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PHYSICAL AND CHEMICAL PROPERTIES OF GERODIETETIC PRODUCT FOR ENTERAL NUTRITION

Introduction. The current global demographic structure of the population shows a significant rate of aging in the world and in Ukraine. One of the modern means of properly meeting the nutritional needs of older people is the consumption (use) of products for enteral nutrition.

Problem. The volume of the Ukrainian market of products for enteral nutrition is less than

ФІЗИКО-ХІМІЧНІ ВЛАСТИВОСТІ ПРОДУКТУ ДЛЯ ЕНТЕРАЛЬНОГО ХАРЧУВАННЯ ГЕРОДІЄТИЧНОГО ПРИЗНАЧЕННЯ

Вступ. Нинішня глобальна демографічна структура населення свідчить про значні темпи старіння у світі та Україні. Одним із сучасних засобів належного задоволення харчових потреб людей старшої вікової категорії є споживання (використання) продуктів для ентерального харчування.

Проблема. Український ринок продуктів для ентерального харчування становить менше

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0.5 % of the world, which requires expanding the range and volume of these products.

The aim of the work is to study the physical and chemical properties of the developed in Ukraine gerodietetic product for enteral nutrition.

Methods. The object of research is the developed gerodietetic dry soluble product for enteral nutrition. The control sample was a similar product Peptamen (TM Nestle, Switzerland).

There were used the following methods: electron microscopy, drying, ashing, potentiometric, refractometric, pycnometric and others.

Results. The microstructure of the dry product is determined by the low bulk density and the positive effect of small particle sizes on the solubility in the liquid. The low mass fraction of moisture (3.1 %) allows to ensure its proper storage and the high ash content (2.6 %) indicates its biological value. The peroxide value of the extract of the fatty component (2.5 mmol/kg $\frac{1}{2}$ O) indicates a low amount of unsaturated fatty acids and the freshness of the product's lipid composition.

The product in liquid form, prepared in accordance with the developed recommendations, is slightly acidic and close to neutral, which maintains the normal acid-base balance of the body and a positive effect on the activity of proteins and nucleic acids. The mass fraction of dry soluble substances (15.1 %) and the solubility index (0.20 cm³ of raw sludge) indicate the high solubility of the components of the product. The experimentally established density value (996.2 kg/m³) indicates compliance with the intended functions.

Conclusions. The developed gerodietetic product for enteral nutrition is characterized by proper physicochemical properties. It was experimentally confirmed that this product has better solubility in dry form and homogenous consistency and digestibility in liquid state.

Keywords: physical and chemical properties, gerodietetic product for enteral nutrition, dry powdery form, ready for consumption liquid product, consumer advantages.

за 0.5 % загальносвітового, що потребує розширення асортименту та обсягів цієї продукції.

Мета роботи – дослідження фізико-хімічних властивостей розробленого в Україні продукту для ентерального харчування геродієтичного призначення.

Методи. Об'єкт дослідження – розроблений сухий розчинний продукт для ентерального харчування геродієтичного призначення. Контроль – аналогічний виріб *Peptamen* (TM Nestle, Швейцарія).

Застосовано методи: електронного мікроскопування, висушування, озолення, потенціометричний, рефрактометричний, пікнометричний та інші.

Результати дослідження. За мікроструктурою сухого продукту визначено низьку насипну вагу та позитивний вплив малих розмірів частинок на розчинність у рідині. Низька масова частка вологи (3.1 %) уможливило добре зберігання, а підвищений вміст золи (2.6 %) свідчить про його біологічну цінність. Пероксидне число екстракту жирової складової (2.5 ммоль/кг $\frac{1}{2}$ O) вказує на низьку кількість ненасичених жирних кислот і свіжість ліпідного складу виробу.

