https://doi.org/10.31891/2307-5732-2025-355-109
УДК 632:654.671

ANTONENKO ARTEM
National University of Life and Environmental Sciences of Ukraine
https://orcid.org/0000-0001-9397-1209
e-mail: artem.v.antonenko@gmail.com
BAL-PRYLYPKO LARYSA
National University of Life and Environmental Sciences of Ukraine
https://orcid.org/0000-0002-9489-8610
e-mail: artem.v.antonenko@gmail.com

SAFETY OF SAUCE PRODUCTS FOR HEALTH PURPOSES

The article notes the peculiarities of the use of dietary supplements and developed the technology of sauces using polydextrose, gum arabic, and protein-fat additives. Mathematical methods based on the physical and chemical parameters of emulsions and chemical composition determined the rational ratio in composite mixtures of protein-fat additive, gum arabic and polydextrose as 0.5:0.3:0.2. Through mathematical processing of experimental data, the regression level was determined, which describes the one-factor space of an independent complex indicator of quality from the concentration of the composite mixture. The rational concentration of the composite mixture in the finished sauce was determined, which is 15% of its mass, for which they have organoleptic, physico-chemical and structural-mechanical properties close to traditional sauces. The use by manufacturers of certain food additives to provide food products with specified organoleptic and structural-mechanical properties, as well as the desire to minimize costs, reduce the duration of the technological process to the deterioration of quality and the danger of consuming such products. The quality was determined based on the safety indicators of the new products in comparison with traditional analogues based on the content of heavy metals. From the microbiological indicators, the number of MAFAnM molds and yeasts, the bacterial group of Escherichia coli, pathogenic microorganisms, including parts of the genera Salmonella, Proteus and Staphyloccocus aureus. All indicators are determined in samples of sauces after preparation and storage. After 48 hours of storage, the count of mesophilic aerobic and facultative anaerobic microorganisms in sauce samples was, on average, 20 times below regulatory standards. The new sauces exhibited lower microbial levels than the control samples, attributed to an increased proportion of dry matter and bound moisture, which elevates osmotic pressure and inhibits microbial growth. No mold, yeast, coliform bacteria (BGKP), or pathogenic microorganisms were detected in the tested samples. The study confirmed that lead, copper, and zinc levels in the sauces remained within maximum permissible limits. Given their nutritional value, these sauces are recommended for inclusion in the diets of all population groups, particularly for workers in hazardous industries and residents of contaminated areas.

Keywords: sauces, vegetable hydrocolloids, protein-fat additive, gum arabic, food fibers, safety, quality, biotechnology, technology.

АНТОНЕНКО АРТЕМ
БАЛЬ-ПРИЛИПКО ЛАРИСА
Національний університет біоресурсів і природокористування України

БЕЗПЕЧНІСТЬ СОУСНОЇ ПРОДУКЦІЇ ОЗДОРОВЧОГО ПРИЗНАЧЕННЯ

У статті відзначено особливості використання БАД та розроблено технологію приготування соусів з використанням полідекстрози, гуміарабіку та білково-жирових добавок. Математичними методами на основі фізико-хімічних показників емульсій та хімічного складу визначено раціональне співвідношення в композиційних сумішах білково-жирової добавки, гуміарабіку та полідекстрози 0,5:0,3:0,2. Шляхом математичної обробки експериментальних даних визначено рівень регресії, який описує однофакторний простір незалежного комплексного показника якості від концентрації композиційної суміші. Визначено раціональну концентрацію композиційної суміші в готовому соусі, яка становить 15 % від його маси, за якої вони за органолептичними, фізико-хімічними та структурно-механічними властивостями близькі до традиційних соусів. Використання виробниками окремих харчових добавок для надання харчовим продуктам заданих органолептичних і структурно-механічних властивостей, а також прагнення мінімізувати витрати, скоротити тривалість технологічного процесу до погіршення якості та небезпеки споживання такої продукції. Якість визначали за показниками безпеки нової продукції в порівнянні з традиційними аналогами за вмістом важких металів. З мікробіологічних показників кількість МАФАнМ пліснявих та дріжджових грибів, бактеріальної групи Escherichia coli, патогенних мікроорганізмів, у тому числі представників родів Salmonella, Proteus та Staphyloccocus aureus. Усі показники визначають у пробах соусів після приготування та зберігання. Після 48 годин зберігання кількість мезофільних аеробних і факультативно-анаеробних мікроорганізмів у зразках соусів була в середньому в 20 разів нижчою за встановлені стандарти. У нових соусах їх рівень був нижчим, ніж у контрольних зразках, завдяки підвищенню частки сухих речовин і зв'язаної вологи, що сприяє збільшенню осмотичного тиску та гальмує розвиток мікроорганізмів. У досліджуваних зразках не виявлено пліснявих грибів, дріжджів, бактерій групи кишкової палички (БГКП) чи патогенних мікроорганізмів. Дослідження показало, що вміст свинцю, міді та цинку в соусах не перевищує гранично допустимих концентрацій. Завдяки покращеній харчовій цінності розроблені соуси рекомендуються для включення в раціон усіх груп населення, зокрема працівників шкідливих виробництв і жителів забруднених регіонів.

