равновесия в условиях жесткого прессинга окружающей среды в тканях медуз являются свободные аминокислоты (до 10% сухой массы) и минеральные элементы, доля последних (до 65% сухой массы) значительно превосходит белковую составляющую (до 20% сухой массы), что отличает их от*

*большинства видов животных. Преобладающими элементами являются натрий, калий, кальций, магний, железо, цинк, медь, хром и селен. Известные технологии переработки медуз направлены на получение плотной и стабильной структуры полуфабриката, в то время как жидкая фракция удаляется в процессе обработки. При этом теряется не менее 70% всей влаги и растворенных в ней минеральных элементов, свободных аминокислот, водорастворимых белков. Предложен способ отделения жидкой фракции тканей медуз от высокомолекулярных примесей с использованием метода ультрафильтрации. Полученный раствор благодаря наличию низкомолекулярных растворимых компонентов может служить основой для создания изотонических напитков, содержащих биологически активные вещества. Разработана рецептура изотонических напитков, позволяющая довести величину показателя осмотического давления полученного продукта до пределов установленных норм (270–330 мОсм/кг). Для этого в состав рецептуры включены углеводы (глюкоза и фруктоза) в количестве 6,5 г на 100 мл продукта. Дополнительно использованы стабилизаторы кислотности и антиоксиданты (лимонная и аскорбиновая кислоты), экстракты ягод для придания привлекательных органолептических свойств и консервант. Кроме выполнения функции восстановления водно-солевого баланса данные напитки могут служить дополнительными источниками таких минеральных компонентов как железо, хром и селен.*

***Ключевые слова:*** *изотонические напитки, осмоляльность, минеральные элементы, аминокислоты, медуза ропилема*

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## INTRODUCTION

Currently, certain types of specialised food products are established for which the osmolality index value is regulated. Specialists of the Federal Research Centre of Nutrition and Biotechnology responsible for developing the national standard «Specialised food. The osmolality determination method» defined the list of food items for which this indicator should be determined. These include baby food, sports supplements and specialised medical and preventive nutrition [1–4].

The osmolality index is commonly used to characterise the osmotic pressure of liquid. The physical mean of osmolality corresponds to the sum of all kinetically active particles (cations, anions and non-electrolytes) dissolved in 1 kg of solvent (water) and expressed in milliosmoles per kg (mOsm/kg). The value of this index is influenced by the concentration of the solution, the dissociation coefficient and the number of ions appearing during the dissociation of its components [1]. Only kinetically active particles have the ability to regulate the process of osmosis. These are molecules, ions or ionic complexes distributed throughout the full volume of the solvent and capable of chaotic movement inside the solution. The physical quantity of osmolality has a significant effect on the tolerability, digestibility and effectiveness of specialised foods [3].

In particular, the osmolality index is of great importance when characterising the quality and effectiveness of sports drinks. With intense physical exertion, the human body loses a large amount of liquid through perspiration. As a result, the concentration of salts in the blood plasma increases. Blood viscosity rises and overloads the cardiovascular system, resulting in fatigue and a decrease in exercise tolerance. Increased consumption of ordinary drinking water during intense workouts places an additional burden on the heart and liver, hence the most rational solution of such problems lies in the appliance of carbohydrate-electrolyte or carbohydrate-mineral specialised drinks. In order to prevent dehydration, restore electrolytes and obtain additional energy, these drinks are recommended for hydration before exercise, as well as for rehydration after or during sports [4–7].

Depending on the osmolality value, the following types of drinks are distinguished: hypotonic (less than 250 mOsm/kg), isotonic (270–330 mOsm/kg) and hypertonic (more than 330 mOsm/kg). Hypotonic drinks quickly compensate for liquid loss, but do not ensure its retention due to containing a lower concentration of mineral salts and sugars than the tissues of the human body. However, the osmolality of isotonic drinks does correspond to this blood plasma indicator. Containing more salts and up to 8-10% of carbohydrates, they quickly compensate for the loss of liquid and energy in the body without causing complications in the work of the gastrointestinal tract. Hypertonic drinks containing even higher concentrations of salts and carbohydrates are used to quickly replenish consumed energy reserves; however, an ensuing imbalance in the gastrointestinal tract is possible [1, 6].

