SECTION 6. FOOD TECHNOLOGY

6.1 The research of consumer properties of gerodietic dry soluble product for enteral nutrition

The current demographic structure of population, both on international and national levels, shows the great increasing of population's aging level. So, according to the data of the World Health Organization's specialists in 2025 the number of older age groups representatives will increase almost by 6 times comparing with 1950. In such a way, the quantity of people, who form elder aging group, will make about 20% of the total Earth population [273]. Also, according to this forecast [273] in 2050 the quantity of people, whose age is over 60, will reach 30% and the quantitative equivalent of them will compose nearly 2 billion of people. Interpolating analyzed facts on national scale, it is necessary to note that our country ranks number 10 in the world ratings in quantity of elder aging group's representatives and total dynamics of population aging [274]. That is why these researches are especially actual for Ukraine.

It is widely recognized that physiological aging is characterized by gradual changes in the state of human body organs and systems, a decrease in the activity of the metabolism. Changes and disorders in the digestive, cardiovascular, immune, nervous, bone and muscular systems are especially noticeable and negative for humans while aging. This situation determines the importance of the geriatric problem, the negative effects of which provoke degenerative diseases of heart, blood vessels, kidneys, digestive organs, musculoskeletal system, including joints, etc. [275, 276]. In this regard it is reasonable to influence the nature, pace and orientation of these changes in metabolism, adaptation and compensatory processes by rationally provided optimal nutrition. Nutrition as one of the most important factors of life should meet the specific needs of natural aging [275–277]. Nowadays there is a considerable amount of theoretical and experimental data in the sphere of gerontology. This scientific information allows to state that its inadequacy of nutrition by its energy value, amino and fatty acids content, vitamins and minerals cause imbalances and, as a consequence, the occurrence of pathologies.

Optimal and scientifically substantiated in accordance with the specificity of aging nutritional needs and the use of special hereditary products, developed in accordance with rational scientifically-based principles, allow to prevent the development of different disorders in the human body of older age groups, contribute to improving of their life quality.

Especially important full-value satisfaction of nutritional needs became for the representatives of elder aging groups, who have high physiological and psycho-emotional loads, metabolic dysfunctions, violations and traumas. That is why in modern practice consumption of food products for special medical purposes – enteral nutrition became widely used. This nutrition contains goal-oriented modeled composition of nutritive components to ensure needs in nutrients and correct smitten physiological processes.

The analysis of market's current state of these special food products group at international and national level gives an opportunity to state its dynamic and rapid development [278, 279]. The volume of these products current world market exceeded 4.5 billion US dollars. It has significant annual growth rates (an average level 10% annually) [278]. This can be explained by an increase in the general level of population morbidity, physical and psycho-emotional stresses, aging rate and natural environmental situation deterioration. At the same time, it is important to note insufficiently saturation of Ukrainian market by products for enteral nutrition [279]. It is explained by high financial value of imported products and absence of properly saturated assortment of these goods, which were produced by national manufactures.

Basing on the comparative analysis of the professional literature [276, 277, 280–283] data and its complex scientifically substantiated systematization, it was researched and found that the optimal ratio of macronutrients (%) in the rationally based nutrition of elder groups representatives is following: proteins : lipids : carbohydrates 16–20 : 25–30 : 55–60. The recommended quantitative norms of consumption major energy substrates for the older age groups representatives are presented in Table 1. Additionally, it must be noted that gerontologists and

nutritiologists recommend limiting carbohydrate intake for people with low-moving lifestyle [275, 276, 278].

Table 1.