Ключові слова: соуси, рослинні гідроколоїди, білково-жирові добавки, гуміарабік, харчові волокна, безпека, якість, біотехнологія, технологія.

Стаття надійшла до редакції / Received 03.05.2025
рийнята до друку / Accepted 26.06.2025

Formulation of the problem

Sauces are dispersed systems formed by two mutually insoluble liquids (polar - "water" and non-polar - "oil"). There are two types of emulsions: direct - "oil in water" and reverse - "water in oil". The most problematic issue in the technology of food emulsions is ensuring their colloidal stability, which is primarily determined by the effectiveness of structure-forming agents (emulsifiers, stabilizers) - low- or high-molecular substances and their

complexes. Of particular interest are high-molecular structure-formers represented by proteins of animal and plant origin and polysaccharides [4].

The use of polysaccharides, in particular hydrocolloids, for the formation and stabilization of emulsions is determined by their functional properties: surface activity, high viscosity when interacting with a solvent, thixotropy, etc. [5].

Polysaccharides that are widely used in low-fat food emulsion technologies include polydextrose and gum arabic, which have prebiotic properties and have a positive effect on physiological processes in the human body: they reduce cholesterol in the blood, stimulate beneficial intestinal microflora, participate in the regulation of energy cell metabolism.

Polydextrose (food additive E-1200) is a polysaccharide consisting of glucose residues. As a food additive, polydextrose is widely used in the creation of products with reduced sugar and fat content. The polydextrose molecule has a fairly voluminous branched structure. It is produced in the form of a soluble white powder, has a low calorie content (1 kcal/g).

Gum arabic (food fiber E-414) is the resin of African acacia, which contains 85–90% of soluble food fibers, is produced in the form of a soluble powder (white color without taste and smell) or granules, has a low calorie content (up to 2 kcal/g), used as a filler in low-sugar and sugar-free recipes. The main chain of the polysaccharide molecule consists of galactose. With a high molecular weight (over 200,000 daltons), gum arabic forms solutions with low viscosity, resistant to temperature and acidic environments. It is used in the recipes of dairy, confectionery, bakery, minced meat products, drinks, ice cream, fruit pastes, mashed potatoes [6].

For the formation of a structure characteristic of sauces, it is advisable to use an additive from soybeans - an important source of vegetable proteins that have a high emulsifying capacity and biological value due to the content of essential amino acids. The protein-fat additive "Super" is suitable for this, manufactured according to the EUSO® technology (TU U 13693522.002–96 "Products awake"), tested by us during the development of new types of sauces [7].

Analysis of recent sources

Considering modern environmental conditions, the human diet should contain a sufficient amount of natural biologically active substances (BAR): essential amino acids, polyunsaturated fatty acids, macro- and microelements, vitamins, dietary fibers, which are able to increase the body's resistance to the influence of negative environmental factors. The work of scientists M. I. Peresichny, M. F. Kravchenko, P. O. Karpenko, A. B. Horalchuk, P. P. Pyvovarov [2], V. N. Korzun, O. M. Grigorenko [3] and others.

The creation of emulsion-based product technologies aims to enhance quality, diversify product ranges, lower calorie content, extend shelf life, and reduce costs. This can be achieved through the targeted use of food additives, which serve both technological purposes and provide specific biological benefits.

The purpose of the work is scientific substantiation, technology development, quality and safety assessment of "Milk pumpkin Sauce" and "White health Sauce".

