

TECHNOLOGIES OF SELENIUM-PROTEIN DIETARY SUPPLEMENTS AND SAUCES WITH THEIR USE

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INTRODUCTION

An important area of research in the field of nutrition is the development and implementation of a new approach to the design of food recipes balanced in nutritional composition, especially daily meals. Such meals include sauces.

Issues related to the scientific substantiation and development of technologies for emulsion products for health and treatment and prevention purposes have been studied by leading domestic and foreign scientists: M.P. Holovko¹, G.V. Deinychenko², A.P. Nechaev³, T.M. Harutyunyan⁴, D.J. McClements, C. Chung, G. Smith, B. Degner⁵ etc.

The modern sauce market is very diverse and flexible. The most common varieties on the Ukrainian market are mustard or mustard sauce, mayonnaise and ketchup or tomato sauce. They are characterized by high consumer properties, digestibility, the ability to regulate the chemical composition, nutritional and biological value, caloric content, technological and functional properties.

Enrichment of food products with protein-Selenium complexes, which form the basis of Selenium-protein dietary supplements (SPDS), is one of the possible options for obtaining health products. SPDS contains organic Selenium compounds, which are the products of chemical

¹ Головко М.П., Применко В.Г. Доцільність розробки функціональних соусів промислового виробництва, збагачених селеном. Київ, 2012. Ч. 1. С. 50–51.

² Спосіб одержання майонезу «Еламінівий» : пат. 94267 Україна : МПК А23L 1/24. №200814915 ; заявл. 24.12.2008 ; опубл. 26.04.2011, Бюл. № 8.

³ Нечаев А.П., Кочеткова А.А. Масложировые продукты здорового питания. Москва, 2004. С. 29–31.

⁴ Арутюнян Т.В. Технологія маргарину та майонезу з використанням пророщених злаків. Харків, 2014. 18 с.

⁵ Chung C., Smith G., Degner B., McClements D.J. Reduced fat food emulsions: physicochemical, sensory, and biological aspects. 2016. Vol. 56, No. 4. Pp. 650–685. DOI: <https://doi.org/10.1080/10408398.2013.792236>.

interaction between Selenium salts and globular whey proteins. Such SPDS can be used not only as a source of the above nutrient, but also as an emulsifier of dispersed systems such as mayonnaise. Their introduction to the sauces' recipe should not adversely affect the organoleptic quality; should improve their emulsion stability; increase the content of organic Selenium, which determines the relevance of the aforementioned studies.

The purpose of this work is to develop technologies for Selenium-protein dietary supplements and their use in the sauces production.

A number of tasks have been formed to achieve this purpose: to substantiate scientifically and to develop SPDS technology as a carrier of safe Selenium compounds; to determine rational concentrations and method of their introduction; to investigate technological, functional-technological properties of SPDS and indicators of their safety; to substantiate scientifically and to develop sauce technologies using SPDS; to determine organoleptic, physicochemical, rheological indicators of quality of sauces and indicators of their safety; to investigate the competitiveness of sauces.

As the objects of the study the technologies of dietary Selenium-protein supplements and sauces using SPDS were selected; the subject of the study – SPDS, toxicological, functional-technological, physiological indicators, chemical composition of SPDS, sauces using SPDS, technological properties, chemical composition, hygienic indicators of safety and competitiveness of sauces with SPDS.

Research methods: organoleptic, physicochemical, structural-mechanical, medical-biological, methods of mathematical processing using computer technology.

The scientific novelty of the obtained results lies in the scientific substantiation of technologies of SPDS and establishment of their influence on the properties of food systems of sauces.

1. Development and scientific substantiation of technologies for the production of Selenium-protein dietary supplements

Previous studies have highlighted the scientific and practical foundations of modern human nutrition, the role of minerals in its nutrition, identified regional Selenium deficiency in Ukraine⁶ and the

⁶ Головко М.П., Применко В.Г., Головко Т.М. Наукові та практичні аспекти вирішення проблеми селенодефіциту в Україні. Донецьк. 2013. Вип. 30, Т. 1. С. 20–25.

biological significance of Selenium⁷ (its biogeochemistry, forms and their bioavailability, functions and diseases associated with element deficiency, bioassimilation, its metabolism in the human body) and ways to correct its insufficiency.

Based on theoretical and experimental researches the technologies of obtaining SPDS “Syvoselen Plus” and “Neoselen” are scientifically substantiated, the character of interaction between amino acid residues of whey proteins and anions of Selenium salts is established; the parameters of acute toxicity of SPDS are determined, their organoleptic, physicochemical, microbiological and technological properties are investigated.

