Розроблено 10 оригінальних рецептур м'ясних паштетів, збагачених біологічно активними компонентами за рахунок використання вітамінізованих купажованих рослинних олій (ВКРО) та білково-жирових емульсій (БЖЕ) на їх основі для загального та спеціального харчування. Створено нові купажі рослинних олій, визначено їх жирнокислотний склад і вміст в них жиророзчинних вітамінів. Здійснено прискорений контроль нової продукції на наявність термостійких спороутворюючих бактерій з використанням сучасних молекулярно-генетичних досліджень (ПЛР). Доведено доцільність впровадження нових безпечних м'ясних паштетів у виробництво

Ключові слова: м'ясні паштети, вітамінізовані купажовані рослинні олії, білково-жирові емульсії, м'ясо птиці, санітарно-гігієнічна безпека

Разработаны 10 оригинальных рецептур мясных паштетов, обогащенных биологически активными компонентами за счет использования витаминизированных купажированных растительных масел (ВКРМ) и белково-жировых эмульсий (БЖЭ) на их основе для общего и специального питания. Созданы новые купажи растительных масел, определен их жирнокислотный состав и содержание в них жирорастворимых витаминов. Осуществлен ускоренный контроль новой продукции на наличие термостойких спорообразующих бактерий с использованием современных молекулярно-генетических исследований (ПЦР). Доказана целесообразность внедрения новых безопасных мясных паштетов в производство

Ключевые слова: мясные паштеты, витаминизированные купажированные растительные масла, белково-жировые эмульсии, мясо птицы, санитарно-гигиеническая безопасность

UDC 664.934: [54.021:577.115.3:577.16]:614.3-049.5
DOI: 10.15587/1729-4061.2017.103913

DEVELOPMENT OF SANITARY-SAFE POULTRY PASTE PRODUCTS WITH BALANCED FATTY ACID AND VITAMIN COMPOSITION

Ye. Kotliar
PhD*
E-mail: yevhenii11@ukr.net
O. Topchiy
PhD, Associate Professor
Department of meat and meat products technology
National university of food technologies
Volodymyrska str., 68, Kyiv, Ukraine, 01601
E-mail: Oksanatopchiy@ukr.net
L. Pylypenko
Doctor of Technical Sciences, Professor**
E-mail: l.n.pylypenko@ukr.net
I. Pylypenko
PhD, Associate Professor**
E-mail: inna_p@live.ru
E. Sevastyanova
PhD, Associate Professor*
*Department of technology of milk, fats and perfume and kosmetycheskyh funds***
Department of Biochemistry, Microbiology and Physiology of Nutrition*
***Odessa National Academy of Food Technologies
Kanatna str., 112, Odessa, Ukraine, 65039

1. Introduction

Solving the problem of healthy nutrition is the most important and topical state task related to the social stability of society and population health [1–3].

Recent studies have shown that polyunsaturated fatty acids (PUFA) contained in vegetable oils are of great value to humans. The unique spectrum of their functional effects has resulted in a wide range of application. Stimulating role of PUFA for protective mechanisms of the organism and particularly in strengthening its resistance to infectious diseases was established [4–6].

Traditional meat paste formulations are evaluated mainly for their organoleptic parameters and energy value without taking into account the product's chemical composition balance. Thus, existing recipes of meat-based pastes do not always meet the standards of special nutrition. Creation of balanced recipes of meat products having high nutritional value with an improved fatty acid composition and enriched with fat-soluble vitamins as well as the possibility of accelerated diagnosis of their safety are important trends in present-day nutrition.

One of the promising study directions is development of paste recipes with addition of vitaminized blended vegetable oils [7–11].

Much attention is paid to development of new types of products with balanced composition that would enter the daily diet and have a positive effect on the human organism. However, there is a need for additional studies in the technologies of polycomponent meat products. Meat pastes are homogenized products based on meat and fat-containing raw materials with a limited content of polyunsaturated fatty acids and fat-soluble vitamins, in particular carotenoids and tocopherols which take part in oxidative-reduction reactions of cells and have antioxidant properties.

In this regard, use of protein preparations, vegetable oils and fat-soluble vitamins is a timely and promising direction.

Taking into account the aforementioned, it becomes urgent to create vitaminized blends of vegetable oils and protein-fat emulsions on their basis with the aim of partial replacement of animal fats with protein-fat emulsions (PFE) in recipes of meat pastes. This will make it possible to adjust diets with essential nutrients, achieve the required ratio ω-6:ω-3 of fatty acids, vitamins: β-carotene and tocopherol and expand the range of meat products with a balanced composition.

The peculiarity of meat paste products is their microbiological instability in storage which results in short regulated terms and conditions. That is why development of ways to improve stability of pastes and use accelerated methods for microbiological control of their safety are the issues of high actuality.

2. Literature review and problem statement

At present, the main innovation offered by manufacturers is creation of products with a balanced composition for adequate nutrition. The present-day consumer reacts positively to the reduced content of fat in foods, their shorter shelf life and enrichment with various natural food additives, pro- and prebiotics, etc. Such products are based on the medical and biological requirements to their nutritional, biological and energy value. The number of such products in the world market increases every year and, according to specialists, they will replace traditional products by 30...50 % in the near future [12–14].

Proper healthy, balanced and rational nutrition contains all necessary vitamins, nutrients, proteins, fats and carbohydrates, it strengthens organism and improves immunity, that is improves health.

The recommendations of medical institutions and WHO suggest that 15...30 % of total energy of the human organism should be derived from consumption of dietary fats including less than 10 % from consumption of NFA, 6...10 % – from PUFA (5...8 % ω6, 1...2 % ω3), 10...15 % from MUFA and less than 1 % from consumption of trans-isomers of fatty acids. The recommended top level of cholesterol in food is 300 mg/day. Scientists have proven that it is normal for human health to regularly use foods that contain long-chain PUFA, in particular eicosapentaenoic or docosahexaenoic fatty acids [15]. Of extreme importance is the ratio between fatty acids. Although it is thought that the less fat in the diet, the better but it should be remembered that some fatty acids are essential in foods.

The objective of the researchers is to achieve an appropriate amount of lipids and a desired profile of fatty acids to optimize compositions in terms of functional properties of meat products. For this purpose, partial replacement of fatty raw materials with vegetable oils which do not contain cholesterol, in particular olive, corn, soya, sunflower, rye, linseed, walnut, pumpkin and other oils [16–18].