The object of research is the technology of sauces of increased nutritional value using a composite mixture of polydextrose, gum arabic and a protein-fat additive.

The technology of sauces "Milk pumpkin Sauce" and "White health Sauce" of increased biological value was developed, the main sauces - white and milk - were chosen as control samples [8].

The mass fraction of protein by the Kjeldahl method (GOST 17444–76), fat (GOST 30004.2–93), dietary fiber (GOST 13496.2–91) was studied; content of Calcium, Magnesium - (GOST 26428-85); Phosphorus - (GOST 17289); Sodium, Potassium, Ferrum - (DSTU ISO 6332–2003), Lead (GOST 26932–86), Cadmium (GOST 26933–86), Arsenic (GOST 26930–86), Mercury (GOST 26927–86), Copper (GOST 26931 –86), Zinc (GOST 26934–86); mycotoxins (GOST 28038–89); pesticides (DSTU EN 12955–2001); of radionuclides [9]. The content of toxic elements and radionuclides compared with the maximum permissible level (MRL).

From the microbiological parameters, the number of MAFAnM (GOST 10444.3–85), molds and yeasts (GOST 10444.12–88), Escherichia coli bacteria (GOST 30518–97), pathogenic microorganisms, including Salmonella genera (DSTU IDF 93A: 2003), Proteus (GOST 28560–90) and Staphyloccocus aureus (GOST 10444.2–94). The content of ascorbic acid, carotene (GOST 8756.22), niacin (RR, GOST 30627.4), fluorometric – thiamine (B1) and riboflavin (B2) (GOST 31483–2012) was determined using a spectrophotometer.

The collected data were analyzed using mathematical statistics and correlation analysis with MathCad software.

Presenting main material

According to the developed technology, in the emulsion-type sauces "Milk pumpkin Sauce" and "White health Sauce", wheat flour is completely replaced by a composite mixture (CS) using a protein-fat additive, gum arabic and polydextrose. Vegetable puree is also added to the "Milk pumpkin Sauce" as a filler. Mathematical methods based on physicochemical parameters and the chemical composition of emulsions determined the rational ratio of components in composite mixtures - protein-fat additive: gum arabic: polydextrose as 0.5: 0.3: 0.2. Mathematical processing of experimental data determined the regression equation, which describes the one-factor space of dependence of the complex quality indicator (CQI) on the concentration of CS (Fig.1 and Fig.2).

With an increase in the content of the composite mixture, the CQI of the model systems increases and reaches its maximum value at a CS concentration of 15%, at which the studied sauces have organoleptic, physico-chemical, and structural-mechanical properties close to traditional ones. At a CS concentration of more than 15%, the sauces acquire a thick consistency compared to the control with a noticeable soy flavor. The technology of "Milk pumpkin Sauce" and "White health Sauce" using a composite mixture is proposed (Fig. 3).

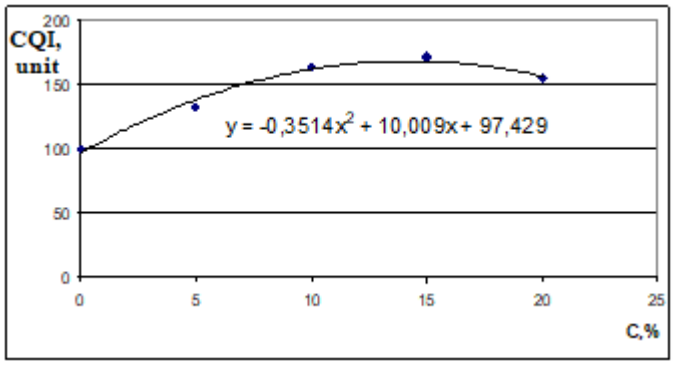

Fig. 1. Dependence of the complex indicator of the quality of the milk sauce model system on the concentration of CS

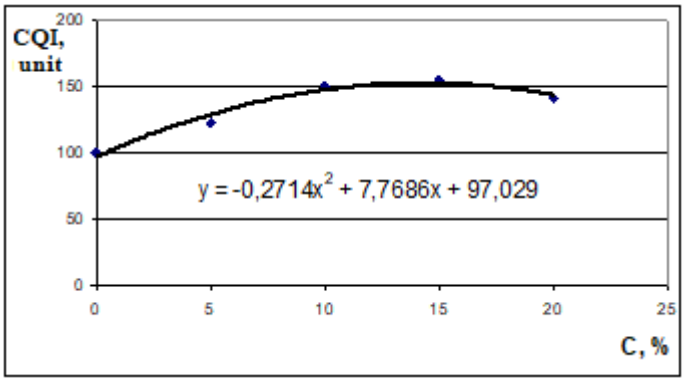

Fig. 2. Dependence of the complex indicator of the quality of the model system of white sauce on the concentration of CS