Рідкий продукт, підготовлений відповідно до розроблених рекомендацій, є слабкокислим і близьким до нейтрального, що забезпечує підтримку нормального кислотно-лужного балансу організму та позитивний вплив на активність білків і нуклеїнових кислот. Масова частка сухих розчинних речовин (15.1 %) та індекс розчинності (0.20 см³ сирого осаду) свідчать про високу розчинну здатність складових компонентів виробу, а значення густини (996.2 кг/м³) – про відповідність передбачуваним функціям.

Висновки. Розроблений продукт для ентерального харчування геродієтичного призначення характеризується належними фізико-хімічними властивостями, що експериментально підтверджено, – має кращу розчинність у сухому вигляді й однорідну консистенцію і засвоюваність у рідкому.

Ключові слова: фізико-хімічні властивості, продукт для ентерального харчування геродієтичного призначення, суха порошкоподібна форма, готовий до споживання рідкий виріб, споживчі переваги.

Introduction. The current global demographic structure of the population indicates a significant rate of aging. This is confirmed by the data of the World Health Organization and the United Nations Organization that the average age of the world's population is growing steadily. According to the forecasts, that were developed by the representatives of these organizations, in 2025 the share of people over 60 years will be about 20 % of the total population and in 2050 it will increase to almost 30 % (approximately 2 billion people) [1; 2].

Nowadays Ukraine is among the top 10 world leaders in terms of the population average age growth rate and the growth dynamics of people over 60 total share [1; 2]. In addition, according to the data of State Statistics Service of Ukraine [3] in early 2021, the total number of people aged 60 and older exceeded 10 million and now is approaching 25 % of the total population. That is why the situation, connected with the population aging, is especially relevant for our country.

It is an indisputable that to ensure proper functioning of human body the appropriate level of nutritional needs should be provided. Especially great importance the optimal level of well-balanced nutrition plays for people, whose body is characterized by changes in metabolism as a result of aging processes, including the functions of the digestive, cardiovascular, immune, nervous, musculoskeletal systems, energy imbalances, decreased overalls of body mobility, its functionality and adaptation abilities, reliability of biochemical and enzymatic mechanisms, speed of metabolic neurohumoral regulation, which acquire a particularly pronounced character after 60 years. That is why the consumption (usage) of specially modeled products for enteral nutrition is considered to be one of the widely spread modern trend of proper nutritional supply for older persons, especially with increased physical and emotional stresses, diseases and injuries, including somatic.

The modern world market of enteral nutrition is characterized by significant and dynamic development. This fact can be proved by the statistical data [4–8] about its volume. In particular, at the end of 2020 it amounted almost 3.98 billion euros and is expected to exceed 6 billion euros in 2025. It is also should be noted that during 2015–2020 the annual growth level of analyzed segment of the international market was nearly 12 % [5; 6].

Problem. It should be stated that in Ukraine the volume of national market of products for enteral nutrition is less than 0.5 % of the world one. It is mainly represented by foreign products: Ukrainian analogs are almost absent at the national market, foreign products have rather high cost and limited assortment for target consumers [8; 9]. As a result, it can be stated that the national market of enteral nutrition is saturated inadequately.

For increasing the level of target customers satisfaction, first of all persons of older age categories, including with increased physical and emotional stresses, during diseases and injuries, including somatic, treatment, rehabilitation after it basing on scientific data about peculiarities of the older aging groups' representatives nutritional needs [10–19] the scientists of the State university of trade and economics and the state institution "Ukrainian national academy of medical sciences institute of gerontology n.a. D. F. Chebotarev" have developed domestic gerodietetic dry soluble product for enteral nutrition [21].

The peculiarities of the target category of consumer needs, the process of enteral nutrition consumption (usage), product's preparation for it, its production, realization, transportation and storage cause increased requirements for physical and chemical properties of this products category, both in dry and soluble and ready for consumption state.