Recommended norms of macronutrients consumption
by representatives of older aging groups

Age and gender groups	Recommended norms of consumption, g/day		
	proteins	lipids	carbohydrates
60–74 years old:			
men	72–105	50–70	240–310
women	64–100	44–67	220–295
74–90 years old:			
men	64–72	44–50	220–240
women	56–68	39–57	193–112

Particular attention in the process of analysis and systematization of data about the nutritional needs of elderly and long-lived people [276, 277, 280–282] deserve information about the composition of basic macronutrients. Such a way, in addition to bringing the amino acid score diet into accordance with the recommendations of FAO/WHO specialists, it is necessary to ensure the proportion of essential amino acids is at least 40% of the total protein [277, 280, 282]. Taking into account the need to form a proper level of digestibility, it is more appropriate to represent the protein component of nutrition at the expense of dairy, egg and fish products. The analysis and systematization of scientific data about the lipid component of gerodietetic diets [281, 282, 284] gives a background to summarize that the optimal ratio of vegetable and animal fats should be 1: 2, omega-3 and omega-6 fatty acids– 4 : 1. In addition, it should also be noted that the optimal intake of dietary fiber should be nearly 30–40 g/day [280, 283].

An important role in rational ensuring the physiological processes of the elder aging groups' representatives is given to vitamins and mineral elements, especially to those, which have antioxidant properties.

Basing on the results of the provided analysis and generalization of scientific literature and experimental data [275, 280–282], it was established that the optimal daily intake of vitamins for elderly and long-lived people must be following, mg: retinol – 0,9–1,1, thiamine – 1,5–1,7, riboflavin – 1,5–2,0, niacin – 13,0–20,0, pantothenic acid – 5,0, pyridoxine – 2,0–3,5, ascorbic acid – 900–1100, tocopherol – 15–20; mcg: biotin – 50, folic acid – 230–400, cyanocobalamin – 3–4, calciferol – 15, phyloquinone – 120.

Also the recommended daily norms of mineral elements consumption were analyzed and systematized, mg: Sodium – 2500, Potassium – 2500, Calcium – 800–1200, Phosphorus – 800–1200, Sulfur – 800–1200, Magnesium – 400–500, Ferum – 10–18, Zinc – 12–15, Fluorine – 0.75–4, Mangan – 2, Cuprum – 1; mcg: Iodine – 150, Molybdenum – 60, Selenium – 50–70, Nikole – 50, Chromium – 50, Aluminium – 30–40, Bromine – 25.

Due to the established relevance of the creation of new products for enteral nutrition and basing on analytic data about peculiarities of the older aging group representatives' nutritional needs [275–284] the specialists of the Kyiv National University of Trade and Economics (KNUTE) and the State Institution “Ukrainian National Academy of Medical Sciences Institute of Gerontology n. a. D.F. Chebotarev” have developed and patented the gerodietetic dry soluble product for enteral nutrition [285]. Its components composition is presented in Table 2.

Table 2.

Qualitative and quantitative component composition of the developed gerodietetic dry soluble product for enteral nutrition

Component, measurement units	Content in 100 g of dry soluble product
maltodextrin monodisperse, g	25,00
glucose, g	21,50

Continuation of Table 2.

Qualitative and quantitative component composition of the developed gerodietetic dry soluble product for enteral nutrition

Component, measurement units	Content in 100 g of dry soluble product
protein concentrate, manufactured from dairy whey WPC-80, g	20,00
omega-3 polyunsaturated fatty acids in casein matrix, g	10,50
fructose, g	10,00
dietary fiber, g	5,40
food starch, g	4,00
l-glutamine, g	2,00
l- methionine, g	0,50
l- tryptophan, d	0,30
ascorbic acid (vitamin C), g	0,25
ginseng root extract, g	0,20
l- tyrosine, g	0,10
glucosamine, g	0,10
creamery calcium, g	0,07
magnesium hydrophosphate, g	0,035
coenzyme Q10, mg	37
β -carotene, mg	5
thiamine (vitamin B1), mg	1
riboflavin (vitamin B2), mg	1
pyridoxine (vitamin B6), mg	1
calciferol (vitamin D3), mcg	6

Preparation of the developed product for consumption (usage) is carried out by dissolving a portion of the dry mixture (50 g) in 200 cm³ of boiled water at a

temperature of 15-40 °C (an additional increase of the water amount on 40 cm³ (depending on the preferences of consumers) is possible). The proposed gerodietetic product for enteral nutrition does not cause a significant increase in blood sugar for people belonging to the older age groups, slowing down the aging process, normalizes nutrient metabolism and emotional state and improves the immune system and antioxidant protection.