Change of the lipid fraction occurs when animal fats are replaced with other fats (mainly vegetable oils and lipids derived from processing of sea products) in order to achieve an optimal ratios ω3:ω6 and PUFA:NFA.

Development of balanced formulations of meat products possessing high nutritional value and an improved fatty acid composition and enriched with fat-soluble vitamins can be considered as an important trend in modern nutrition, which determines the tendency of development of a number of related branches of the meat processing industry [19].

Therefore, one of the promising research directions is the development of a new sanitary-safe meat paste product with a balanced content of fatty acids and vitamins [17, 18].

The risk of pathogenic microorganisms is the reason for analysis of the frequency of outbreaks caused by them, likelihood of their detection in food raw materials and finished products, development of methods for their microbiological analysis for various groups of food products, especially meat, as well as improvement of their accuracy and fastness characteristics. It is believed that at least 7 % of food poisonings are associated with food contamination by *Clostridium perfringens*. About 10,000 alimentary disease cases associated with *C. perfringens* are recorded annually in the United States. Severity of the disease varies but in the case of necrotic enteritis, a high probability of lethality exists [20, 21]. *Bacillus cereus* is another potential spore-forming causative agent of food poisoning widely spread in environment and food products. Diagnosis of poisoning with *B. cereus* occurs in virtually all countries. According to the CDC Foodborne Outbreak Online Database, over 60,000 cases of diseases caused by *B. cereus* are annually recorded in the United States [20, 22].

B. cereus bacteria can cause a wide range of human diseases including food poisoning, systemic and local purulent infections including lightning sepsis, meningitis, brain abscess, endophthalmitis, pneumonia, endocarditis, osteomyelitis, skin gas gangrene type, etc. and mastitis in cattle [23]. It is noted that some patients with vomiting symptoms under bacillary food infection are mistakenly diagnosed with an intoxication syndrome caused by *Staphylococcus aureus* while the *Clostridium perfringens* is considered a false diarrhea-causative agent of this toxicoinfection [24].

Taking into account potential survival of spore-causing agents of food poisoning, even in cases of compliance with the requirements to thermal conditions (temperature of 72±2 °C in the center of the product should be ensured) of treatment of meat paste products, a particular attention is paid to the definition of namely these microorganisms.

Limited and short shelf life of baked meat pastes in comparison with protracted classical methods of microbiological studies requires an accelerated control of their sanitary safety.

Thus, development of a sanitary-safe, balanced-composition meat paste products to meet present-day nutrition requirements is relevant and has a scientific and practical importance.

3. The study objective and tasks

This work objective was to develop new types of paste products having balanced composition at a guaranteed sanitary safety for general and special nutrition.

To achieve this goal, the following tasks were set:

– compare fatty acid composition and physical and chemical parameters of vegetable oils and make their choice for blending at an optimal ratio ω-6:ω-3 of fatty acids;

– establish optimal concentrations of β-carotene and tocopherol in order to increase stability of vitaminized blended vegetable oils (VBVO) and ensure the daily needs of the organism in fat-soluble vitamins;

– develop scientifically substantiated formulations of products which are balanced with fatty acid and vitamin

content in accordance with requirements of special nutrition; study influence of VBVO and PFE on the quality indices of the minced systems and meat pastes and improve their technology;

– carry out accelerated control of sanitary safety to study quality indices of developed meat paste recipes balanced with fatty acid and vitamin content and substantiate biological value of the developed products for the effect on the basic functions of organism.

4. Materials and methods used in study of meat pastes

The subject of research was the technology and a set of indices of quality and safety of new types of meat paste with a balanced composition using vitaminized blended vegetable oils and PFE on their basis, a sample of meat paste No. 1 is shown in Fig. 1.

Fig. 1. Sample of meat paste No. 1

More detailed description of the methods used in the study of meat pastes is given in [25].

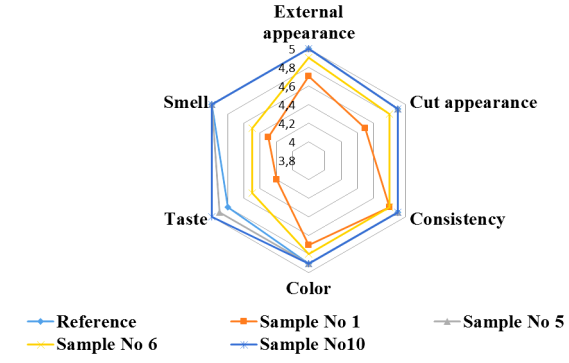

Fig. 2. Organoleptic evaluation of meat pastes baked using BKPO and PFE on their basis

Table 1

Organoleptic parameters of meat paste balanced by fatty acid and vitamin content n=8, p≤0.1

Main indices	Recipe samples										
	Reference	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Physical appearance	5.0	5.0	4.9	5.0	5.0	5.0	5.0	5.0	4.9	4.9	4.9
Cut appearance	4.8	4.9	4.8	4.9	4.9	4.9	4.9	4.7	5.0	4.7	4.8
Consiss tency	4.9	4.8	4.8	4.9	4.9	4.7	4.8	4.8	4.7	4.8	4.7
Color	4.9	5.0	4.9	4.9	5,0	5.0	5.0	5.0	5.0	4.9	4.9
Taste	5.0	5.0	4.9	5.0	4.9	4.9	5.0	4.9	4.9	4.9	4.9
Smell	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Overall assessment	4.93	4.95	4.88	4.95	4.95	4.92	4.95	4.90	4.92	4.87	4.88

5. Results of study of meat pastes

The complex of indices that determine quality of meat pastes includes organoleptic parameters. These include those product quality parameters which determine consumer properties, that is the properties directly affecting human's sense organs. The most significant of these parameters, taste and smell, are not measurable formally so they are subject to expert evaluation. The main advantage of organoleptic analysis, as a method for assessing the product quality is the ability to relatively quickly determine suitability of the product for consumption. Such indicators as color, taste, smell, consistency give a general idea of the product and indicate correct choice of main ingredients and their correlation.