Isotonic drinks in current production are composed of electrolyte salts (mainly sodium, potassium and magnesium) of natural or synthetic origin (premixes of mineral elements, mineral waters, sea salt). Carbohydrates in the form of mono- and polysaccharides (glucose, fructose, maltodextrine, etc.) provide an energy component at a recommended concentration of 8–10%. These elements provide the

required osmolality values of 270–330 mOsm/kg. Additionally, the composition of such drinks may include vitamins, natural juices, dyes, as well as flavourings for improving organoleptic properties and other consumer characteristics.

In this connection, the presence of natural organisms inhabiting the marine environment and adapted to conditions of severe external osmotic pressure, having a water content of 93–97% in their bodies, is of great interest. Among these are included jellyfish, whose dry tissue mass mineral component reaches 65%, while the protein content is not more than 20%. While jellyfish has a low-nutritional value, it contains a significant amount of biologically active substances, such as valuable carbohydrates, minerals and nitrogenous compounds. At least 7% of its dry tissue mass consists of free amino acids characterised by the well-known role in maintaining osmotic pressure in the tissues of hydrobionts [8].

Since the beginning of the 2000s, a sharp increase in the jellyfish population has been observed throughout the entire world ocean, including in the Sea of Japan. Currently, some types of jellyfish are commercially utilised, not only in the countries of the Asia-Pacific region, but also in the south of the Far East of Russia. In the bays of the Primorsky Krai, the main species of jellyfish present in commercially-viable concentrations is the rhopilema jellyfish *Rhopilema Asamushi,* which reaches an individual mass of 60 kg. The jellyfish processing technology aimed at obtaining semi-processed food products involves the dehydration of raw materials. Rhopilema jellyfish is sold in the countries of Southeast Asia in the form of a salted dried semi-processed product treated with potassium alumen, which is used as a preservative to stabilise the structure. At the same time, at least 70% of all moisture and mineral elements, free amino acids and water-soluble proteins, dissolved in it, are lost. The study of the composition and concentration of components contained in the separated water fraction and a preliminary calculation of its osmolarity show that this product can serve as the basis for isotonic drinks containing biologically active substances.

Based on the above, the aim of the present work is to provide an underlying rationale for the use of the liquid fraction (tissue fluid) of the Rhizostomeae jellyfish *Rhopilema Asamushi*, separated during the process of its dehydration, in order to create isotonic drinks, as well as to develop a product formulation and experimental confirmation of its functionality.

## EXPERIMENTAL PART

The object of the research was the rhopilema jellyfish Asamushi *(Rhopilema Asamushi),* caught in Peter the Great Bay over the August–September period in 2013–2015. The diameter of the dome and the weight were 64 ± 2 cm and 15 ± 3 kg, respectively. The proportion of the dome ranged from 47 to 67%, with rhopalia (mouth processes) and the insides accounting for 26–45% and 2–8% of the body weight, respectively. Altogether, 220 jellyfish units with a total weight of 3,620 kg were used for the study.

The determination of the mass fraction of protein, fat and water was carried out according to GOST 7636-85 «Fish, marine mammals, marine invertebrates and the products of their processing. Method of analysis». The composition of free amino acids was determined using a Hitachi L-8800 amino acid analyser (Japan). The colorimetric method of Elson and Morgan [9] was used to estimate the content of the sum of hexosamines. The content of uronic acids was established by a modified carbosol method [10].The collagen value was calculated by the amount of hydroxyproline [11]. The mineral element concentration was obtained by atomic-absorption spectrometry using a Nippon Jarrell-Ash AA-855 spectrometer (Japan).A Shimadzu AA-6800 atomic-absorption spectrophotometer (Japan) was used to evaluate the concentration of cadmium, cobalt, nickel, lead, arsenic and selenium.

According to GOST R 55578-2013 «Specialised food products. The osmolality determination method», computational methods cannot be used for the determination of osmolality in food products consisting of multicomponent mixtures. For this reason, a cryoscopic method, which consists in the measurement of the freezing point of aqueous solutions and the degree of its decrease in comparison with that of a clean solvent, is recommended. In accordance with this, the determination was conducted using an OSMOMAT 030 cryoscopic osmometer («Gonotec GMBH» Germany).

