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INVESTIGATION OF THERMAL AND TECHNOLOGICAL CHARACTERISTICS OF NEW MEAT PASTES PRODUCTION

Об'єктом дослідження є термічні і технологічні характеристики виробництва м'ясних пащтетів, а саме пащтетів з курячого м'яса та печінки, як смачного, поживного (засвоюється на 94–96 %) і в той же час низькокалорійного продукту. Одним з найбільш проблемних місць є якісне управління процесом проектування функціональних харчових продуктів з урахуванням їхнього цільового призначення. Створення м'ясопродуктів на основі поєднання м'ясної та рослинної сировини є одним з ефективних шляхів вирішення проблеми збалансованого харчування, регулювання властивостей та оптимізації біологічної цінності готового продукту.

В роботі представлено дослідження розроблених рецептур пащтетів для нутрієнтно-адекватного оздоровчо-профілактичного харчування підвищеної біологічної цінності. Ці дослідження дають можливість розширити асортимент м'ясних продуктів, збагатити добовий раціон корисними нутрієнтами і харчовими волокнами, які сприяють збереженню здоров'я, працездатності і активного творчого довголіття людини.

В ході дослідження використовувалися методики органолептичних, фізико-хімічних, функціонально-технологічних та структурно-механічних досліджень. Для визначення оптимальної кількості запропонованих інгредієнтів проведено дослідження їх впливу на органолептичні і функціонально-технологічні показники модельних комбінованих систем.

Компоненти нових пащтетів і готова продукція проходили різну термічну (теплову або холодильну) обробку. Окремі компоненти фаршу попередньо охолоджували або заморожували, інші варили або бланшували, готовий фарш стерилізували в жерстяній тарі, обжарювали в металевих формах або варили в пароповітряній суміші чи гарячій воді. Готовий продукт охолоджували. В роботі надаються результати дослідження зміни теплового навантаження під час термічної обробки шматкових м'ясопродуктів. Ці дані одержані прямим вимірюванням густини теплового потоку за допомогою малогабаритних малоінерційних тепломірів, які не заважають протіканню технологічного процесу.

Результати органолептичної оцінки модельних виробів показали їх приємний смак і аромат, однорідну, ніжну, мазеподібну консистенцію. Це дозволило рекомендувати для масового виробництва три розроблені рецептури пащтетів «Грибний», «Пікантний» та «Особливий».

Ключові слова: оздоровчо-профілактичне харчування, м'ясні пащтети, харчова і біологічна цінність, фізико-хімічні показники.

1. Introduction

The beginning of the XXI century is characterized by a dynamic growth in the production of healthy food products, the global market for these products increases by 10–15 % annually. More than a quarter of food products produced in the EU fall into this category, in Ukraine this share is much smaller. Alarming is the tendency to reduce the level of protein intake, which is no longer consistent with the rational norm (0.8–1.0 g per 1 kg of human weight per day).

One of the main tasks of the meat industry in reducing the number of cattle and pigs, the constant shortage of raw materials is the production of high-grade food and biological value of products. Replacing animal meat, meat and offal of poultry, as well as components of plant origin is one of the fastest and most effective ways to solve protein deficiency. The use of soy as a source of protein substitute showed that the products from it do not belong to the health and preventive.

Chicken meat is a delicious, nutritious (digested by 94–96 %) and at the same time low-calorie product. It is

a source of high quality, easily digestible proteins (19–22 %), amino acids, vitamins, minerals, which are indispensable material for the formation and functioning of the body. Adipose tissue (on average, 5.2 %) has a large amount of polyunsaturated fatty acids, which are not synthesized in sufficient quantities in the body, but play a large role in maintaining its functions.

The presence in the raw meat of chicken of biologically active substances of a broad spectrum of action, such as bioactive peptides, zinc, iron, selenium, vitamins, fatty acids, dietary fiber, determines its functional properties:

- improvement of the general condition of the body;
- stimulating the activity of enzymes of the detoxification system and antioxidant protection;
- increase of immune potential and resistance.

Chicken liver contains a lot of nitrogenous extractives, as well as vitamins and minerals, especially a large amount of chitin, biotin, vitamins A (50 mg %), C (25–40 mg %), niacin, and all B vitamins. It is widely used in clinical nutrition for anemia, radiation sickness, general weakening and low hematopoietic ability of the body.