In the course of organoleptic assessment and tasting samples, teachers and students of the Department of Technology of Meat and Meat Products of the National University of Food Technologies (Kyiv, Ukraine) determined external appearance, cut appearance, consistency, color, taste and smell of experimental meat pastes. Organoleptic evaluation was performed according to a five-point scale. The data of organoleptic evaluation of all samples are presented in Table 1, and samples with the most rationally selected formulations are shown in Fig. 2

Comparative assessment of physico-chemical and technological parameters of the meat pastes which are given in Table 2 proves positive effect of the proposed technological measures on forming consumer properties of finished products. Samples No. 1, No. 6 are optimal due to the use of PFE with high-performance proteins which cause an increase in water retention capacity WRC and are a prerequisite for an increase in the product yield by 6...8 %.

On the basis of experimental studies, analytical and graphic regression models were constructed using mathematical modeling (Fig. 3, 4). In the experiments for determining content of moisture in meat pastes, (WRC), plasticity, yield of the finished product in terms of complete factor experiment (CFE) 2^3, a linear model, variations of these parameters were studied depending on the amount of PFE added to the minced meat, quantity of vitaminized blended vegetable oil and the type of protein contained in composition of PFE.

$$Yield=116.5208-2.5051\cdot C1-0.4599\cdot C2-$$
$$-0.1428\cdot C3+0.0506\cdot C1\cdot C2+0.0163\cdot C1\cdot C3+$$
$$+0.0018\cdot C2\cdot C3-0,0002\cdot C1\cdot C2\cdot C3,$$

where C1 is protein-fat emulsion in the minced meat, %; C2 is quantity of vitaminized blended vegetable oil, %; C3 is type of protein, %.

Table 2

Physico-chemical and technological indices of meat pastes

Receipt samples	Weight fraction, %							
	Moisture	Protein	Fat	Ash	pH	WRC, % to total moisture	Plasticity	Yield
Reference acc. to DSTU 4432:2005	65.0±0.3	17.4±0.2	16.6±0.1	0.95±0.02	6.30±0.06	83.50±1.31	10.00±0.3	90.80
Receipt No. 1 with PFE	64.1±0.3	19.02±0.2	15.9±0.2	0.93±0.02	6.25±0.06	87.83±1.26	7.80±0.30	98.80
Receipt No. 5 with VBVO	63.8±0.3	19.17±0.1	16.1±0.1	0.93±0.02	6.33±0.06	80.28±1.20	13.20±0.3	96.40
Receipt No. 6 with PFE	64.0±0.3	19.1±0.1	15.9±0.1	0.94±0.02	6.30±0.05	87.73±1.35	8.40±0.30	99.40
Receipt No. 10 with VBVO	64.0±0.3	18.80±0.2	16.3±0.1	0.94±0.02	6.35±0.06	81.29±1.29	12.50±0.3	96.80

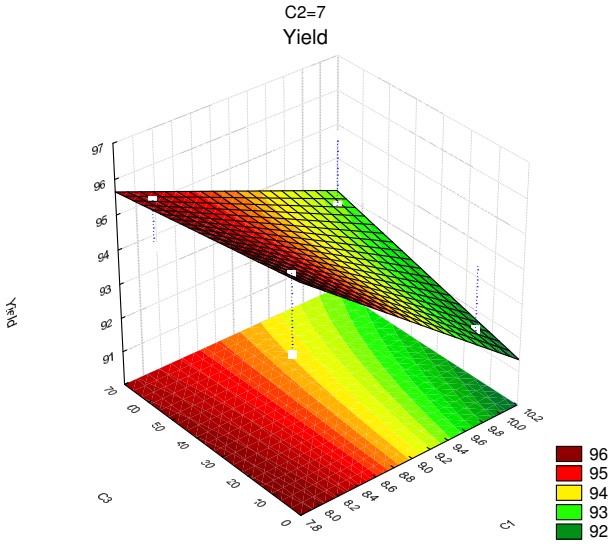

Fig. 3. Surface of response to variation of the amount of vitaminized blended vegetable oil added to the minced meat and the type of protein which was part of PFE at C2=7 %

Due to the fact that vegetable oils consist mainly of lightly oxidizing unsaturated fatty acids, the degree of their preservation in the finished pastes which were subjected to thermal treatment at up to 72 °C in the center of the product was checked. For this purpose, composition of fatty acids before and after thermal treatment of pastes prepared according to the developed formulations was checked. The obtained results are shown in Table 3.

Changes in the fatty acid composition after thermal treatment can also be shown due to differences in composition of fatty acids. Fig. 5 shows content of NFA, MUFA and PUFA in a test sample of paste before and after thermal treatment.

An important component of balanced products is fat-soluble vitamins that can exist in active and inactive forms (in the form of provitamins). Natural vitamins are unstable because they are destroyed by the action of oxygen, light and elevated temperatures. However, manufacturers of vitamin preparations declare high thermal stability of their products to a temperature of 150 °C inclusive. Since the technology of making meat pastes involves heating to a temperature up to 72 °C in the middle of the product, it is advisable to check the degree of preservation of the added vitamins after thermal treatment, as shown in Table 4.

Table 3

Content of unsaturated fatty acids in meat pastes before and after thermal treatment

Name of the introduced blended vegetable oils	Content of unsaturated fat oils, %						Ratio ω-6:ω-3, 5:1...10:1
	Before thermal treatment			After thermal treatment			
	Oleic C18:1	Linoleic C18:2	Linolenic C18:3	Oleic C 18:1	Linoleic C18:2	Linolenic C18:3	
Chicken meat pastes, recipe No. 1							
Sunflower (77.5 %)+ +false flax (13 %)+ +linseed (9.5 %)	24.11	55.60	8.91	24.16	55.31	8.56	6.20:1
Pumpkin (80 %)+ +linseed (20 %)	24.22	55.92	5.97	24.27	55.66	5.25	9.40:1
Turkey meat pastes, recipe No. 10							
Pumpkin (77 %)+ +false flax (13 %)+ +linseed (10 %)	21.03	52.45	10.32	21.36	52.15	10.02	5.08:1
Pumpkin (80 %)+ +linseed (20 %)	24.27	55.62	5.93	24.33	55.21	5.43	9.40:1

Table 4

Content of fat-soluble vitamins in meat pastes after thermal treatment

Name of vitaminized blendings of vegetable oils	Content in the additive, mg %		Content of tocopherols, mg %				Content of β-carotene, mg %
	E306	E160a	α	β	γ+δ	Σ	
Chicken meat pastes, recipe No. 1							
Sunflower (77.5 %) + false flax (13 %) + + linseed (9.5 %)	22.50	7.50	2.46	20.72	1.65	24.83	7.45
Pumpkin (80 %) + linseed (20 %)	22.50	7.50	–	20.60	0.10	20.70	7.52
Turkey meat pastes, recipe No. 6							
Pumpkin (77 %) + false flax (13 %) + + linseed (10 %)	22.50	7.50	0.06	20.36	0.81	21.23	7.51
Pumpkin (80 %) + linseed (20 %)	22.50	7.50	–	20.62	0.10	20.72	7.50