It is envisaged that the proposed product can be used for both oral nutrition and tube feeding. It should also be noted that the use of the product is preferably orally, as an additional source to the main nutrition (approximately 2-5 servings/day per 50 g of dry product in the dissolved state depending on the human body condition and physiological characteristics). Also, it is specified by provided recommendations that the developed gerodietetic product for enteral nutrition can be used as a staple source of nutrition during a short period of time (up to 5-7 days).

The normative documentation (changing to the existing Technical Condition (TC) of Ukraine 15.8-32453003-002: 2007 “Functional dry products of special purpose TM “Vansiton” and new Technological Instruction (TI) for the manufacturing of the proposed gerodietetic product for enteral nutrition was developed and approved.

To study the nutritional, in particular energy and biological, value of the developed dry soluble gerodietetic product for enteral nutrition, which determines the level of needs satisfaction of the target consumers group, a complex of experimental laboratory researches has been implemented. During its realization the samples of the proposed product, which were manufactured in the production conditions of legal entity “DelMas LTD” (Dudarkiv village, Kyiv region, Ukraine), were researched.

The dry soluble product for enteral nutrition “Peptamen”, manufactured by Nestle corporation (Switzerland), was used as a control sample. It has similar recommendations for usage and also, it must be mentioned, is realized in tin cans with a plastic lid. The components of its ingredient content are maltodextrins, enzymatically hydrolyzed dairy whey and soy proteins, sucrose, fructose, medium chain triglycerides, potato starch, soybean oil, soy lecithin, calcium carbonate, sodium phosphate, magnesium chloride, choline bitartrate, flavoring, identities natural (vanillin),

potassium phosphate, sodium ascorbate, magnesium citrate, carnitine, taurine, niacin, zinc sulfate, pyridoxine hydrochloride, retinol acetate, thiamine, riboflavin, folic acid. Sampling and preparation of dry soluble products samples for research were carried out by random sampling in accordance with GOST 15113.0-77 [286].

The main factor that makes it possible to evaluate the nutritional, especially energy, value of products for enteral nutrition is the content of macronutrients. In view of this, the content of its proteins, lipids, and carbohydrates was investigated for establishing the conformity of the products to the needs of the target contingent of consumers (representatives of the older age groups). While carrying out these researches following methods were used: protein content was determined by the Kjeldahl method [287], lipids – by the Soxhlet [288], carbohydrates – by the Bertrand method [289]. The results, which were received in the process of research, are presented in Table 3.

Table 3.

The content of macronutrients in dry soluble products, g/100 g

$P \geq 0,95$, $n=15$

Macronutrients	Control sample	Developed product
Proteins	18,49±0,21	18,18±0,26
Lipids	17,79±0,15	11,82±0,12
Carbohydrates	56,81±0,48	62,08±0,44

The obtained experimental data allow us to conclude that the investigated products for enteral nutrition are characterized by a high content of protein component. This is due to the fact that proteins have the specific metabolic effects, which are explained by special metabolic activity of these products on the human body (recovery of protein losses, provision of plastic material for muscles and bones). It should also be noted that the lipid content of the proposed product is almost on 50% lower and the level of carbohydrates on 9% higher.

For the determination of the conformity of the macronutrients content in the samples to those norms, which are recommended for the elderly people [275–284], the

total energy value of 100 g of dry soluble mixtures and the percentage of major nutrients in the total energy value were calculated. The received results are presented in Table 4.

Table 4.

Total energy value and percentage of major macronutrients in it
for the researched products

Products	Total energy value, kcal	Macronutrients share in total energy value of products, %		
		Proteins	Lipids	Carbohydrates
Control sample	461,4	16,0	34,8	49,2
Developed product	421,4	17,3	25,2	57,5

Basing on the results of the calculation and analysis of the energy value of the developed product sample, comparing with the control one, the conclusion that the control product is characterized by a higher energy value (on 9.4%) must be made. Also, basing on the obtained results of the experiments about the ratio of macronutrients in the developed gerodietetic product for enteral nutrition, it can be stated that it meets the analyzed specific needs of the elder people in the main food substrates. At the same time, the percentage of macronutrients in the total energy value for the control product does not meet the norms recommended for people of older age groups [275–284].