The analysis of latest researches and publications. The great contribution for the development of gerodietetic nutrition's basic provisions, its principles forming has been done by national and foreign researchers: D. Chebotariov, Yu. Hryhorov, P. Karpenko [14], Yu. Havalko [15], M. Russell [10], P. S. Shwe, S. A. Ward [11], N. Abd Aziz [12], L. Lorenzo-López [13], J. Wei, W. Chen [16] and others.

The significant role for research of products for enteral nutrition physical and chemical properties and the development of recommendations for them is stated in the works of following scientists: N. Prytulska, M. Hulich, Yu. Motuzka [21], in particular the properties of the developed products for enteral nutrition were researched, O. Loshak [22] evaluated the effectiveness of products for enteral nutrition consumption was studied, I. Baiu [23], O. Ojo [24], J. Payne-James [25], P. Guenter [26] studied consumer advantages of these products group.

The aim of this work is to study the physical and chemical properties of the developed in Ukraine gerodietetic product for enteral nutrition.

Methods. The object of presented in manuscript research is the developed gerodietetic dry soluble product for enteral nutrition based on whey protein concentrate as described earlier [20]. The product for similar purpose *Peptamen*, dry soluble product for enteral nutrition, produced by the foreign company Nestle (Switzerland), was the control sample. For being the control sample the most presented in the market of Ukraine product was chosen. Products sampling and their preparation for the experiments were provided according ISO 707:2008 [27].

During providing the research of products in dry powdery form physical and chemical properties the following methods were used: the particle size – by electronic microscopy using Digital Microscope BW-400X (China) and computer program Micro-Measure Version 1.20, mass fraction of moisture and ash – by drying to constant mass [28] and ashing without the use of accelerators [29] using drying cabinet Ulab DHG-9070A, peroxide value of lipid component's extract – by visual titrometric oxidation after the corresponding extraction of the sample using Soxhlet apparatus [30]. For the investigation of the physical and chemical properties of the products in liquid ready for consumption form, the next methods were used: active acidity – by potentiometric titration using pH-meter Ulab MP 511, total (titrated) acidity – by visual titrometric method [32], mass fraction of dry instant substances – by refractometry [33], solubility index – by centrifugation and measuring insoluble precipitate in product sample in liquid form [34], density – by pycnometricly [35].

During providing the research replication of the experiments was quintuple, the analysis was repeated three times. Mathematical and statistical data analysis was provided using computer with a help of computer program *MS Excel*. The identified reliability of the obtained results was higher than 95 %.

Results. One of the basic factors, which determine the level of needs satisfaction for target consumers of products for enteral nutrition and its

customers advantages, is their physical and chemical properties. They determine the compliance of these products with metabolic peculiarities of their consumption (usage), easiness of preparation for it, transporting, realization and storage.

Taking into account the fact that during realization on consumer market products for enteral nutrition will be presented in dry soluble form a great attention was paid to the research of their microstructure. As a result of electronic microscopy research the data about particle size of dry instant products was received (Table 1).

Table 1

The results of dry instant products for enteral nutrition particles size research

$P \geq 0.97; n = 5$

Tested samples	Particle size, μm	
	minimum	maximum
Control sample	261.0 \pm 1.5	987.5 \pm 1.5
Developed product	215.5 \pm 1.5	947.0 \pm 1.5

The detailed analysis of the research results gives a possibility to confirm that particle size of the developed dry soluble product was smaller than the same parameter of control sample (minimum on 17–18 %, maximum – on 4 %). In addition, it should be noted that the particle size of proposed dry mixture was generally characterized by uniform dimensions. Thus, it gives a possibility to claim low bulk density of the developed product and positive influence of small particle size on solubility in liquid substances [36].

Also, mass fraction of moisture, ash and peroxide value of lipid component's extract were determined in gerodietetic dry soluble product for enteral nutrition (Table 2).