Therefore, it is relevant to study the technology of combined meat paste for healthy nutrition using raw materials of plant and animal origin. This combination reduces the caloric content, and at the same time, the content of cholesterol and unsaturated fatty acids. At the same time, products are enriched with natural biologically active substances, vegetable proteins, carbohydrates, vitamins, minerals, ballast substances and other compounds necessary for the normal functioning of the human body.

2. The object of research and its technological audit

The object of research is the thermal and technological characteristics of the production of meat pastes, namely pastes made from chicken meat and liver, as a tasty, nutritious (absorbed 94–96 %) and at the same time low-calorie product.

Subject of research: multicomponent model systems containing meat and poultry by-products, vegetable raw materials: oyster mushrooms and champignons, hydrated 1:3 wheat fiber.

One of the best solutions to the problem of improving nutrition is the production of pastes. According to the provisions of DSTU 4432:2005, meat paste is a pasty consistency product made from minced meat made from boiled and/or raw meat raw material with fat added, baked in metal form or subjected to heat treatment and packaging.

The technology of paste production involves the use of various types of raw materials of animal and vegetable origin in their properties, which determines the variety of used processing methods. Combining cooking, blanching, browning, roasting, homogenizing and other types of thermal and mechanical effects, let's obtain a gentle homogeneous product of pasty consistency, which has a pleasant taste, smell and color.

One of the most problematic places is the quality management of the process of designing functional food products, taking into account their intended purpose.

3. The aim and objectives of research

The aim of research is development of a scientifically based technology of a combined meat paste for healthy nutrition using raw materials of plant and animal origin, and has functional properties.

To achieve this aim it is necessary to perform the following objectives:

1. To justify the optimal amount of replacement of raw meat per plant.
2. To investigate the nutritional and biological value, organoleptic and technological indicators of the quality of the developed combined products and compare the results obtained with generally accepted quality requirements.

4. Research of existing solutions of the problem

Analysis of the meat market in the world [1, 2], and in particular in Ukraine, shows that there is a rapid development of the poultry industry (Fig. 1) and, as a result, an increase in the production capacity of meat and

poultry meat products. Ukraine is among the ten largest exporters of chicken meat and eggs [3, 4].

Analysis of the meat market in the world suggests that there is a rapid development of the poultry industry [1]. Ukraine also has a significant growth in the poultry industry (Fig. 1) and, as a result, an increase in the production capacity of meat and poultry meat products [2]. Today, Ukraine is in the top 10 global suppliers of chicken and TOP-3 – in the EU with a figure of 313.4 million USD [3]. The increase in global consumption of chicken meat is associated with the dietary properties of chicken and its products [4]. In connection with the growth of production and export of chicken from Ukraine, the availability of producers of accompanying poultry products, in particular stomachs, hearts, liver, etc., is growing, the demand for which is less than for carcasses and thighs. This stimulates the need to strengthen the processing base and to develop and introduce into production new canned meat from chicken.

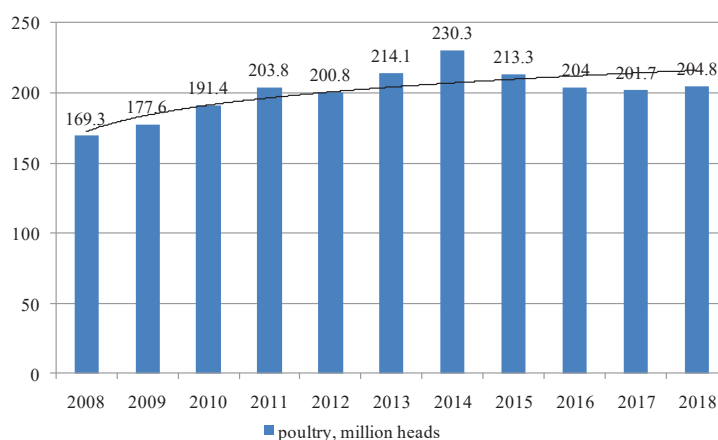


Fig. 1. The number of poultry in Ukraine [2]

Among the packaged meat products the paste occupies the leading place, they are in demand because of the delicate taste and pasty consistency. Protein content in paste is 10 %, fat 10–45 %. For nutritional value, the pastes are not inferior to the highest grade of sausages [5, 6].

In order to transform chicken meat and liver paste into a nutrient-adequate health-preventive food product, it is necessary to add the corresponding biologically active substances to the recipe. The source of such substances is edible mushrooms and products from them [7]. As a result of scientific research and on the basis of complex experimental studies, the possibility of using cultivated mushrooms in recipes of boiled meat products was proved [8].