The statement that the proteins are one of the most important food substances is considered to be dogmatic from the standpoint of modern nutritional science. The main factor, which defines proteins' biological value, is the balance and correspondence of amino acids composition [290, 291].

The relevant researches were conducted with the aim to identify qualitative and quantitative data about the content of amino acids in the developed product. It was identified by using the liquid-column ion-exchange chromatography method [294, 295]/ The automatic analyzer of amino acids AAA 400 (produced by company Ingos-Laboratory Instruments (Czech Republic) was used for it after preliminary done acid

hydrolysis. Fractionation of amino acids into individual ones was made on a chromatographic column, filled with an ion exchanging resin Ostion LG FA. The research results about samples amino acids qualitative and quantitative composition are presented in Table 5.

Table 5.

The amino acids composition of products for enteral nutrition, mg/g of crude protein

$P \geq 0,95$; $n = 5$

Amino acids name	Products content, mg/g of crude protein	
	Control sample	Developed product
Essential amino acids		
Isoleucine	$45,8 \pm 2,2$	$44,8 \pm 2,6$
Leucine	$79,4 \pm 3,8$	$71,4 \pm 3,4$
Lysine	$65,6 \pm 3,1$	$64,8 \pm 3,2$
Methionine	$22,5 \pm 0,9$	$35,6 \pm 1,7$
Threonine	$48,1 \pm 2,2$	$50,1 \pm 2,7$
Tryptophan	$14,4 \pm 0,6$	$17,4 \pm 0,8$
Phenylalanine	$27,9 \pm 1,2$	$34,3 \pm 1,4$
Valine	$57,3 \pm 2,3$	$51,5 \pm 2,2$
Total	$361,0 \pm 16,3$	$369,7 \pm 18,2$
Conditionally essential amino acids		
Cystine	$13,5 \pm 0,7$	$10,4 \pm 0,5$
Tyrosine	$25,7 \pm 1,1$	$26,4 \pm 1,2$
Total	$39,2 \pm 1,8$	$36,8 \pm 1,7$
Nonessential amino acids		
Alanine	$46,1 \pm 2,1$	$47,4 \pm 1,8$
Arginine	$39,5 \pm 1,8$	$22,1 \pm 0,7$
Asparagine acid	$107,5 \pm 5,1$	$103,4 \pm 4,3$

Continuation of Table 5.

Amino acids name	Products content, mg/g of crude protein	
	Control sample	Developed product
Glutamine	$237,1 \pm 11,0$	$268,1 \pm 11,8$
Glycine	$21,0 \pm 0,9$	$21,1 \pm 0,6$
Histidine	$34,7 \pm 1,2$	$15,7 \pm 0,6$
Ornithine	Traces	
Proline	$64,0 \pm 2,9$	$63,8 \pm 2,4$
Serine	$49,9 \pm 1,8$	$51,9 \pm 1,9$
Total	$599,8 \pm 26,8$	$593,5 \pm 24,1$

Basing on the conducted analysis of the received data results, it was established that the developed gerodietetic product for enteral nutrition proteins are characterized by high content of essential amino acids (369,7 mg/g of crude protein). Also, it has been established that the proposed product contains conditionally essential amino acids (36,8 mg/g of crude protein) and nonessential amino acids (593,5 mg/g of crude protein). The presence in the developed product of high glutamine content (268,1 mg /g of crude protein) is stipulated by the necessity for human body regeneration and satisfying the nutritional needs [275, 294]. The content of essential, conditionally essential and nonessential amino acids in the developed product is almost equal with the control one. The difference is within the measurement accuracy.

The basic method, which is used nowadays for assessment of proteins biological value, is the researching of amino acid score. In its turn, it allows to characterize the proteins basing on the content of each essential amino acids residues in relation to its master sample values, which are developed in accordance with the recommendations of the FAO/WHO profile committee specialists [295] (Table 6).

Table 6.