The fact of substitution or combination of Se with S-containing fragments of protein molecules has been established. The expediency of using whey for obtaining SPDS in terms of nutritional and biological value in comparison with cottage cheese and casein ones, and sodium selenite – with calcium selenite has been proved. However, the list one dissociates into ions Ca^{2+} and SeO_4^{2-} in a liquid serum medium and enters into redox reactions with serum proteins. This aspect confirms the development of two technologies for obtaining SPDS, taking into account the properties of the ingredients⁸.

The nature of the reactions under such initial quantitative parameters of raw materials between ingredients is established (Fig. 1). First, the process of obtaining SPDS “Neoselen” is characterized by predictability of results (Fig. 1, b), in particular, that is clearly visible in $c_{\text{protein}}=1.25 \times 10^4$ mg/kg of whey (almost linear relationship between W_{Se} in the finished SPDS and $W_{\text{Na}_2\text{SeO}_3}$).

⁷ Головко М.П., Применко В.Г., Лозова Н.П. Біологічне значення селену для організму людини. Луганськ, 2013. С. 46–47.

⁸ Применко В.Г., Сефіханова К.А., Щеньова В.Б. Дослідження способів корекції селенодефіцитних станів людини. Prague, Czech Republic, 2020. Pp. 88–92. DOI: <https://doi.org/10.30525/978-9934-588-79-2-2.22>.

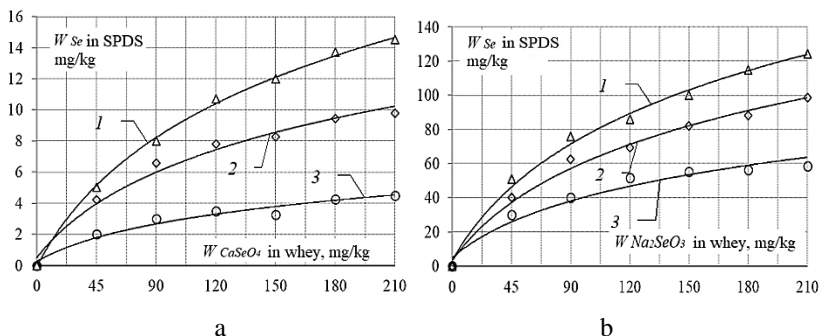


Fig. 1. The dependence of the amount of Se in the finished SPDS (a – “Syvoselen Plus”, b – “Neoselen”) by the number of SeO_3^{2-} and SeO_4^{2-} in whey at a protein concentration in it, mg/kg: 1 – 1×10^4 , 2 – 1.25×10^4 , 3 – 1.45×10^4

Secondly, to obtain SPDS “Syvoselen Plus” containing Se in the amount of $W_{Se}=13.7$ mg/kg require for to add $CaSeO_4$ in the amount of $W_{CaSeO_4} \geq 180$ mg/kg into whey ($c_{білка}=1.45 \times 10^4$ mg/kg).

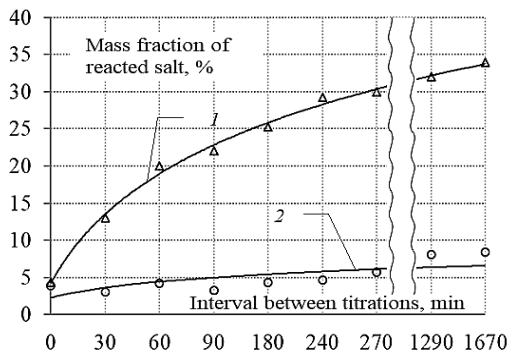


Fig. 2. Kinetics of redox reactions between Se salts and whey protein during SPDS production: 1 – Na_2SeO_3 , 2 – $CaSeO_4$

The optimal (appropriate) value of the saturation intensity time of the protein matrix Se is determined based on experimental data based on the theory of regression analysis⁹. It was found that a significant part, for

⁹ Головка М.П., Применко В. Г. Обґрунтування вибору часових параметрів насичення білкової матриці селеном. Мелітополь, 2015. С. 235–236.

example, Na_2SeO_3 reacts rapidly with whey; then the reaction slows down (Fig. 2).

During the first day, the amount of Na_2SeO_3 decreases by 30%, and during the second – by another 9%. Only 39% of the total amount of Na_2SeO_3 was converted into other Selenium compounds.