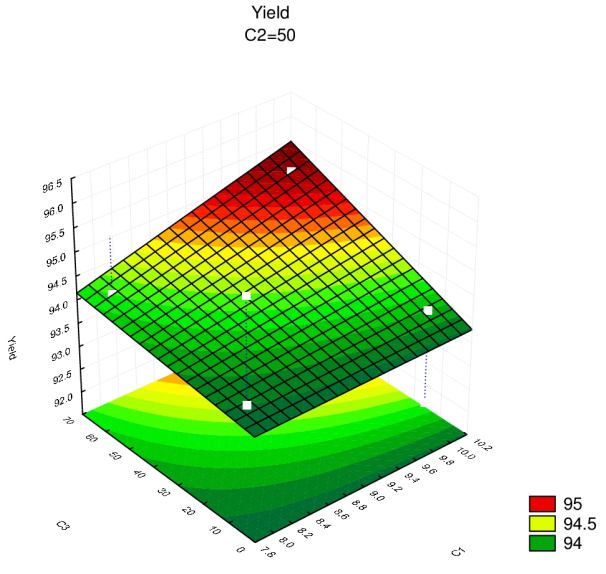

Fig. 4. Surface of response to variation of the amount of vitaminized blended vegetable oil added to the minced meat and the type of protein which was part of the PFE at C2=50 %

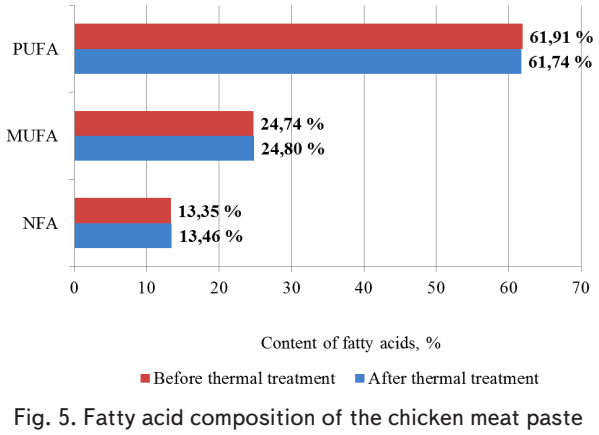

Fig. 5. Fatty acid composition of the chicken meat paste according to recipe No. 1 and three-component VBVO before and after thermal treatment

Contents of tocopherols (Fig. 6) and carotenoids (Fig. 7) were determined by the method of high-resolution liquid chromatography after extraction of fat from the finished meat pastes.

Analysis of biological value of the fatty portion in the developed pastes after thermal treatment has been compared with a hypothetical ideal fat. It was shown that all recipes were within the recommended limits concerning the fatty acid spectrum, content of fat-soluble vitamins, risk of atherogenic action and protection against lipid peroxidation,. The results are shown in Table. 5

Accelerated assessment of presence of regulated thermoduric microorganisms was carried out by molecular genetic methods: polymerase chain reaction (PCR). In particular, results of amplification of the 16S rRNA gene of *C. perfringens* were compared with PCR genomic DNA extracted from other bacteria ($5 \cdot 10^5$ cells) for confirmation of veracity and specificity of the method for detection of *C. perfringens* in the developed products (Fig. 8).

Model samples of meat pastes contaminated by *C. perfringens* and *B. cereus* strains were also studied. For detection of microorganisms of the *Bacillus cereus* group, PCR with group-specific primers to *groEL* gene was carried out. For identification of microorganisms of the species *Bacillus cereus,* PCR with species-specific primers to *nhe A* gene was performed. In this case, products of amplification with sizes of 400 and 553 bp were formed, respectively. The results of studies for two non-contaminated samples of pastes and four samples contaminated by pathogens of food poisoning are given in Table 6.

The amount of residual microflora correlates with the source amount: it is more the higher contamination of the minced meat paste by microorganisms before thermal treatment [26, 27]. More bacteria survive in meat pastes with high fat content because fat creates a protective zone around their cells.

After baking, the meat pastes were subjected to fast cooling to avoid reproduction of residual microflora in them [28]. When these products are in storage, a secondary infection of the surface and a gradual increase in the number of bacteria take place. The number of microflora grows faster the higher storage temperature and relative air humidity.

Therefore, microbiological safety during storage of products was investigated according to the indices given in Table 7 for all recipes developed. As an example, the results of microbiological tests of sample No. 1 are presented in Table 7.

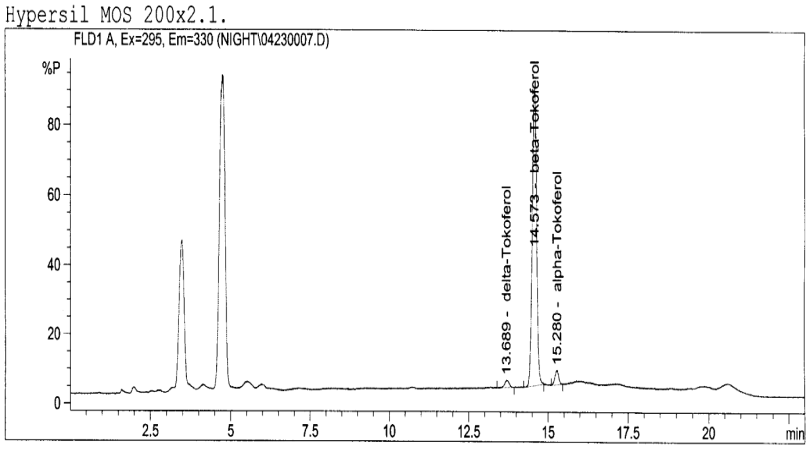

Fig. 6. Chromatogram of the content of tocopherols in the paste, recipe No. 1, after thermal treatment