Products for enteral nutrition essential amino acids score

Essential amino acids	FAO/WH O scale [295]	Control sample		Developed product	
		mg/g of crude protein	score, %	mg/g of crude protein	score, %
Isoleucine	40	45,8	114,5	44,8	112,0
Leucine	70	79,4	113,4	71,4	102,0
Lysine	55	65,6	119,3	64,8	117,8
Methionine + cystine	35	36,0	102,9	46,0	131,4
Threonine	40	48,1	120,3	50,1	125,3
Tryptophan	10	14,4	144,0	17,4	174,0
Phenylalanine + tyrosine	60	53,6	89,3	60,7	101,2
Valine	50	57,3	114,6	51,5	103,0
Total	—	409,6		406,7	—

Basing on data, stated in Table 6, it was confirmed, that the protein part of the developed gerodietetic product for enteral nutrition is characterized by high protein component biological value. It is so because it contains a balanced essential amino acids composition. The dominant amino acid for both samples is tryptophan (174,0% for developed product, 144,0% for control one); limited – phenylalanine and tyrosine (101,2% for developed product, 89,3% for control one). The improvement of the developed product's amino acid composition can be explained by the usage of protein-based whey concentrate WPC-80 of high biological value.

The conducted assessment of the analyzed products proteins amino acid score doesn't give an opportunity to research their biological value totally. The proteins component of nutrition, which is used for building and plastic processes, can be spent only in measures of limiting amino acids. The excess of these nutrients is directed for meeting energy needs. That is why the protein component's biological value was also

assessed by using the amino acid score difference factor (AASDF) by comparing with the content of ideal one (according the recommendations of FAO/WHO expert committee specialists [295]) and using the following formula [296, 297]:

$$BV = 100 - AASDF = 100 - \sum \Delta RAAS / n$$

where BV – the biological value of product protein component, %;

AASDF – the amino acid score difference factor, %

$\sum \Delta RAAS$ – the ratio of each essential amino acid (EAA) score to the minimal essential amino acid score, %;

n – the quantity of essential amino acids (8).

The received results of it are presented in Table 7.

Table 7.

The biological value of products for enteral nutrition protein component

Index	Master sample	Control sample	Developed product
The amino acid score difference factor (AASDF), %	0	25,4	19,7
Biological value, %	100	74,6	80,3

Basing on the results of the conducted research it was established that the developed gerodietetic dry soluble product's for enteral nutrition amino acid score difference factor (AASDF) was 19,7%. It is 28,9% less than the corresponding index of the control sample. The biological value of the developed gerodietetic product's protein part is on 7,6% higher than the corresponding index of the control sample.

Another important factor that provides nutritional, first of all biological, value is the elemental composition of products. It is very important to note that in products for enteral nutrition it mainly depends on the elemental composition of used raw materials.

The elemental composition of products for enteral nutrition was researched by using the method of mass spectrometry with inductively coupled plasma [298–300]

after the mineralization of the samples. Mass spectrometer VARIAN 320MS (Australia) and special software ICPMS Expert were used for it. Repeatability of experiments was quintuple, of analyzes – triple. The mathematical and statistical processing of the experiments results was performed on a computer using MS Excel program. The reliability of the obtained results deviation was identified: its value should be no more than 3%.

The results of elemental compositions contents research of control sample and the developed gerodietetic dry soluble product for enteral nutrition are presented in Table 8. Also, the data about the level of needs in mineral elements satisfaction for elder aging group representatives after the prepared (dissolving 100 g of dry soluble mixes in boiled water in accordance with the provided recommendations) products portions' consumption is demonstrated in this table.

Table 8.

Elements composition of products for enteral nutrition

 $P \geq 0.97$; $n = 15$

Element	Daily requirement	Control sample content	Developed product content
Macroelements, mg/100 g			
Potassium	2500	576,74±0,46	593,82±0,41
Sodium	2500	364,42±0,14	553,44±0,22
Calcium	1000	358,63±0,44	364,26±0,27
Magnesium	450	186,41±0,57	172,03±0,29
Phosphorus	1000	325,17±0,52	342,11±0,32
Chlorine	2300	466,82±0,02	167,13±0,01
Sulfur	1000	10,51±0,03	20,66±0,02
Microelements, mcg/100 g			
Ferum	14000	5386,17±0,37	3242,72±0,28

Continuation of Table 8.