Molecular Se, which is part of Na_2SeO_3 , can be reduced under the action of whey proteins to elemental Se^0 . It was experimentally found that 26.7% of Se during the production of SPDS is released in the elemental state (Fig. 3).

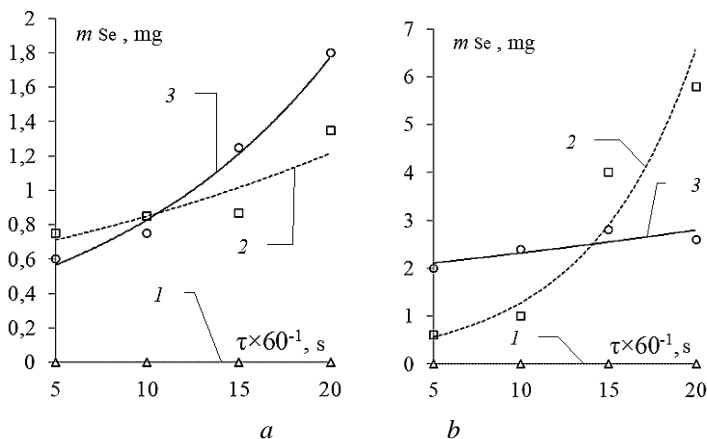


Fig. 3. The dependence of the yield of reduced Se^0 on the hydration time of SPDS: a – “Neoselen”; b – “Syvoselen Plus”; 1 – dry whey; 2 – SPDS semi-finished product; 3 – aqueous solution of the finished SPDS

The regularities obtained during the research allowed to determine the optimal technological parameters of the synthesis of SPDS “Syvoselen Plus” and “Neoselen”¹⁰. Thus, the basic technological scheme of obtaining SPDS “Syvoselen Plus” involves the use as a mother liquor of whey containing protein, which is adjusted to a temperature of 8... 10°C, adding the CaSeO_4 in amount of 0.09...0.18 g/l (or 0.0087... 0.0176%), stirring for 6...7 minutes, followed by keeping the saline solution for 1380...1440 minutes, adding ethanol in an amount of 0.1...5% by volume of serum, re-mixing and keeping for 1380...1440 minutes,

¹⁰ Головко М.П., Головко Т.М., Применко В.Г. Аналіз технологічного процесу одержання добавок дістичних селен-білкових. 2018. Вип. 1 (85). С. 87–95.

decanting with its subsequent drying to a humidity of not more than 15% and grinding (particle size $d \leq 0.001 \text{ m}$)¹¹.

The technology of obtaining SPDS “Neoselen” is based on creating a method of obtaining a supplement enriched in organic Selenium compounds by reducing the time of its production and without the use of additional raw materials, which provides increased nutritional value, regulation of mineral composition, expanding the range of dietary supplements, reducing labor, energy resources, reducing the cost of finished products and increase the efficiency of the technological process¹².

It is proved that the quality and yield of SPDS “Syvoselen Plus” largely depends on the settling time and temperature regime, in contrast to the technology of obtaining SPDS “Neoselen”. To obtain it, sodium selenite is used as a source of Selenium, the dissociation of which in aqueous solutions Selenium ions SeO_3^{2-} require less energy to replace S in thiol (-SH) groups of peptides or serum proteins than ions of other salts containing Selenium and therefore does not occur the need to attract additional raw materials¹³.

On the basis of experimental researches, the practical safety of additives at calculated values of indicators LD_{50} is proved (SPDS “Syvoselen Plus” – 425.5 mg/kg of test rat weight, as “Neoselen” – 3955.8 mg/kg), which corresponds to the 5th class of toxicity of additives¹⁴.

The chemical composition of SPDS was studied (Table 1).

It is proved that as a result of redox processes between SeO_3^{2-} , SeO_4^{2-} and functional groups of whey proteins in the finished SPDS accumulates 27.4...317.84 mg/kg Se, which is much more (101... 1174 times) compared to the control value. The functional and technological properties of SPDS, in particular, their moisture-retaining (MRA), moisture-absorbing (MAA), fat-retaining (FRA) and fat-emulsifying (FEA) abilities were studied (Table 2).

¹¹ Спосіб одержання біологічно активної добавки «Сивоселен Плюс»: пат. на корисну модель 99720 Україна; заявл. 21.10.2014; опубл. 25.06.2015, Бюл. № 12.

¹² Головка М.П., Применко В.Г., Головка Т.М. Технологія біологічно активної добавки «Неоселен». Київ, 2015. С. 26–27.