Ultrafiltration was carried out using an AR-2 hollow fibre apparatus (Experimental Design Bureau of Delicate Biological Machinery, Kirishi city) equipped with a VPU 100-PA polyamide membrane characterised by a molecule transmission limit of 100 kDa.

## RESULTS AND DISCUSSION

Rhopilema Asamushi (*Rhopilema Asamushi*) belongs to the class of the scyphoid jellyfish (*Scyphozoa*), and is characterised by a hemispherical dome and branching oral processes (ropalia) that form numerous folds. Jellyfish tissues consist of water (up to 96%) with traces of fat (up to 0,05%) and a low amount of protein (from 0,5 to 1,5%). Along with this, the total amount of protein in the dome is 3 times lower than that in ropalia. The amount of carbohydrates is lower than 0,5%. In comparison with these values, the proportion of mineral components in the total composition of the original substances is relatively high and ranges from 3 to 5%. Table 1 shows the content of components in relation to the dry mass.

*Table 1*

***Composition of rhopilema jellyfish tissues expressed in % of the dry mass (the amount of water in the original dome and ropalia tissue being 96,1–96,9% and 94,6–95,0%, respectively)***

*Таблица 1*

***Компонентный состав тканей медузы ропилемы, % от сухой массы (содержание воды в исходной ткани купола 96,1–96,9%, ропалий 94,6–95,0%)***

| Part of the body | Lipids | Protein | Collagen | Carbohydrates | Glucosamines | Hyaluronic Acid | Mineral elements |
|---|---|---|---|---|---|---|---|
| Dome | 1,1 ± 0,3 | 12,9 ± 2,0 | 7,4 ± 1,1 | 12,3 ± 1,8 | 3,2 ± 0,2 | 2,0 ±0,4 | 74,3 ± 5,4 |
| Ropalia | 0,9 ± 0,3 | 32,3 ± 2,8 | 19,5 ± 2,3 | 12,7 ± 2,1 | 3,7 ± 0,8 | 2,7±0,5 | 53,7 ± 4,9 |

*Table 2*

***Amounts of free amino acids in rhopilema jellyfish tissues, mg/kg of moistured tissue***

*Таблица 2*

***Содержание свободных аминокислот в тканях медузы ропилемы, мг/кг сырой ткани***

| Amino acid | Value, mg/kg | Amino acid | Value, mg/kg |
|---|---|---|---|
| Phosphoserine | 6,39 ± 0,12 | Leucine | 12,58 ± 0,71 |
| Taurine | 101,55 ± 2,03 | Tyrosine | 7,78 ± 1,11 |
| Aspartic Acid | 2,08 ± 0,05 | Phenylalanine | 8,13 ± 0,72 |
| Threonine | 13,25 ± 0,44 | β-alanine | 1,72 ± 0,24 |
| Serine | 357,45 ± 10,02 | Threonine | 1,34 ± 0,11 |
| Glutamic acid | 1231,29 ± 19,76 | Ethanolamine | 0,75 ± 0,02 |
| Glycine | 214,84 ± 9,81 | Hydroxylysine | 3,70 ± 0,16 |
| Alanine | 112,66 ± 6,19 | Ornithine | 1,82 ± 0,23 |
| Valin | 80,56 ± 2,72 | Lysine | 14,06 ± 0,54 |
| Cystine | 7,30 ± 0,83 | Histidine | 4,90 ± 0,62 |
| Methionine | 3,86 ± 0,62 | Arginine | 9,41 ± 0,64 |
| Cystathionine | 2,31 ± 0,15 | Carnosine | 3,54 ± 0,17 |
| Isoleucine | 8,40 ± 0,65 | | |
| **Total amount** | | **2208,96 ± 24,66** | |