A significant increase in dietary fiber was noted in the developed sauces - 15-17 times. The content of proteins and fats also increased. The mineral composition of sauces has improved - primarily due to an increase in the content of Ferrum by 4.3 and 6 times, as well as Pot assium, Calcium, Magnesium and Phosphorus. The higher content of macronutrients in "White health Sauce" compared to "White Sauce" is due to the chemical composition of the recipe components of the sauces. In the new sauces, the content of ascorbic acid, thiamine, niacin, and carotene in "Milk pumpkin Sauce" increased - due to the addition of vegetable puree from carrots and pumpkin (Table 1).

Table 1

Comparative chemical composition of sauces based on a composite mixture

Indicator	Units of measurement	Milk sauce		Difference, %	White sauce		Difference, %
		Control	"Milk pumpkin Sauce"		Control	"White health Sauce"	
Protein	%	3.50	4.74	35.4	1.27	3.20	152.0
Fats	"	2.96	3.28	10.8	4.39	5.30	21.0
Food fibers	"	0.41	7.14	1650.0	0.40	6.00	1400.0
Mineral substances:							
Sodium	mg/100g	320.00	396.00	24.0	416.00	489.00	18.0
Potassium	"	156.00	308.00	97.0	51.00	141.00	152.0
Calcium	"	113.00	136.00	21.0	56.00	74.00	31.0
Magnesium	"	25.00	57.00	134.0	5.30	17.50	230.0
Phosphorus	"	99.00	138.00	40.0	45.50	77.50	70.0
Ferum	"	0.35	1.50	329.0	0.16	0.96	500.0
Vitamins:							
Ascorbic acid	mg/100g	1.17	6.70	472.0	3.20	3.70	15.5
Thiamine	µg/100g	0.07	0.12	57.0	0.02	0.08	300.0
Riboflavin	"	0.16	0.17	6.3	0.01	0.03	70.5
Niacin	"	0.40	1.10	175.0	0.18	0.31	65.0
Provitamins:							
Carotene	µg/100g	0.07	1.15	1543.0	0.05	0.11	102.0

Manufacturers often use food additives to enhance the sensory and structural properties of food products while aiming to cut costs and shorten processing times, which can compromise quality and increase consumption risks. The quality of the novel "Milk-pumpkin sauce" and "Healthy white sauce" was evaluated using safety parameters, compared to traditional "Milk" and "White" sauces, focusing on heavy metal content.