¹³ Спосіб одержання біологічно активної добавки «Неоселен»: пат. на корисну модель 104883 Україна; заявл. 05.08.2015; опубл. 25.02.2016, Бюл. № 4.

¹⁴ Головка М.П., Применко В.Г., Головка Т.М. Визначення параметрів гострої токсичності біологічно активної добавки «Сивоселен Плюс». Харків, 2015. Вип. 1 (21). С. 222–231.

Table 1

Chemical composition of SPDS¹⁵

Indicator	Whey (control)		Selenium-protein dietary supplement			
			“Syvoselen Plus”		“Neoselen”	
	on a natural sub-stance	on absolutely dry matter	on a natural sub-stance	on absolutely dry matter	on a natural sub-stance	on absolutely dry matter
Mass fraction of moisture, %	93.12±2.3	–	15.0±0.38	–	15.0±0.38	–
Mass fraction of dry matter, %:	6.90±0.2	100.0±2.5	85.0±2.2	100.0±2.5	85.0±2.2	100.0±2.5
Mass fraction of total protein, %	0.86±0.02	13.35±0.33	12.95±0.32	15.24±0.4	30.25±0.8	35.58±0.9
Mass fraction of total fat, %	0.36±0.09	1.1±0.03	0.44±0.01	1.03±0.03	–	–
Mass fraction of carbohydrates, %	5.14±0.10	76.93±1.9	57.68±1.4	67.32±1.7	39.27±1.0	46.2±1.2
Mass fraction of raw ash, %, including:	0.50±0.01	8.60±0.22	12.50±0.31	14.70±0.4	14.0±0.35	16.50±0.4
Calcium, %	0.10±0.01	2.05±0.05	2.15±0.05	2.50±0.06	0.18±0.01	0.21±0.01
Phosphorus, %	0.08±0.01	1.35±0.03	1.50±0.04	1.80±0.04	1.50±0.04	1.75±0.04
Selenium, mg/kg	0.02±0.01	0.30±0.01	24.0±0.6	28.70±0.7	266.10±6.6	318.20±7.9

Satisfactory values of FRA and SPDS are determined, thanks to which the additives will show stabilizing and emulsifying properties in food systems. The complex of such technological characteristics is due to the modification of whey proteins during the production of SPDS, namely: their interaction with serum enzymes (reductases, oxidases, etc.), Se salts, which are both reducing agents and oxidants, pH, temperature, etc. The above indicators of FRA and FEA can be explained by the technological properties of the hydrophobic functional groups of SPDS proteins present on their contact surface ($-\text{CH}_3$, $-\text{C}_2\text{H}_5$ and so on). The hypothesis is confirmed by MRA and MAA studies of SPDS.

¹⁵ Головка М.П., Применко В.Г., Головка Т.М. Дослідження хімічного складу біологічно активної добавки «Сивоселен Плюс». Харків, 2015. С. 115–116.

Table 2

Functional and technological properties of SPDS¹⁶

Indicator	Selenium-protein dietary supplement					
	“Syvoselen Plus”			“Neoselen”		
MRA, %	109±1.1			35±0.35		
MAA, %	30°C	60°C	90°C	30°C	60°C	90°C
	17.4±0.2	16.7±0.2	221.4±2.2	25.64±0.14	39.1±0.3	336.8±3.4
FRA, %	80.2±0.8			75.4±0.7		
FEA, %	16.8±3.8			216.5±2.1		

Regularities of change of SPDS quality indicators during storage are defined (Table 3): organoleptic (Table 4), microbiological (Table 5)¹⁷.

Table 3

Changes in SPDS quality indicators during their storage

Group of indicators	Selenium-protein dietary supplement		
	Duration of storage, days		
	30	90	180
Organoleptic, including: appearance	Homogeneous powder, without foreign inclusions	Unchanged	Unchanged
color	Inherent in additives	Unchanged	Unchanged
consistence	Homogeneous, powdery	Unchanged	Unchanged
flavor	Pleasant, milky	Unchanged	Unchanged
taste	Neutral	Unchanged	Unchanged
Microbiological, including:			
MAFAM number, CFU in 1 g	No more than 1×10^2	Unchanged	Unchanged
E. coli group (coliforms) in 1 g	Not removed	Unchanged	Unchanged
pathogenic, including Salmonella, in 25 g	Not removed	Unchanged	Unchanged
yeast, CFU in 1 g	Not removed	Unchanged	Unchanged
molds, CFU in 1 g	Not removed	Unchanged	Unchanged

¹⁶ Головка М., Головка Т., Применко В. Жироэмульгвальна здатність добавок дієтичних селен-білкових. Київ, 2018 р. Ч. 1. С. 338.