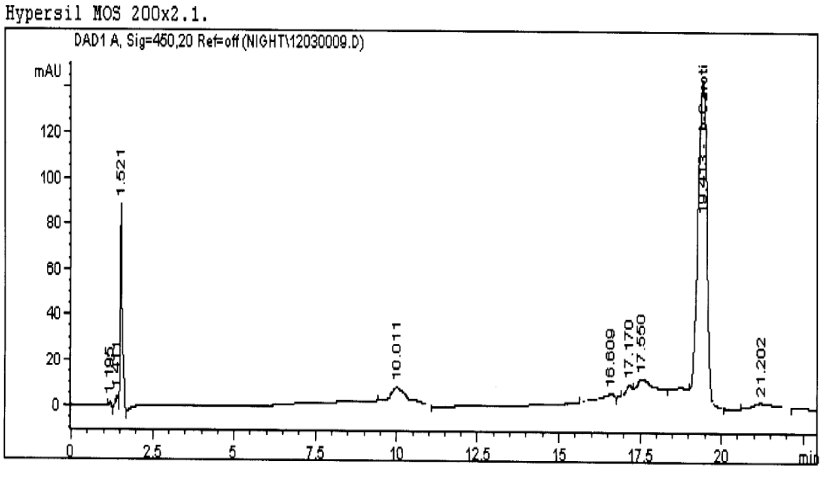

Fig. 7. Chromatogram of β-carotene content in the paste, recipe No. 1, after thermal treatment

Table 5

Indices of the biological value of the fatty component in the developed pastes after thermal treatment

Indices	Ideal fat	Name of blending added to pastes			
Food value, kcal/100 g		Chicken meat paste, recipe No. 1		Turkey meat paste, recipe No. 10	
		Sunflower (77.5 %)+ +false flax (13 %)+ +linseed (9.5 %)	Pumpkin (80 %)+ +linseed (20 %)	Pumpkin (77 %)+ +false flax (13 %)+ +linseed (10 %)	Pumpkin (80 %)+ +linseed (20 %)
Food value, kcal/100 g	900	893	889	891	889
Indices of assessment of fat-acid composition					
Ratio NFA:UFA:PUFA	1:1:1	1:1.8:4.6	1:1.9: 4,8	1:2.4:6,1	1:1.9:4.7
Ratio PUFA:NFA	>0.2	4.6	4.8	6.1	4.7
Ratio $C_{18:2}$:$C_{18:1}$	>0.25	2.29	2.29	2.44	2.27
Ratio $C_{18:2}$:$C_{18:3}$	>7.0	6.5	10.6	5.2	10.2
Indices of assessment of bioactive substance content					
Vitamin A, μg %	300	745	752	751	750
Vitamin E, mg %	10	23.83	20.70	21.23	20.72
Indices of assessment of atherogeneity					
Cholesterol content*, mg %	<300	4.9	4.9	4.9	4.9
Ratio holesterol:PUFA	>1:4	1:12,6	1:12.7	1:1:12.7	1:12.6
Indices of protection against peroxidation					
Ratio vitamin E:MFA+PFA	<1:10,000	1:3,490	1:4,202	1:4,223	1:4,192

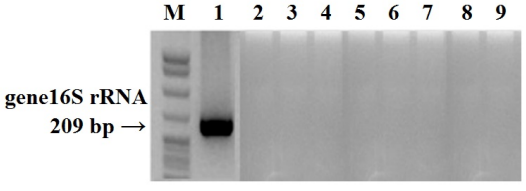

Fig. 8. Results of amplification of 16S rRNA gene of *C. perfringens* (209 bp) by PCR in comparison with PCR of genomic DNA extracted from other bacteria, rows: 1 — *C. perfringens*; 2 — *C. butyricum*; 3 — *C. sporogenes*; 4 — *Lactobacillus plantarum;* 5 — *Bacillus licheniformis*; 6 — *B. subtilis*; 7 — *Staphylococcus aureus*; 8 — *Bifidobacterium adolescentis*; 9 — *B. cereus*; M — *DNA markers*

Table 6

PCR for identification of *C. perfringens* and *B. cereus* pathogens of food poisoning in model experiments and samples of pastes

Investigated samples	Specific primers for which amplicones of certain size, bp, are formed		
	553	400	209
Meat paste No. 1 contaminated by *B. cereus* ATCC 11778	+	+	–
Meat paste No. 5 contaminated by *B. cereus* ATCC 10702	+	+	–
Meat paste No. 10 contaminated by *B. cereus* UCM B 5650	+	+	–
Meat paste No. 1 contaminated by *C.perfringens*	–	–	+
Meat paste No. 1	–	–	–
Meat paste No. 10	–	–	–

Note: "+" means creation of a specific PCR product; "–" – no PCR product; ATCC means American Type Culture Collection; UCM *means Ukrainian Collection of Microorganisms*

Table 7

Microbiological studies of a sample of meat paste No. 1

Name of indices determined according to DStU 4432:2005	Indice values			
	According to requirements of DSTU 4432:2005	Obtained values, days		
		1	3	5
MAFAnM	$1.0 \cdot 10^3$	$1.3 \cdot 10^2$	$2.8 \cdot 10^2$	$1.3 \cdot 10^3$
Coliforms (BGEC)	Impermissible	Not found		
Sulfitereducing clostridia in 0.1 g of product	Impermissible	Not found		
Staphylococcus aureus in 1 g of product	Impermissible	Not found		
L. monocytogenes in 25 g of product	Impermissible	Not found		
Salmonella in 25 g of product	Impermissible	Not found		

Medico-biological studies were performed with experimental animals, linear middle-aged rats (12 months). The animals were divided into 3 groups. The first group (5 rats) of intact animals was kept on a standard diet; second group (5 rats), experimental, was fed with meat paste with animal fat; third group (5 rats), experimental, received meat paste with balanced fatty acid and vitamin content. The content of cholesterol, protein and triglycerides in blood at the beginning of the study and after 21 days is presented in Table 8.

Table 8

Content of cholesterol, protein and triglycerides at the beginning of the study and after 21 days

Investigated groups	Duration	Cholesterol, mmole/l		Protein, g/l		Triglycerides, mmole/l	
		Content	Norm	Content	Norm	Content	Norm
1st group (5)	At the beginning	5.6	3.1...5.2	58	65...85	0.40	0.5...1.8
	After 21 days	5,6	-//-	58	-//-	0.40	-//-
2nd group (5)	At the beginning	5.6	-//-	56	-//-	0.39	-//-
	After 21 days	5.1	-//-	60	-//-	0.50	-//-
3rd group (5)	At the beginning	5.4	-//-	54	-//-	0.40	-//-
	After 21 days	3.6	-//-	78	-//-	0.80	-//-

6. Discussion of the results obtained in the study of meat pastes

Eight recipes of poultry pastes were worked out using developed PFEs as a part of recipes in an amount of 15...20 %, and two recipes with vitaminized blended vegetable oils of two-component and three-component formulations in an amount of 10 %. Samples of pastes prepared according to DSTU 4432:2005 containing 10 % of stab bacon were used as reference samples.