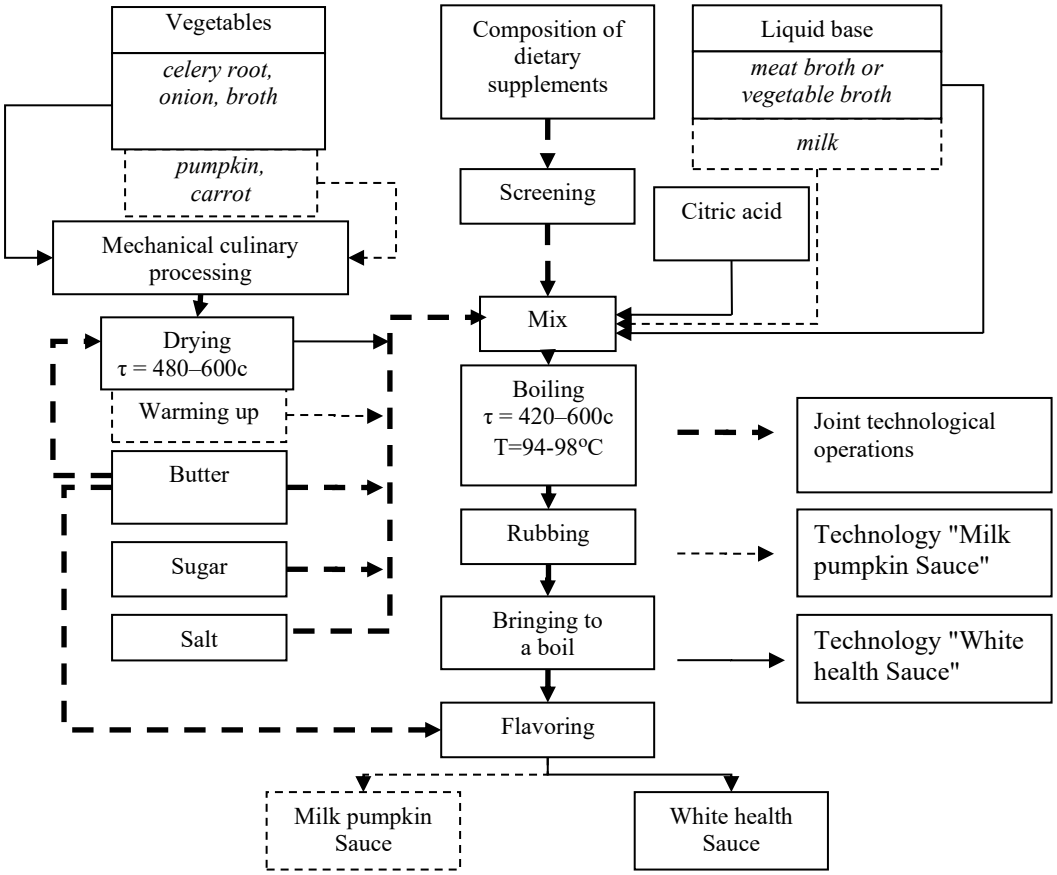

Fig. 3. Technological scheme of the production of "Milk pumpkin Sauce" and "White health Sauce" based on a composite mixture

Microbiological tests assessed the presence of pathogenic microorganisms, including molds, yeasts (MAFAnM), coliform bacteria, Salmonella, Proteus, and Staphylococcus aureus. These parameters were measured in sauce samples post-preparation and during storage. After 48 hours of storage, the levels of mesophilic aerobic and facultative anaerobic microorganisms in the sauces were, on average, 20 times below regulatory standards [9]. The new sauces showed lower microbial counts than the control sauces, attributed to higher dry matter and relative humidity, which increase osmotic pressure and inhibit microbial growth. No molds, yeasts, coliforms, or pathogenic microorganisms were found in any samples.

The study also showed that lead, copper, and zinc levels in the sauces remained within maximum permissible concentrations (MPC) (Table 2). Cadmium, arsenic, mercury, mycotoxins (aflatoxin B1 and patulin), and pesticides (HCCR gamma isomer, heptachlor GRX, and DDT) were absent in both control and test samples, as per MPC standards [9].

Table 2

Safety indicators of new sauce products

The name of the sauce	Content of heavy metals, mg/kg *			Content of radionuclides, Bq/kg **		Number of MAFAM, $10^2 \cdot$ CFU/g for the storage period, hours ***			
	Pb	Cu	Zn	^{137}Cs	^{90}Sr	0	12	24	48
"Milk Sauce"	0.02	0.12	0.42	6.6	4.7	1.40	2.21	3.61	5.41
"Milk pumpkin Sauce"	0.02	0.04	0.43	6.2	45	1.31	2.02	3.31	5.12
"White Sauce"	0.02	0.11	0.51	5.4	4.5	1.34	2.05	2.92	5.41
"White health Sauce"	0.02	0.12	0.51	5.2	4.1	1.34	2.05	2.62	5.22

Remark: * maximum permissible levels, mg/kg: Pb – 0.1; Cu – 0.5; Zn – 3.0;
** maximum permissible levels, Bq/kg: ^{137}Cs –30; ^{90}Sr – 20;
*** number of MAFAnM - no more $1 \cdot 10^4$ КУО/г.

In both control and experimental sauce samples, levels of cesium and strontium radionuclides were within the maximum allowable limits [10].

Conclusions

The production methods for "Milk-Pumpkin Sauce" and "White Health Sauce" have been scientifically validated and established. These sauces exhibit enhanced biological value and comply with food safety standards. They received favorable approval from the State Health and Epidemiology Research. The use of combined gum arabic, polydextrose, and protein-fat additive mixtures shows promise as a structural component in sauce technology development. Due to their nutritional benefits, "Milk-Pumpkin Sauce" and "White Health Sauce" are suitable for consumption by all population groups.