¹⁷ Головка Т.М., Применко В.Г. До питання управління якістю та безпекою добавки «Неоселен». Київ, 2017. С. 75–76.

Table 4

Organoleptic quality indicators of SPDS

Indicator	Characteristic	
	SPDS “Syvoselen Plus”	SPDS “Neoselen”
Appearance	Homogeneous powder, without foreign inclusions	
Color	From light brown to brown	From light red to deep red
Consistence	Homogeneous, powdery	
Flavor	Pleasant, milky	
Taste	Neutral, slight bitterness is possible	

Table 5

Microbiological quality indicators of SPDS

Indicator	Norm	SPDS
The number of mesophilic aerobic and facultative anaerobic microorganisms, CFU in 1 g, no more than	1×10^3	1×10^2
Bacteria of the Escherichia coli group (coliforms) in 1.0 g	Not removed	Not removed
Pathogenic microorganisms, including bacteria of the genus Salmonella, in 25 g	Not removed	Not removed
Yeast, CFU of 1.0 g	1×10^3	Not removed
Molds, CFU of 1.0 g	1×10	Not removed

The conditions and terms of storage of SPDS are substantiated: not more than 180 days at a temperature not exceeding 20°C, relative humidity of air in the storage room of $70 \pm 5\%$ without direct sunlight.

The results of the study confirm the compliance of SPDS with the requirements of the state system of food control; they are the basis of TC U 10.8-01566330-329:2018 “Mineral and organic food additives. Specifications”.

2. Development and scientific substantiation of technologies for the production of Selenium-enriched sauces

Based on the generalization of experimental and analytical research, technological schemes for the production of sauces with SPDS are developed, the recipe composition and parameters of technological operations are substantiated.

A method of producing mayonnaise containing deodorized refined sunflower oil (62.0...72.0%), egg powder (2.0...3.0%), whole milk

powder (2.5...3,0%), granulated sugar (1.5...2.0%), baking soda (0.03...0.05%), mustard powder (1.5...1.95%), water (16.0...21.0%), table salt (1.0...1.5%) and acetic acid 80% (1.0...1.55%), differs the fact that as a biologically active additive contains a dietary Selenium-protein supplement “Syvoselen Plus” (1.0...2.0%)¹⁸.

The method of production of ketchup “Selenium” includes boiling tomato paste 30% (30...60%) with spices (0.05...1.5%), gradual addition of sugar-salt solution (table salt (0.75...1.5%), granulated sugar (2...4%), water (55...75%)) to the required amount of dry matter in the product in accordance with the requirements of the categories, 3...4 minutes before the end of boiling acetic acid topping 9% (2...6%) (taking into account the natural acidity of tomato products) with spices, bottling the product and cooling, adding thickeners (flour, starch, gum), adding spices (cloves, cinnamon, onions, black and red peppers, paprika, mustard), which differs containing dietary Selenium-protein supplement “Neoselen” (1”0...2”0%) in hydrated form¹⁹.

The method of production of mustard “Selenova” includes sifting of loose ingredients, filtering of liquid. Sifted mustard powder (55...60%) and SPDS (1.0...2.0%) are combined, mixed, filled with hot water (70...85°C) and kept in a closed vessel for 2...3 hours. Spices (1.0...2.0%), white sugar (8.0...10.0%) and table salt (6.0...8.0%) are filled with water and brought to a boil, after which the solution is allowed to stand for 24 hours and filtered. To the mustard mass add marinade and filtered vinegar (1.5...2.5%) with refined deodorized sunflower oil (2.0...3.0%) and homogenize. The resulting mustard is cooled and prepared for sale²⁰.

Organoleptic (Table 6) and physicochemical (Table 7) parameters of sauces with SPDS were studied.

The form of communication and structure of system water contained in food systems of sauces with SPDS and changes of a condition of their

¹⁸ Перспективи використання біологічно активної добавки «Неоселен» у технології емульсійних соусів / Головка М.П. та ін. Львів, 2015. С. 137–141.

¹⁹ The technology of ketchup enriched with Selenium / V. Prymenko & etc. *Scientific Works of NUFT*. 2020. Vol. 26, No. 5. Pp. 139–148. DOI: 10.24263/2225-2924-2020-26-5-18.