Chicken and turkey meat (pre-blanched), chicken liver (pre-blanched) and hen's eggs were used as the main raw material in the paste recipes. The proposed raw material imparts diet quality to the product, balances it by the amino acid composition. Also, the recipes of experimental samples included such ingredients as passaged carrots and onions, farina, wheat bread (pre-hydrated). Introduction of the developed vitaminized blended vegetable oils and PFE on their basis makes it possible to balance the product as for fatty acid and vitamin content. Table 9 presented the paste recipes.

The flow diagram of production of meat paste of a balanced composition is shown in Fig. 9.

As a result of the organoleptic evaluation of baked meat pastes, it was found that organoleptic indices were even higher than in the reference sample.

For example, the reference sample had a dense and grained consistency and the pastes with PFE had a homogeneous, pleasant elastic mashed structure. Use of vitaminized blended vegetable oil has ensured a soft and pasty consistency.

It can be concluded that addition of 15...20 % PFE or 10 % of vitaminized blended vegetable oils to the meat pastes positively affects organoleptic characteristics of the finished product.

Structural and mechanical indices were defined. They show that adding of PFE with vitaminized blended vegetable oils to the paste mass leads to a slight decrease in the relative force of penetration. The highest values of

extreme strain of shear (ESS) and dynamic viscosity were observed in samples No. 1 and No. 6 which can be explaned by substitution of unsaturated vegetable oils for saturated triglycerides in stab bacon in this system.

Table 9

Meat paste recipes using VBVOs and PFE on their basis

Raw material	Reference acc. to DStU 4432:2005	Recipe variant number									
		1	2	3	4	5	6	7	8	9	10
Quantity of basic raw materials, % per 100 kg											
Chicken meat, blanched	35	36	38	40	41	35	–	–	–	–	–
Turkey meat, blanched	–	–	–	–	–	–	36	38	40	41	35
Chicken liver, blanched	13										
Stab bacon	10	–	–	–	–	–	–	–	–	–	–
VBVO	–	–	–	–	–	10	–	–	–	–	10
PFE No. 1 or No. 2	–	20	18	16	15	–	20	18	16	15	–
Bread	10	3	3	3	3	5	3	3	3	3	5
Hen's eggs	4										
Carrots	5										
Onions	5										
Farina	4	–	–	–	–	4	–	–	–	–	4
Water for hydration	14										
Quantity of auxiliary raw materials, kg per 100 kg of the main raw material											
Salt	1.4										
Pepper	0.1	0.05									
Garlic	0.1										
Blend of spices	–	0.1									

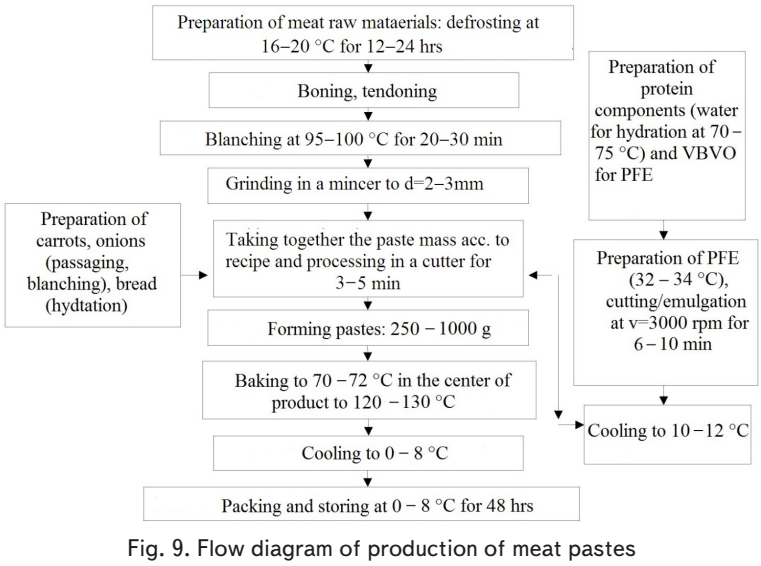

Fig. 9. Flow diagram of production of meat pastes

It was shown that changes in the acid and peroxide numbers in the experimental samples of the pastes proceeded more slowly than in the reference sample. This was due to the fact that PFE and vitaminized blended vegetable oils contain more unsaturated fat acids than the stab bacon. Moreover, they are additionally enriched with vitamins that exhibit action of antioxidants. For example, in conditions of accelerated kinetic oxidation, the acide number (AN) of the control sample ncreased in 2.2 times while the experimental samples had only a 1.2...1.3 times increase. The corresponding figures for peroxide number (PN) were 1.9 and 1.3...1.4 times, respectively.

The characteristic of the amino acid composition have shown that the developed paste samples contained all essential amino acids. The use of PFE in recipes brings the amino acid composition to an optimal one by the use of animal proteins.

Significant preservation of the fatty acid composition of the meat pastes after their thermal treatment has been established. It is known that for a perfect fat, ratio ω-6:ω-3 is 5:1 and 10:1 and therefore it can be asserted that the predicted ratio in the paste after thermal treatment corresponds to the ideal fat.

The data of the group composition of fatty acids were well correlated with the values of the content of individual fatty acids that allows one to assert again that preservation of the vitamin complex in the worked out meat pastes at a level of 95 % in the course of their production takes place.

Analysis of fatty acid composition and content of fat-soluble vitamins in the developed meat pastes makes it possible to establish the index of object protection against lipid peroxidation (LPO). This is the ratio between the amount of vitamin E and the sum of unsaturated fatty acids at a level not exceeding 1:10,000. This connection is explained by predominant oxidation of unsaturated acids which may be prevented due to the presence of a sufficient amount of vitamin E.

Based on the obtained results, it can be concluded that the developed pastes are characterized by high content of biologically active substances, they have a low level of atherogeneity and a high degree of protection against peroxidation.