References

1. Mazaraki A.A. (2012). Tekhnologiya harchovih produktiv funkcional'nogo priznachennya. Kiïv: KNTEU. 1116 s. [in Ukrainian].

2. L'vovych I.Ya. (2016). Perspektyvni trendy rozvytku nauky: tekhnika i tekhnolohii. Odesa: KUPRIYENKO S.V. 197 s. [in Ukrainian].

3. Antiushko, D., Bozhko, T., Shapovalova, Nutritional value of a dry soluble gerodietetic product for enteral nutrition. Eastern-European Journal of Enterprise Technologies. 2021. № 5. C. 35–42. [in Ukrainian].

4. Cherevko O.I. (2017). Innovacijni tekhnologiï harchovoï produkciï funkcional'nogo priznachennya. Harkiv: HDUHT. 591 s. [in Ukrainian].

5. Yatsenko V.M. (2017). Financial-economic and innovative support of entrepreneurship development in the spheres of economy, tourism and hotel-restaurant business. Agenda Publishing House, Coventry, United Kingdom. 619 s. [in United Kingdom].

6. Hamaiumova V.V. (2020). Innovatsiini tekhnolohii v zhytti suchasnoi liudyny. Ch. 3: Seriia monohrafii Odesa. KUPRIYENKO SV. 209 s. [in Ukrainian].

7. Preobrazhenskyi A.P. (2019). Riven rozvytku tekhniky i tekhnolohii v XXI stolitti. V 2 chastynakh. Chastyna 1: Seriia monohrafii. Odesa. KUPRIYENKO SV. 227 s. [in Ukrainian].

8. Lvovych Y.Ia., Nekrasov V.A., Preobrazhenskyi A.P. Perspektyvni trendy razvytku nauky: tekhnika i tekhnolohii. Odesa. KUPRIENKO SV. 2016. 197 s. [in Ukrainian].

9. Chepurda H.M. Stratehii staloho rozvytku v turyzmi ta hotelno-restorannomu biznesi: mozhlyvosti i problemy zaprovadzhennia v Ukraini. Cherkasy. ChDTU. 2021. 189 s. [in Ukrainian].

10. Wissenschaft fьr den modernen Menschen: wirtschafts, management, marketing, tourismus, rechts und politikwissenschaften. Monografische Reihe «Europdische Wissenschaft» [Brovenko T.V., Antonenko A.V. and others] Buch 4., Teil 6. 2021. [in Germany].

Література

1. Мазаракі А.А. (2012). Технологія харчових продуктів функціонального призначення. Київ: КНТЕУ. 1116 с.

2. Львович І.Я. (2016). Перспективні тренди развитку науки: техніка і технології. Одеса: КУПРИЄНКО С.В. 197 с.

3. Antiushko, D., Bozhko, T., (2021). Nutritional value of a dry soluble gerodietetic product for enteral nutrition. Eastern-European Journal of Enterprise Technologies. № 5. C. 35–42.

4. Черевко О.І. (2017). Інноваційні технології харчової продукції функціонального призначення. Харків: ХДУХТ. 591 с.

5. Yatsenko V.M. (2017). Financial-economic and innovative support of entrepreneurship development in the spheres of economy, tourism and hotel-restaurant business. Agenda Publishing House, Coventry, United Kingdom. 619 с.

6. Гамаюмова В.В. (2020). Інноваційні технології в житті сучасної людини. Ч. 3: Серія монографій Одеса. КУПРІЄНКО СВ. 209 с.

7. Преображенський А.П. (2019). Рівень розвитку техніки і технологій в XXI столітті. В 2 частинах. Частина 1: Серія монографій . Одеса. КУПРІЄНКО СВ. 227 с.

8. Чепурда Г.М. (2021.)Стратегії сталого розвитку в туризмі та готельно-ресторанному бізнесі: можливості і проблеми запровадження в Україні. Черкаси. ЧДТУ. 189 с.

9. Wissenschaft fьr den modernen Menschen: wirtschafts, management, marketing, tourismus, rechts und politikwissenschaften. Monografische Reihe «Europdische Wissenschaft» [Brovenko T.V., Antonenko A.V. and others] Buch 4., Teil 6. 2021.