²⁰ Технологія виробництва гірчиці, збагаченої селеном / Головка М.П. та ін. *Вчені записки ТНУ імені В.І. Вернадського. Сер.: Технічні науки*. 2020. Т. 31 (70), Ч. 2, № 1. С. 109–115. DOI: <https://doi.org/10.32838/2663-5941/2020.1-2/20>.

system water during the recommended terms of storage are investigated by a method of EPR-spin labels (Fig. 4)²¹.

Table 6

Organoleptic quality indicators of sauces enriched in Se

Indicator	Characteristic		
	Mayonnaise “Selenium”	Ketchup “Selenium”	Mustard “Selenium”
1	2	3	4
Appearance	Homogeneous, creamy thick product with single air bubbles	Homogeneous grated or crushed mass of a mixture of fresh tomatoes or concentrated tomato products, fruits, vegetables, vegetable oil with small pieces of spices, etc.	Homogeneous thick product with single air bubbles
Color	From white to creamy yellow, or due to the color of the additives	From deep red to dark red. Darkening of the surface layer is allowed	From light yellow to yellow, brown and other shades are allowed
Consistence	Homogeneous throughout the mass		
	Homogeneous, dense, bridge	From liquid to lubricating	Homogeneous, dense, bridging mass
	without lumps and foreign inclusions and impurities		
Taste and flavor	Inherent to mayonnaise without foreign taste and flavor	Inherent to ketchup (sweet and sour, moderately salty, suitable for a mixture of components used) without foreign ones	Inherent to mustard (spicy; medium-spicy; sweet-spicy; soft, medium-spicy, etc.)

²¹ The investigations of equitability of microelements distribution in the volume of emulsion type sauces enriched by dietary additives / Golovko T. & etc. *ScienceRise*. 2018. No. 6 (47). Pp. 19–23. DOI: <https://doi.org/10.15587/2313-8416.2018.134393>.

Table 7

Physical and chemical parameters of sauces enriched with Se

Indicator	Norm			Control method
	Mayonnaise “Selenium”	Ketchup “Selenium”	Mustard “Selenium”	
Moisture, %	According to the maintenance sauce			GOST 30004.2
Fats, %	not less 30.0	not less 0.1	5.7–10.0	DSTU 4560
Acidity in terms of acetic acid, %	According to the recipe	0.2–2.5	1.5–2.5	GOST 25555.0
Stability of the emulsion, %, not less	97	–	–	GOST 30004.2
Soluble dry matter, %, not less	–	14.0	29.0	GOST 28561, GOST 28562
30% tomato paste, %, not less	–	24.0	–	According to control documentation
Chlorides, %	–	0.5–3.0	1.3–2.8	GOST 26186
Calcium for sauce with SPDS, mg/100 g, not less:	80			DSTU ISO 6491 DSTU ISO 8070
Selenium for sauce with SPDS, mg/100 g, not less:	10			DSTU 7132

The insignificant influence of sedimentation on the homogeneity of the system water structure was revealed under storage of the studied food systems in containers with a height of not more than 60 mm for a period of not more than 45 days.

The results of the study of the blood of white linear rats on biochemical parameters are presented, the recommendations for the use of innovative sauces in the technology of health products and daily diets are developed. There was a slight change in the activity of alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (AF) in the serum of subjects compared with intact rats of the control group during the study period. The results of that studies of the serum of white linear rats correspond to normalized values for healthy animals²².

²² Головка М.П., Головка Т.М., Применко В.Г. Медико-біологічні дослідження добавки дієтичної селен-білкової та соусу з її використанням. Харків, 2018. Вип. 2 (28). С. 45–55. DOI: 10.5281/zenodo.2395580.