The advantage of mushrooms is the unique balancing of all biologically valuable food components – proteins, fats, carbohydrates, vitamins, microelements. Arginine and lysine contained in fungi have a positive effect on the development of memory and activate mental activity of a person. Biologically active substances of mushrooms normalize appetite, increase immunity, reduce low-density cholesterol, reduce the risk of heart attack, and prevent the occurrence of atherosclerosis.

In Ukraine, about 100 large companies and 1000 small farms produce mushrooms. Two thirds of mushroom products are champignons, about one third are oyster mushrooms. Acquires accelerated shiitake mushroom production.

Another biologically active additive to the recipes of pastes, which increases their health and preventive function, is germinated cereals [9]. During germination, the content of proteins and minerals increases, while fats and complex carbohydrates decrease. In terms of the number of essential acids, the proteins of germinated grain approach those of animal origin.

In the conditions of modern energy shortage to the technologies of new combined meat products, it is necessary to establish energy saving requirements. Components of new pastes and finished products must undergo various thermal (thermal or refrigeration) processing. The individual components of mincemeat are pre-cooled or frozen, others are boiled or blanched, the finished mince is sterilized in a tin container, fried in metal molds or boiled in an air-steam mixture or hot water. The finished product is cooled. In technological instructions, not enough attention is paid to the intensity of thermal processes and their connection with changes in technological indicators. Set the final temperature of the product and the duration of treatment, which is often calculated using an inaccurate model of heat transfer. So, during sterilization in cans, which height is greater than the diameter, heat transfer is calculated as for a flat wall. To optimize technological processes in terms of energy saving, information on the dynamics of heat transfer is necessary [10].

5. Methods of research

The research results of changes in heat load during the heat treatment of lumpy meat products are provided. These data are obtained by direct measurement of the heat flux density using small-sized low-inertia heat meters, which do not interfere with the process flow.

In the development of new pastes and finished products, methods of organoleptic, physico-chemical, functional-technological and structural-mechanical research are used.

Formulations of pastes are developed, in accordance with the requirements of TU U 15.1-30183690.014-2003 «Cooked sausage products and pastes for baby food with food additives made by Wiberg (Austria)». To determine the optimal amount of the proposed ingredients, a study is conducted of their influence on the organoleptic and functional-technological characteristics of model combined systems.

6. Research results

Models of pastes of various processing and packaging and their components during cooling are pieces of beef with a size of 10×10×8 cm³, beef tongues and the fate of beef

brain. Heat meters-disks with a diameter of 12–15 mm and a thickness of 1.2–1.5 mm are applied and fixed in the central part of the sample surface. The EMF signals of heat meters, which are proportional to the surface density of the heat flux q , W/m², are recorded with an electronic device. Cooling chamber is a closed evaporator of a small refrigeration unit with free air convection with a temperature of 6 °C.

120 minutes of cooling (Fig. 2), the heat flux from the beef sample decreased from 350 to 200 W/m² (sample 1), the tongue – from 330 to 70 W/m² (sample 2), the brain lobe – from 330 to 50 W/m². This irregularity of the heat load on the refrigeration unit must be taken into account in technological and instrumental calculations.

From the experimental data, approximating equations are obtained (Table 1).