A significant redistribution of chemical components that support the structure of jellyfish tissues is clearly observed in comparison with not only terrestrial animals, but also with other hydrobionts (fish, molluscs, crustaceans), whose bodies predominantly contain proteins that play a significant role in the formation of their organs and tissues. Among the proteins of jellyfish, a large part (not less than 60% of the total protein) is presented by collagen that forms a stable structure together with glycosaminoglycans. The stability of this structure is largely provided by bivalent metal ions. Mineral elements in combination with free amino acids, which are not part of proteins, maintain the osmotic pressure in the jellyfish tissues. It is found that the jellyfish tissues contain high amounts of glutamic acid, serine, glycine and taurine. In addition, dipeptide carnosine is present, as well as various non-proteinogenic amino acids, such as phosphoserine, cystathionine, β-alanine, ornithine (Table 2).

According to our results, the most characteristic mineral elements in the tissues of rhopilema are sodium (691,3 mg/kg), potassium (188,6 mg/kg), calcium (218,9 mg/kg) and magnesium (27 mg/kg moisturised tissue). The concentrations of trace elements are as follows: iron – 17,3; zinc – 2,4; chromium – 1,0; selenium – 0,32; copper – 0,25; manganese – 0,16; nickel – 0,06; cobalt – 0,01 mg/kg of the raw tissue. The number of toxic elements such as arsenic, cadmium and lead is insignificant and does not exceed the maximum permissible concentrations. Mercury is not detected in the samples.

The analysis of methods broadly used for processing rhopilema shows that almost all technologies are aimed at obtaining a dense and stable structure of the semi-finished product, while the liquid fraction is removed during processing and is not subsequently used. The main processing methods involve drying, multi-stage salting, moisture adsorption using, e.g., mineral raw materials. In the latter case, the raw material is dehydrated to a value of the dry matter concentration equal to 25–35% of its initial mass [8]. In most industrial technologies, only ropalia are used to obtain a product of desired quality, with the dome that accounts for up to 70% of the body weight being disposed of.

With the purpose of justifying the choice of a technology for manufacturing isotonic drinks from this raw material, we compared the content of basic mineral elements in jellyfish tissues, sea salt (often used as a premix for making isotonic drinks) and the average proportion of minerals contained in existing isotonic drinks [2, 4, 12, 13]. A large similarity of the studied values in the commercial carbohydrate-mineral drinks and the liquid fraction from the jellyfish tissues has been established (Table 3). It should also

be noted that the prevailing mineral ratio in the composition of jellyfish and sea salt is generally observed. An exception is magnesium, whose content in jellyfish is relatively higher than that of calcium and potassium. In the overwhelming majority of isotonic drinks currently available, only sodium and potassium are present. Moreover, while sodium is believed to be the main water-holding factor, the addition of other elements to ensure this function is considered controversial [2]. However, the presence of nutritious macro- and microelements in an accessible form results in a specialised product that not only provides rehydration but also introduces bioactive ingredients into the body. This fully applies to the tissue fluid of the rhopilema jellyfish that contains such elements as chromium and selenium known to be active antioxidants and regulators of metabolic processes.

According to our technique, after grinding the jellyfish tissue and water extraction of the obtained homogenate, the liquid was separated with a subsequent purification from high molecular weight impurities by ultrafiltration (UF) using hollow fibre membrane filters with a transmission limit value of 100 kDa. The ultrafiltration not only purifies the liquid fraction from high-molecular compounds, but also ensures its transparency and, to a large extent, ameliorates the specific smell and taste characteristics of the raw materials, as well as eliminating microbial contaminants. Thus, when determining the transparency of the fluid fraction following UF, no particulate matter was detected in transmitted light. The sensory smell assessment for distilled water (control), the liquid fraction prior to UF and the liquid fraction following UF produced the following results: 0 (no smell), 10 (a pronounced specific smell characteristic of the raw material) and 3 points (weakly expressed), respectively.

When determining the content of microbiological indicators, the liquid fraction before the UF was established to correspond to the normalised indicators according to GOST 10444.15-94 «Food products. Methods for determining the number of mesophilic aerobic and facultative anaerobic microorganisms». The value of NMAFAnM in CFU/g was equal to $5{,}5 \cdot 10^2$ with respect to the normal value of $5 \cdot 10^4$. Immediately after UF, microbial contamination was absent.