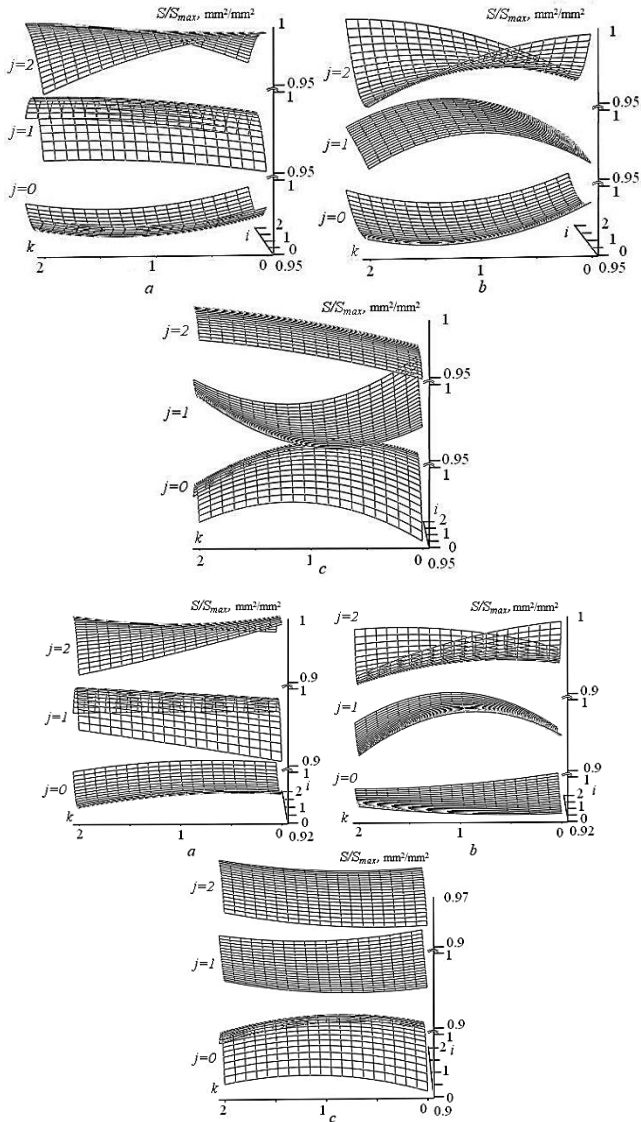


Fig. 4. Distribution of systemic liquid acting as a solvent of ionic salt, by volume of food system before (1) and after (2) storage for 45 days:
a – mayonnaise; b – ketchup; c – mustard

It is established that with increasing shear rate at a temperature of 20°C and at a shear rate $Dr=100\text{ s}^{-1}$ the viscosity of sauces using SPDS is reduced to a constant value of at least 0.5 Pa·s, at the shear rate 10 s^{-1} remains constant, regardless of its change. Newly created sauces with SPDS have a stable structure; each value of the gradient corresponds to a certain equilibrium state of sauces²³.

Complex indicators of competitiveness of the developed production are defined, models of its quality and profiles are developed (Fig. 5). Thus, ketchup “Selenium” with SPDS “Neoselen” turned out to be a highly promising product with the highest comprehensive quality indicator, acceptable cost level, patent protection and customer satisfaction, which is confirmed by a comprehensive indicator of competitiveness: mayonnaise – IC = 91.48 units, ketchup – IC = 91.62 units, mustard – IC = 94.6 units²⁴.

According to the results of calculations, it is determined that the selling price of 1 package (100 g) of mayonnaise “Selenium” will cost UAH 5.70, ketchup “Selenium” – UAH 10.90, and mustard “Selenova” – UAH 10.00.

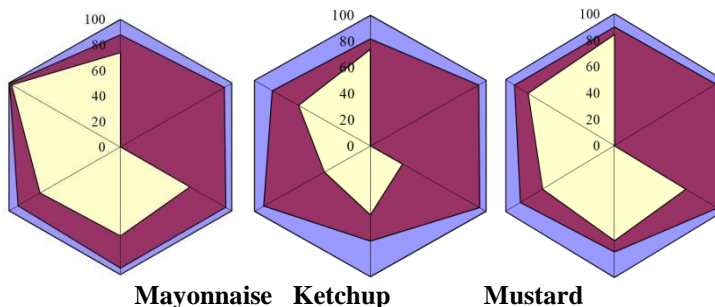


Fig. 5. Competitiveness profiles of the developed sauces: ■ – standard; ■ – experiment; ■ – control; OE – organoleptic evaluation; SC – Selenium content; PC – protein content; PCP – physical and chemical properties; MC – mineral complex; EV – energy value

²³ Головка М.П., Применко В.Г. Дослідження реологічних показників майонезу «Селенового». Харків, 2017. Ч. 1. С. 180–181.

²⁴ Головка М.П., Применко В.Г., Головка Т.М. Дослідження конкуренто-придатності соусів емульсійного типу, збагачених на селен. *Східно-Європейський журнал передових технологій*. 2015. № 5/11 (77). С. 42–48. DOI: <https://doi.org/10.15587/1729-4061.2015.51101>.