Element	Daily requirement	Control sample content	Developed product content
Zinc	1200	6332,64±0,64	3156,32±0,36
Mangan	2000	1214,51±0,23	181,63±0,12
Cuprum	1000	623,66±0,14	213,84±0,06
Iodine	150	42,11±0,29	33,43±0,32
Selenium	60	17,63±0,03	18,31±0,04
Molybdenum	60	5,67±0,04	9,16±0,07
Chrome	50	17,36±0,04	18,57±0,02
Nicole	50	4,71±0,84	11,16±0,11
Aluminum	35	3,62±0,08	7,20±0,09
Bromine	25	0,42±0,01	1,74±0,01

It was researched (figure 1) that consumption of prepared portion of the developed product for enteral nutrition provides the average recommended daily requirement of the older aging groups representatives in mineral elements on 2,07–38,23% (control product on 1,05–41,42%). It should be noted that the developed product provide an ability to satisfy daily needs in mineral elements in more propriate, balanced way at the level 10,40–25,8%, while control sample – 1,0–62,4%. Also, the proposed product is characterized by a high level of satisfaction of the daily requirement in Calcium and Magnesium (33,94% and 38,23%), which are especially needed in the process of human body bones and soft tissues rehabilitation and regeneration.

Figure 1. The level of satisfaction of the average daily requirement of older age groups in the main mineral elements

It has been experimentally researched that the ratio of elements Potassium / Sodium, Calcium / Phosphorus in the developed gerodietetic product for enteral nutrition is 1.07 and 1, 1.06 and 1 respectively (for the control sample this ratio is 1.58: 1 and 1.1: 1 respectively). It must be told that these values are very close to the recommended for the optimal fixing (1 : 1 and 1 : 1 respectively) [301–304]. This, in its turn, indicates a high degree of these elements fixing availability by the human body.

The data obtained confirm that the usage of the selected raw material components makes it possible to partially provide the developed gerodietetic product for enteral nutrition with the necessary macro- and microelements. Thus, the main components at the expense of which the formation of the elemental composition of the developed product was ensured, were whey protein concentrate WPC-80, omega-3 polyunsaturated fatty acids (based on seaweed of the species *Ulkenia* sp.), ginseng extract and additionally introduced minerals (dairy calcium and magnesium hydrophosphate). The satisfaction of the full daily needs of a human organism in mineral elements is supposed to be expensed by consumption of other food products.

It is experimentally proved that elemental composition of developed dry soluble product for enteral nutrition of elder aging groups representatives is better than the appropriate one of control sample, in which only 7 elements out of 18 have higher content (Magnesium, Chlorine, Ferum, Zinc, Mangan, Copper, Iodine). In particular, developed product contains almost twice as much Sodium, Sulfur, Molybdenum, Aluminum, Nicole and Bromine. Also, in contrast to the control product, in which the mineral elements were added artificially in the form of salts, in the developed product they are presented in the native form. Therefore, the elements of developed product will be better absorbed by the human body.

In such a way, on the basis of the analyzed information about the composition of nutrients, protein value (amino acid composition), the qualitative and quantitative content of vitamins and mineral elements of the developed gerodietetic dry soluble product for enteral nutrition its high nutritional and biological value was determined.

Finally, on the basis of the analyzed information on the composition of nutrients, amino acid composition, mineral elements' qualitative and quantitative content of the developed gerodietetic dry soluble product for enteral nutrition, its rather high energy and biological value were determined. It was found that the content of macronutrients, the balance of amino acid composition, the content of macro- and micronutrients of the proposed product meet the norms, recommended for older age groups representatives. Through this process, the developed gerodietetic product for enteral nutrition can be recommended for consumption by representatives of the older age groups with high physiological and psycho-emotional loads, metabolic dysfunctions, disorders and injuries, also during treatment and rehabilitation periods.