In the filtrate obtained at the UF stage, the salt-, protein- and carbohydrate- content, as well as the dry substance mass fraction and osmolality were determined. Raw jellyfish contains minerals making the electrolyte composition sufficient to a drink preparation. However, the measurement of the osmolality of the liquid fraction (filtrate) reveals its unsuitability for utilisation as an independent isotonic drink.

As a result, an isotonic drink was formulated, taking into consideration the necessity of adjusting osmolality, as well as flavour and aromatic properties. The composition of the drink was complemented with glucose at a rate of 15 g/l, fructose (50 g/l), citric or ascorbic acid (2,5 g/l), dry soluble concentrate of blueberries in the amount of 16 g/l and the sodium benzoate preservative (0,04 g/l). To expand the range, other vegetable concentrates (for example, sea buckthorn, lingonberry, green and black tea) were also tested. Prior to the introduction of herbal supplements, the obtained products had a mildly sweet taste, with a slight tinge of sea saltiness. The addition of vegetable concentrates made it possible to neutralise the shades of the sea taste and to give the drink its desired organoleptic properties. The threshold of taste sensitivity corresponded to 15–30 g of concentrates per 1 litre of the drink, which slightly changed the osmolality and energy values.

***Table 3***

***Quantities of the main mineral elements in isotonic drinks, tissues of the rhopilema jellyfish and sea salt, mg/kg***

***Таблица 3***

***Содержание основных минеральных компонентов в изотонических напитках, тканях медузы ропилемы и морской соли, мг/кг***

| Mineral component | Isotonic drinks by different manufacturers* | Rhopilema jellyfish | Edible sea salt ** |
|---|---|---|---|
| Sodium | 260–1450 | 690 ± 74 | $(366 \pm 20) \cdot 10^3$ |
| Calcium | 0–290 | 220 ± 11 | $(76 \pm 7{,}2) \cdot 10^3$ |
| Potassium | 120–240 | 190 ± 18 | $(16 \pm 5{,}1) \cdot 10^3$ |
| Magnesium | 0–120 | 30 ± 0,4 | $(35 \pm 4{,}1) \cdot 10^3$ |
| Iodine | – | 0,62 | 0,8 ± 0,02 |
| Bromine | – | – | 20 ± 0,01 |
| Iron | – | 1,39 | <0,01 |
| Zinc | – | 1,19 | <0,01 |
| Chromium | – | 1,20 | <0,01 |
| Selenium | – | 0,32 | <0,01 |
| Copper | – | 0,25 | <0,01 |
| Manganese | – | 0,16 | <0,01 |
| Nickel | – | 0,06 | <0,01 |
| Cobalt | – | 0,01 | <0,01 |

** According to Nikityuk et al. [2]; ** according to Krasnova and Tokayeva [4].*

*Table 4*

***Composition, osmolality and energy values of the semi-finished and finished drink products made from the rhopilema jellyfish***

*Таблица 4*

***Состав компонентов, осмоляльность и энергетическая ценность полуфабриката и готового напитка из медузы ропилемы***

| Indicators | Filtrate | Drink |
|---|---|---|
| Mineral elements. Mass fraction, mg/100 ml | | |
| Sodium | 50,83 ± 8,2 | 52,46 ± 9,0 |
| Potassium | 15,63 ± 1,1 | 19,01 ± 1,7 |
| Calcium | 12,65 ± 1,5 | 12,41 ± 3,2 |
| Magnesium | 1,99 ± 0,4 | 2,42 ± 1,0 |
| Iron | 1,06 ± 0,07 | 1,23 ± 0,9 |
| Zinc | 0,120 ± 0,01 | 0,132 ± 0,04 |
| Chromium | 0,052 ± 0,005 | 0,055 ± 0,008 |
| Copper | 0,020 ± 0,003 | 0,024 ± 0,04 |
| Selenium | 0,019 ± 0,003 | 0,017 ± 0,001 |
| Manganese | 0,012 ± 0,008 | 0,015 ± 0,008 |
| Nitrogenous substances | 115,6* ± 12,3 | 161,4 ± 15,2 |
| Carbohydrates | 370 ± 24,5 | 7280 ± 241,1 |
| Osmolality, mOsm/kg | 172 ± 14 | 299 ± 14 |
| Energy value, kcal/100 g | 1,9 | 30 |