Table 2

Mass fraction of moisture, ash, peroxide value of lipid component's extract of dry instant products for enteral nutrition

$P \geq 0.95; n = 15$

Indexes	Tested samples	
	control sample	developed product
Mass fraction of moisture, %	4.16 \pm 0.04	3.11 \pm 0.03
Ash, %	2.492 \pm 0.016	2.611 \pm 0.015
Peroxide value of lipid component's extract, mmol/kg $\frac{1}{2}$ O	2.5 \pm 0.5	2.5 \pm 0.5

Based on the obtained results, the fact that mass fraction of moisture in the developed gerodietetic product for enteral nutrition corresponds to the requirements, established by Technical conditions [37] of the product's manufacturing enterprise, was established. This index's value in the proposed mixture is lower than appropriate in the control sample (on 33.7 %). It is, probably, explained by the difference of moisture's mass content in raw components that were used in the process of the researched products manufacturing.

The identified ash value, which indicates the presence and content of mineral elements and is stipulated by used mineral substances and other raw components, confirms that developed gerodietetic product for enteral nutrition in dry powdery form is characterized by rather high content of mineral inorganic substances in a form of salts. In particular, ash value of the developed dry soluble product is slightly higher (on 4.7 %) comparing with the control sample

The identified peroxide value of lipid component's extract of the developed gerodietetic product for enteral nutrition in dry powdery form is the same with the value of appropriate index for control sample and indicates low quantity of unsaturated fatty acids and freshness of lipid composition.

To identify the compliance of physical and chemical indexes of products for enteral nutrition in ready for consumption liquid state (prepared according with the developed recommendations [20]) with special metabolic needs of target consumers category and factors, which determine an ability for usage and the convenience of preparation for consumption, the research, results of which are presented in *Table 3*, was held.

Table 3

**Physical and chemical properties of products for enteral nutrition
in ready for consumption liquid form**

$P \geq 0.95$; $n = 15$

Indexes	Tested samples	
	control sample	developed product
Active acidity, pH units	6.31 ± 0.01	6.07 ± 0.01
Total (titrated) acidity, °T	22 ± 1	20 ± 1
Mass fraction of dry instant substances, %	15.2 ± 0.5	15.1 ± 0.5
Solubility index, ml of sediment	0.20 ± 0.05	0.20 ± 0.05
Density, kg/m ³	998.20 ± 0.02	996.22 ± 0.02

The analysis of obtained data gives an opportunity to state that the active and total (titrated) acidity indexes values are weakly acidic and close to neutral level. It indicates an ability to maintain a normal acidic-base balance, positive influence on activity of proteins and nucleic acids. Identified mass fraction of dry soluble substances and solubility index values that are almost the same for both samples indicate rather high solubility of used constituent components.

It is widely accepted that for providing proper consumption (usage) conditions products for enteral nutrition should be characterized by homogeneous liquid consistency and low density. Its importance is provided by the possibility of enteral nutrition (in ready for consumption form) probe insertion and the necessity of need to minimize the efforts for its oral consumption. Obtained results of conducted mass fraction of dry soluble substances, density's researching, that are almost the same as analogue ones for the control sample, show the rationality of raw components selection and compliance with the desired properties of the developed gerodietetic product.

Thus, the conducting of physical and chemical researches of the developed gerodietetic product's for enteral nutrition quality in dry soluble and pre-prepared liquid form give an opportunity to establish rational choice of constituent components for ensuring safety, rather high mineral value, weakly acidic and close to neutral acidity, high solubility in water, proper density. It, in its turn, confirms developed product's proper physical and chemical properties and high consumer advantages.

Conclusions. The developed gerodietetic product for enteral nutrition is characterized by proper physicochemical properties, as evidenced by the smaller particle size in the dry soluble state, so it will dissolve better and then form a more proper consistency, lower mass fraction of moisture and higher ash content, which indicates about the content of necessary mineral elements. It was established that in the ready-to-eat liquid state the developed product is characterized by a lower value of acidity and density and will be better digested.

The prospects of further researches are the detailed identification of the developed gerodietetic product's for enteral nutrition consumer advantages and approbation of its properties physiological effectiveness in clinical conditions.

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