The basis for creation of high-quality food products consists in the choice and substantiation of the spectrum of raw materials in proportions that provide nutritional and functional properties and possess a maximum balance of nutrients by chemical composition.

Microbiological evaluation of contamination of the initial ingredients showed their compliance with the regulated requirements. During baking of meat pastes (until the temperature reaches 72±2 °C), content of microorganisms is reduced by 90 ... 99 %. Usually, sporose sticks are preserved among which there may be some toxin-producing species.

The accelerated molecular-genetic study of presence of food poisoning agents in the developed types of meat pastes by PCR method showed their safety. In particular, the developed method [29] has found that the samples of the developed paste products were free from *C. perfringens* which forms a product of amplification containing 209 nucleotide pairs or base pairs.

As the results of amplification of the genes of different bacteria show (Fig. 8), the amplification product containing 209 nucleotide pairs was found only for *C. perfringens* and no other types of microorganisms were detected. This confirms the specificity of the developed method of identifying *C. perfringens* and the ability to accelerate determination of these contaminants in products.

The results of microbiological studies of meat pastes showed that MAFAnM for the third day was $2.8 \cdot 10^2$ CFU/g at an acceptable norm of $1.0 \cdot 10^3$ CFU/g. Previous studies of AN and PN found that they are within the acceptable range for

the third day of storage which confirms safety of the product and makes it possible to double the shelf time, up to 48 hours compared to 24 hours specified by DSTU 4432:2005.

Medico-biological studies in a group of experimental animals showed that when animals were fed with meat paste balanced in terms of fatty acid and vitamin content, there were marked changes in their blood biochemistry regarding content of cholesterol, proteins and triglycerides which stimulates immune functions of the animal organism. The results of biomedical studies obtained *in vivo* have made it possible to affirm that the develop d meat paste balanced in terms of fatty acid and vitamin content has an improved digestibility.

7. Conclusions

1. Based on the analytical and experimental studies, a new sanitary-safe meat paste product possessing a balanced fatty acid and vitamin composition has been developed thru the use of vitaminized blends of vegetable oils and PFE on their basis for general and special nutrition.

2. Choice of vegetable oils has been substantiated and it has been established that the use of 10 % VBVO or 20 % PFE on their basis for meat pastes positively affects the complex of their organoleptic, physico-chemical, biochemical, functional-technological, structural-mechanical, sanitary-hygienic and medico-biological indices.

3. Based on the results of 95 % preservation of fatty acid and vitamin complex and the intensity of their oxidation transformations, optimal recipes and composition of vitaminized blends of vegetable oils were established, namely: 1 % tocopherol in an amount of 2.5 g and 0,2 % β-carotene in an amount of 3.750 g which provides 30 % of daily requirement for above vitamins. The expediency of combined use of tocopherol and β-carotene has been confirmed which makes it possible to stabilize oxidation and increase the induction period in 1.5...2 times.

4. The use of modern molecular genetic studies allows one to carry out accelerated and precise control of new products for the presence of thermoduric food poisoning agents which is especially important for paste products with regulated terms and conditions of their sale. Based on the conducted physico-chemical and microbiological studies of the meat pastes, it was established that due to addition of VBVO, the guaranteed period of their storage is increased by 2 times (up to 48 hours).

5. Medical-biological studies of the meat pastes with balanced fatty acid and vitamin composition established their influence on the animal organism. It has been found that addition of this product to the diet of rats has brought about normalization of lipid and protein metabolism: the content of cholesterol decreased by 1.8 mmol/l (34.6 % to the baseline) and the amount of protein and triglycerides increased by 24 g/l and 0.4 mmol/l (28.2 % and 22.2 % respective to the baseline).

References

1. Peshuk, L. V. Perspektyva rozrobky spetsial'nykh produktiv kharchuvannya na m'yasniy osnovi [Text] / L. V. Peshuk, O. P. Karpenko // Myasnoy biznes. – 2005. – Issue 2. – P. 14–15.
2. Pro yakist' ta bezpeku kharchovykh produktiv ta prodovol'choyi syrovyny [Text]. – Verkhovna Rada Ukrayiny, 2005. – No. 2809-IV.
3. Jimenez-Colmenero, F. Healthier lipid formulation approaches in meat-based functional foods. Technological options for replacement of meat fats by non-meat fats [Text] / F. Jimenez-Colmenero // Trends in Food Science & Technology. – 2007. – Vol. 18, Issue 1. – P. 567–578. doi: 10.1016/j.tifs.2007.05.006
4. Astley, S. B. The European Nutrigenomics Organisation: linking genomics, nutrition and health research [Text] / S. B. Astley, R. M. Elliott // Journal of the Science of Food and Agriculture. – 2007. – Vol. 87, Issue 7. – P. 1180–1184. doi: 10.1002/jsfa.2791
5. Bretillon, L. Lipid nutrition and eye health [Text] / L. Bretillon, N. Acar, O. Berdeaux, A. Bron, C. Creuzot-Garcher // Lipid Technology. – 2010. – Vol. 22, Issue 6. – P. 130–133. doi: 10.1002/lite.201000028
6. Ruiz-Samblas, C. Quantification of blending of olive oils and edible vegetable oils by triacylglycerol fingerprint gas chromatography and chemometric tools [Text] / C. Ruiz-Samblas, F. Marini, L. Cuadros-Rodriguez, A. Gonzalez-Casado // Journal of Chromatography B. – 2012. – Vol. 910. – P. 71–77. doi: 10.1016/j.jchromb.2012.01.026
7. Simakhina, H. O. Kontseptsiya ozdorovchoho kharchuvannya ta shlyakhy yiyi realizatsiyi [Text] / H. O. Simakhina // Naukovi pratsi NUKhT. – 2010. – Issue 33. – P. 10–13.
8. Mohamed, K. M. Improving Thermal Stability of High Linoleic Corn Oil by Blending with Black Cumin and Coriander Oils [Text] / K. M. Mohamed, R. M. Elsanhoty, M. F. R. Hassanien // International Journal of Food Properties. – 2013. – Vol. 17, Issue 3. – P. 500–510. doi: 10.1080/10942912.2012.654560
9. Topchiy, O. A. Principles of blending fatty acid balanced vegetable oils [Text] / O. A. Topchiy, Ye. O. Kotlyar // Eastern-European Journal of Enterprise Technologies. – 2015. – Vol. 1, Issue 6 (73). – P. 26–32. doi: 10.15587/1729-4061.2015.35997
10. Kotlyar, Y. Development of formulation multicomponent protein-fat emulsion [Text] / Y. Kotlyar, T. Goncharenko, O. Topchiy // Food science and technology. – 2016. – Vol. 10, Issue 4. doi: 10.15673/fst.v10i4.250
11. Sebranek, J. G. Comparison of a natural rosemary extract and BHA/BHT for relative antioxidant effectiveness in pork sausage [Text] / J. G. Sebranek, V. J. H. Sewalt, K. L. Robbins, T. A. Houser // Meat Science. – 2005. – Vol. 69, Issue 2. – P. 289–296. doi: 10.1016/j.meatsci.2004.07.010
12. Functional food product development [Text] / J. Smith, E. Charter (Eds.). – Wiley-Blackwell: Oxford, 2010. – 528 p. doi: 10.1002/9781444323351
13. Borchers, A. Food Safety [Text] / A. Borchers, S. S. Teuber, C. L. Keen, M. E. Gershwin // Clinical Reviews in Allergy & Immunology. – 2009. – Vol. 39, Issue 2. – P. 95–141. doi: 10.1007/s12016-009-8176-4