** Represented by free amino acids.*

According to the analysis conducted, the proportion of dry substances in the initial liquid fraction of the jellyfish amounted to 1,2 ± 0,4%, with an osmolality of 182 ± 14 mOsm/kg. After adding additional ingredients, these indicators equalled 8,6 ± 0,6% and 299 ± 14 mOsm/kg, respectively. The compositions of the initial and final products are presented in Table 4.

It is known that, during intense physical exertion, the human body loses such salts as sodium sulphate, potassium phosphate, calcium bicarbonate, magnesium chloride most of all [6, 14, 15]. The electrolyte composition of the resulting drink is shown to be capable of rehydrating the body during and after exercise by replenishing the loss of water and mineral elements, especially sodium, which stimulates the absorption of water and glucose at given concentrations.

Sodium constitutes the main extracellular ion, which is involved in the transfer of water, glucose, generation and transmission of electrical nerve signals and muscle contraction. Calcium is known as a regulator of the nervous system and muscle contractions. Magnesium, manifesting itself as a co-factor of many enzymes (including energy metabolites), participates in the synthesis of proteins and nucleic acids and acts as a stabilising agent for membranes. Potassium – the main intracellular ion – regulates the water, acid and electrolyte balance and the conduction of nerve impulses. Iron not only facilitates the transport of electrons and oxygen and redox reactions, but also activates peroxidation. Zinc is important for regulating the processes of gene expression, as well as for the synthesis and disintegration of carbohydrates, proteins, fats and nucleic acids. Copper is part of various enzymes and the redox system, participating in the metabolism of iron. Moreover, it stimulates the absorption of proteins and carbohydrates and provides the tissues of the human body with oxygen. Manganese affects the growth of the body, metabolism of the reproductive system and bone tissue, as well as the carbohydrate and lipid metabolism. Selenium presents itself as an essential element of the antioxidant defence system of the body. It displays an immunomodulatory effect and regulates the action of hormones and the metabolism of tissues of the musculoskeletal system. Chromium contributes to the regulation of the blood glucose level, enhancing the effect of insulin [14].

Thus, in terms of microelement composition, the drink based on the tissue fluid of the rhopilema jellyfish contains a number of essential components that can positively affect the metabolism of both individual organs and the entire organism. The calculation of the recommended daily intake of mineral elements is given for different quantities of the developed product according to the «Norms of physiological needs for energy and nutrients for different groups of the population of the Russian Federation» MP 2.3.1.2432-08 (Table 5).

The presence of carbohydrates in the form of mono- and polysaccharides in sports drinks not only prevents the development of hypoglycemia by maintaining or increasing the concentration of glucose in the blood during prolonged exercise, but also increases endurance. The mixtures of glucose and fructose have an advantage over monocomponent compositions, since they increase the overall level of the exogenous oxidation of carbohydrates. In addition, fructose represents an easily accessible source of energy that does not stimulate insulin secretion [15, 16].

*Table 5*

***Content of mineral elements and the calculation of their daily intake in the isotonic drink produced from the rhopilema jellyfish***

*Таблица 5*

***Содержание минеральных элементов и расчет их суточного потребления в изотоническом напитке на основе медузы ропилемы***

| Position | Daily rate, mg * | Per serving of drink 330 g | Per serving of drink 500 g |
|---|---|---|---|
| Sodium | 1300 | 173 (13,3% of RDV) | 262 (20,1% of RDV) |
| Potassium | 2500 | 63 (2,5) | 95,5 (3,8) |
| Magnesium | 400 | 9 (1,9) | 12 (3,0) |
| Calcium | 1000 | 41 (4,1) | 62 (6,2) |
| Iron | 14 | 4 (29) | 6 (43) |
| Zinc | 12 | 0,7 (5,5) | 1 (8) |
| Copper | 1 | 0,08 (7,9) | 0,12 (12) |
| Manganese | 2 | 0,04 (1,9) | 0,06 (3) |
| Chromium | 0,05 | 0,182 (363) | 0,275 (550) |
| Selenium | 0,063 | 0,056 (89) | 0,085 (135) |