When calculating the expected profit from the sale of SPDS at the level of 23%, the manufacturer can obtain a financial result in the form of retained earnings in the amount of 8.3 thousand UAH/t to 8.5 thousand UAH/t of product. If the prices for innovative sauces are set on the same level as the competitive ones, the additional income of their producer will be from UAH 8.00 (for mayonnaise) to UAH 412.00 (for ketchup and mustard) for every 100 consumer packages of sold products weighing 100 g of each.

CONCLUSIONS

1. The scientific and practical preconditions for the emergence of elemental deficits in Ukraine and the world, a special place in which is given to Se-deficiency, are considered. It is established that the deficiency of the element in the diet leads to a number of pathologies of cardiovascular, oncological diseases, diseases of the immune, reproductive, endocrine systems, etc. Analytical review of the literature, patent search and generalization of scientific and technical information proved the prospects for the development of dietary Selenium-protein supplements and their further use in the technology of sauces.

2. SPDS “Syvoselen Plus” and “Neoselen” technologies containing Se-organic compounds have been scientifically substantiated and developed. The maximum allowable concentrations of Se-containing salts in the mother medium of dietary supplements are set: for “Syvoselen Plus” ($W_{Se}=13.7$ mg/kg) $W_{CaSeO_4} \geq 180$ mg/kg, “Neoselen” ($W_{Se}=124.3$ mg/kg) – $W_{Na_2SeO_3} \geq 180$ mg/kg. The forms in which Selenium is represented in SPDS and the nature of its combination with whey proteins are established. Thus, during the first day from the beginning of the process of obtaining SPDS 26.7% of metallic Selenium, 39% of Selenium-protein compounds and 33% – in the form of unreacted inorganic compounds were detected. The possibility of creating organic Selenium-protein complexes based on whey, $CaSeO_4$ and Na_2SeO_3 has been proven.

3. For the first time, the chemical composition of additives and the toxicokinetics of SPDS were studied on the example of model laboratory animals (white linear adult rats). The 5th class of toxicity of additives is established, i.e. they are practically non-toxic. Based on the LD_{50} indicator, recommendations for the use of SPDS “Syvoselen Plus” and “Neoselen” as dietary supplements in food technology in the following amounts have been developed: SPDS “Syvoselen Plus” –

$W \leq 23.3$ mg/kg, SPDS “Neoselen” – based on the daily human need for Se and the influence of the amount of additives on the technological indicators of product quality for special purposes.

4. The indicators of functional and technological properties of additives are determined and scientifically substantiated. Thus, SPDS “Neoselen” in terms of moisture absorption and fat emulsifying ability exceeds SPDS “Syvoselen Plus” by 1.5 and 11.5 times, respectively. The prospects of a wide range of uses of SPDS “Neoselen” in the technology of products of daily diet and special food (including sauces) are proved, based on the study of toxicological, functional and technological properties and chemistry of its production. Due to the practical non-toxicity SPDS “Syvoselen Plus”, it is recommended for dietary nutrition and inclusion in therapeutic and prophylactic diets, as well as technology of dishes exposed to high-temperature processing.

5. Technologies of mayonnaise, ketchup and mustard sauces have been developed using SPDS “Neoselen”. Organoleptic, physicochemical, structural-mechanical and hygienic indicators of quality of the developed production are investigated.

Based on studies of the forms of communication and structure of systemic water contained in food systems of sauces, and their microbiological indicators, the standard shelf life for the developed products is set (≤ 45 days). The antagonistic effect of SPDS on the studied groups of pathogenic microorganisms was revealed.

6. The prospects of the developed products on a complex indicator of quality, an acceptable level of cost, patent protection and satisfaction of needs of consumers are established: mayonnaise – IC = 91.48 units, ketchup – IC = 91.62 units, mustard – IC = 94.6 units.

SUMMARY

The current study is devoted to the scientific substantiation of the technology of Selenium-protein dietary supplements and sauces with their use. The maximum admissible concentrations of Se-containing salts in the uterine environment of dietary supplements have been established. The forms, in which Selenium is presented in the SPDS, and the nature of its combination with milk serum protein are established. The technologies of SPDS “Syvoselen Plus” and “Neoselen” containing organic compounds of Se are developed. The expediency of application

of the developed SPDS in the food products' technology is proved. The technology of mayonnaise "Selenovy", ketchup "Selenovy" and mustard "Selenova" using the SPDS "Neoselen" was developed. The organoleptic, physical and chemical indicators of the developed products' quality are investigated. The methods of promising production and sales of Selenium-enriched sauces have been proven.

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