14. Rounds, L. Plant Extracts, Spices, and Essential Oils Inactivate Escherichia coli O157:H7 and Reduce Formation of Potentially Carcinogenic Heterocyclic Amines in Cooked Beef Patties [Text] / L. Rounds, C. M. Havens, Y. Feinstein, M. Friedman, S. Ravishankar // Journal of Agricultural and Food Chemistry. – 2012. – Vol. 60, Issue 14. – P. 3792–3799. doi: 10.1021/jf204062p
15. Caballero, B. Encyclopedia of human nutrition [Text] / B. Caballero. – 2th ed. – Academic Press, 2005. – 2168 p.
16. Fogliano, V. Functional foods: Planning and development [Text] / V. Fogliano, P. Vitaglione // Molecular Nutrition & Food Research. – 2005. – Vol. 49, Issue 3. – P. 256–262. doi: 10.1002/mnfr.200400067
17. Kaprel'yanc, L. V. Funkcional'nye produkty: tendencii i perspektivy [Text] / L. V. Kaprel'yanc, G. A. Homich // Food science and technology. – 2012. – Issue 4. – P. 5–8.
18. Mohamed, K. M. Improving Thermal Stability of High Linoleic Corn Oil by Blending with Black Cumin and Coriander Oils [Text] / K. M. Mohamed, R. M. Elsanhoty, M. F. R. Hassanien // International Journal of Food Properties. – 2013. – Vol. 17, Issue 3. – P. 500–510. doi: 10.1080/10942912.2012.654560
19. Pat. No. 85607 UA. Pashtet m'yasnyy zapechenyy «Osoblyvyi». MPK A23L 1/100 (2013.01) [Text] / Topchiy O. A., Kotlyar Ye. O., Tymchenko D. O.; vlasnyk Nats. univ. kharch. tekhnolohiy. – No. u2013 06739; declareted: 29.05.2013; published: 25.11.2013, Bul. No. 22. – 4 p.
20. Dzhey, Dzh. M. Sovremennaya pishchevaya mikrobiologiya [Text] / Dzh. M. Dzhey, M. Dzh. Lyossner, D. A. Gol'den. – Moscow: BINOM. Laboratoriya znaniy, 2011. – 886 p.
21. Pilipenko, I. V. Clostridium perfringens: characterization, biological activity, the indication in food [Text] / I. V. Pilipenko // Technology audit and production reserves. – 2015. – Vol. 2, Issue 4 (22). – P. 4–8. doi: 10.15587/2312-8372.2015.39107
22. Bottone, E. J. Bacillus cereus, a Volatile Human Pathogen [Text] / E. J. Bottone // Clinical Microbiology Reviews. – 2010. – Vol. 23, Issue 2. – P. 382–398. doi: 10.1128/cmr.00073-09
23. Dohmae, S. Bacillus cereus nosocomial infection from reused towels in Japan [Text] / S. Dohmae, T. Okubo, W. Higuchi, T. Takano, H. Isobe, T. Baranovich et. al. // Journal of Hospital Infection. – 2008. – Vol. 69, Issue 4. – P. 361–367. doi: 10.1016/j.jhin.2008.04.014
24. Dierick, K. Fatal Family Outbreak of Bacillus cereus-Associated Food Poisoning [Text] / K. Dierick, E. Van Coillie, I. Swiecicka, G. Meyfroidt, H. Devlieger, A. Meulemans et. al. // Journal of Clinical Microbiology. – 2005. – Vol. 43, Issue 8. – P. 4277–4279. doi: 10.1128/jcm.43.8.4277-4279.2005
25. Kotliar, Y. Complex of chemical-technological and sanitary-hygienic quality indicators of the new pastry products of special nutrition [Text] / Y. Kotliar, O. Topchiy, L. Pylypenko, I. Pylypenko, E. Sevastianova // EUREKA: Life Sciences. – 2017. – Issue 3. – 35–42. doi: 10.21303/2504-5695.2017.00363
26. Pylypenko, I. Epiphytic and regulated microbial contaminants of food vegetable raw materials and products [Text] / I. Pylypenko, L. Pylypenko, E. Sevastyanova, E. Kotlyar, R. Kruchek // Ukrainian Food Journal. – 2016. – Vol. 5, Issue 2. – P. 272–280. doi: 10.24263/2304-974x-2016-5-2-6
27. Melngaile, A. Microbiological risk analysis in public catering establishments [Text]: Summary of Doctoral Thesis / A. Melngaile. – Jelgava, 2008. – 64 p.
28. Yamborko, H. V. Chemotaxonomic features and plasmid profiles of aerobic and facultative anaerobic spore-forming bacteria from vegetables [Text] / H. V. Yamborko, A. M. Ostapchuk, Zh. Yu. Serhyeyeva, L. M. Pylypenko, I. V. Pylypenko // Microbiology&Biotechnology. – 2017. – Issue 1 (37). – P. 56–72. doi: 10.18524/2307-4663.2017.1(37).96576
29. Pat. No. 111266 UA. Sposib vyznachennya Clostridium perfringens kharchovykh produktakh. S2 MPK (2016.01) [Text] / Sava V. M., Pylypenko L. M., Pylypenko I. V. – No. a201409534; declareted: 29.08.2014; published: 11.04.2016, Bul. No. 7.