** Norms of physiological needs for energy and nutrients for various groups of the population of the Russian Federation: guidelines. MR 2.3.1.2432-08.*

The presence of carbohydrates in the form of mono- and polysaccharides in sports drinks not only prevents the development of hypoglycemia by maintaining or increasing the concentration of glucose in the blood during prolonged exercise, but also increases endurance. The mixtures of glucose and fructose have an advantage over mono-component compositions, since they increase the overall level of the exogenous oxidation of carbohydrates. In addition, fructose represents an easily accessible source of energy that does not stimulate insulin secretion [15-16].

Amino acids in the developed drink composition should be considered as one more type of osmoregulators. Each of these biologically active compounds plays its own functional role; altogether, they exhibit a moderate antioxidant effect. The addition of flavour components stimulates the consumer to increase the volume of the liquid intake. In this article, we discuss in detail only one example of such products; however, their range can be expanded by adding other flavour compositions that meet various specific requirements.

The calculations performed have shown that this drink can be used not only for the rehydration of the body during intensive training, but also as an additional source of iron, chromium and selenium. In accordance with MP 2.3.1.2432-08, the concen-tration of chromium in such drinks exceeds the established physiological need for adults. However, the upper permissible level for this element is not defined.

The recommended concentration of carbohydrates in isotonic drinks is equal to 2–8%, with the physiological need for available carbo-hydrates (adult) amounting to 50-60% of the daily energy requirement (257–586 g/day) [11, 14]. In the drink proposed, the total carbohydrate content ranges from 7,5 to 8,2%, which does not lead to an undesirable sugar load, but improves the functional and organoleptic properties of the product.

**CONCLUSION**

In comparison with known analogues, the defining feature of the developed drink product consists in the completely natural origin of its essential components including mineral complex and flavour additives. In the formation of the required level of osmolality, the main role is played by mineral elements. In addition, the basic level of the target indicator of the original product is slightly lower than required, with the possibility of supplementing the drink with energy components (carbohydrates) within the recommended limits, improving its organoleptic properties and normalising its osmolality.

Among the essential components of this drink product, the first element to be mentioned is selenium, which forms selenoproteins having high antioxidant properties. Selenium is also valuable in maintaining normal immune system function, disruptions to which are characteristic of high-performance athletes. The selenium content comprises 89-135% of the recommended consumption rate.

Additionally, a high chromium concentration, which exceeds the established physiological need, is revealed. It is known that food products contain chromium in the form of inorganic salts, and that their bioassimilability in the gastrointestinal tract does not exceed the value of 0,5–1% [17]. According to the data of the National Academy of Sciences of the USA, the human body needs 50-200 μg of chromium per day. It is also known that chromium, like zinc, can only be converted into a digestible form by being combined with amino acids. The presence of amino acids of natural origin (115,6-161,4 mg/100 ml) is also a distinguishing feature of the proposed drinks, which enhances their functional effectiveness [15]. The chromium toxicity threshold is 5 mg/day, which is 18–28 times higher than its content in the drink; moreover, existing natural food products are known to contain higher concentrations of chromium. For example, sea buckthorn contains 980% of the daily requirement of this element in 100 g of fruit. Never-

in 100 g of fruit. Nevertheless, this type of raw food material does not have any restrictions on quantitative consumption and is recommended as a natural source of the biogenic form of chromium [17].

Thus, the conducted research proposes a new functionally-oriented product on the basis of tissue fluid of rhopilema jellyfish, whose osmolality meets the requirements for isotonic drinks. This product can serve as an additional source of a number of essential mineral elements, complementing the energy component of an athlete's diet and, at the same time, having pleasant organoleptic properties.

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Pivnenko T.N., Esipenko R.V., Kovalev A.N. carried out the experimental work, on the basis of the results summarized the material and wrote the manuscript. Pivnenko T.N., Esipenko R.V., Kovalev A.N. have equal author's rights and bear equal responsibility for plagiarism.

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