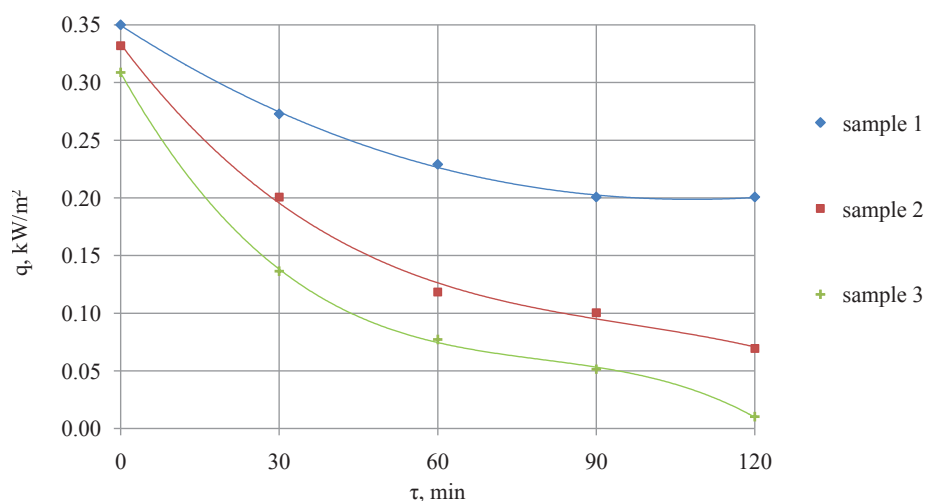


Fig. 2. Heat flow during cooling samples of models of pastes

Table 1

Sample approximation results		
No. of the sample	Equations	Approximation accuracy value, R ²
1	$q = -2 \cdot 10^{-9} \tau^3 + 2 \cdot 10^{-5} \tau^2 - 0.003 \tau + 0.3496$	0.9991
2	$q = -2 \cdot 10^{-7} \tau^3 + 6 \cdot 10^{-5} \tau^2 - 0.0061 \tau + 0.3333$	0.9973
3	$q = -4 \cdot 10^{-7} \tau^3 + 9 \cdot 10^{-5} \tau^2 - 0.0082 \tau + 0.3084$	0.9997

Fig. 3 shows the dynamics of heat load in semi-logarithmic coordinates. Experimental data on cooking in water are well approximated. This indicates that there is a so-called regular thermal regime. For it, the thermal calculations of technological processes are greatly simplified.

The dynamics of heat load during cooking meat products are studied with samples in stainless steel oval-shaped vessels. The thickness of the samples is 80 mm (sample 1) or 44 mm (sample 2), the weight of the samples is 400 and 200 g, respectively. The filled vessel is sealed.

Samples are cooked in a heat chamber steam-air mixture with a temperature of 80–82 °C.

From the experimental data, approximating equations are obtained (Table 2).

During cooking with an air-steam mixture, the heat load changes irregularly through unsatisfactory mixing of steam and air: the heat transfer from the steam condenses on the vessel much more than from hot air.

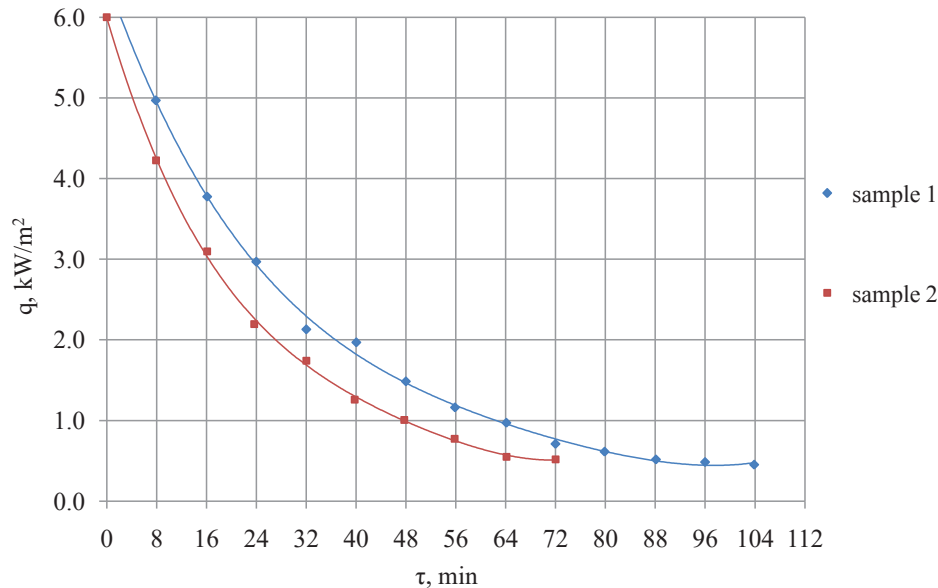


Fig. 3. Dynamics of heat load of samples of models of pastes

Table 2

Sample approximation results of heat load dynamics

No. of the sample	Equations	Approximation accuracy value, R^2
1	$q = 1.10 \cdot 10^{-7} \tau^4 - 3.10 \cdot 10^{-5} \tau^3 + 0.0037 \tau^2 - 0.2184 \tau + 0.6427$	0.9976
2	$q = 4.10 \cdot 10^{-7} \tau^4 - 7.10 \cdot 10^{-5} \tau^3 + 0.006 \tau^2 - 0.2627 \tau + 5.9932$	0.9994

The sequence of technological operations in the production of pastes includes the preparation of raw meat and meat stuffing. The main and auxiliary raw materials are cutters during 8–12 minutes, are filled with ready-made paste mass into shells and loaves are tied. Heat treatment included cooking at $t=85\text{--}90\text{ }^\circ\text{C}$ and $\tau=120\text{--}180\text{ min}$, up to t in the center of the loaf $71 \pm 1\text{ }^\circ\text{C}$. The loaves are cooled at $t=8\text{--}10\text{ }^\circ\text{C}$, $\tau=10\text{--}30\text{ min}$.

One of the components in the recipe of pastes is mushrooms. The chemical composition of cultivated mushrooms in various regions of Ukraine turned out to be almost the same, since they are grown on compost of the same composition. The trace element composition in oyster mushrooms and champignons is significantly different (Table 3).

For oyster mushrooms grown on different substrates, the protective properties of toxic Pb (II), Cd (II), and Hg (II) ions are determined (Table 4).

Table 3

The micronutrient composition of cultivated mushrooms

Mushrooms	The content of the element, mg/1 kg of product					
	K ⁺	Na ⁺	Ca ²⁺	Cu ²⁺	Fe ³⁺	P(V)
Champignon	100	60	21.2	1.18	15.7	3.7
Oyster	92.2	118.2	27	1.34	30.6	4.7

Table 4

Protector property of oyster mushrooms

Grown oyster mushroom biomass powder	Sorption of metal ions, mg/1 g sample		
	Pb (II)	Cd (II)	Hg (II)
1. In straw	39.4	76.5	65.5
2. In rapeseed meal	39.6	66.0	20.5
3. In amaranth meal	32.9	71.0	20.5
4. In wheat germ meal	40.0	66.5	35.5

In the development of model paste systems, the control sample was minced chicken meat, chicken liver, blood of slaughter animals, linseed oil, powdered milk, hydrated 1:3 wheat fiber, broth from the liver, onions, salt and pepper. The results of the organoleptic evaluation of model products showed their pleasant taste and aroma, uniform, delicate, ointment-like consistency. This makes it possible to recommend for mass production three recipes of «Mushroom», «Spicy» and «Special» pastes (Table 5).

Table 5

Recipes of developed pastes

Component	Content, %			
	Control	Mushroom	Spicy	Special
Minced chicken	38.0	28.0	28.0	35.0
Boiled chicken liver	25.0	25.0	25.0	25.0
Linseed oil	5.0	5.0	5.0	5.0
Wheat fiber hydrated	20.0	15.0	10.0	20.0
Blood	5.0	5.0	5.0	5.0
Dry milk	2.0	2.0	2.0	2.0
Mushrooms champignons blanched	–	15.0	10.0	–
Sea kale	–	–	10.0	–
Oyster mushroom biomass	–	–	–	3.0
Bouillon	5.0	5.0	5.0	5.0
Bow	2.0	2.0	2.0	2.0
Salt	2.0	2.0	2.0	2.0
Pepper	0.01	0.01	0.01	0.01

The chemical composition and the energy value of the new paste are determined (Table 6).

Table 6

Chemical composition and energy value of pastes

Sample	Content, %			Energy value, kcal/100 g
	Protein	Moisture	Fat	
According to the requirements of TU U 15.1-30183690.014-2003	Not less 12.9	70	No more 15.4	190.02
Control	20.24	61.14	16.93	233.97
«Mushroom» paste	14.41	68.54	15.16	194.08
«Spicy» paste	16.23	68.47	13.78	188.94
«Special» paste	20.16	64.42	13.73	204.21

Replacing animal fat with vegetable oil leads to the enrichment of pastes with polyunsaturated fatty acids, including quinoleic, α and γ -pinolenic and oleic. New pastes meet the requirements of TU U 15.1-30183690.014-2003 «Cooked sausage products and pastes for baby food with food additives made by Wiberg (Austria)». Microbiological studies of pastes have shown the absence of pathogenic microflora. The possibility of recommending pastes for nutritional nutrition is tested and gives results:

- no negative effects of the product on the patients' health, blood test values, liver and kidney tests, sugar metabolism were detected;
- a positive effect on cholesterol levels is revealed.

Technological operations in the production of pastes, part of the meat in which is replaced by germinated grains of oats, barley, wheat and corn are similar, except for the different preparation of mushroom and vegetable raw materials. The model systems this time differed in the number of phytocomplex germinated grains from 5 % to 30 %. A control sample is taken for dietary and prophylactic nutrition (Table 7).

Table 7

Model systems of developed pastes

Name of raw materials	Content, %					
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Chicken meat	40.0	41.0	51.0	41.0	30.0	29.0
Boiled chicken liver	36.0	30.0	15.0	20.0	26.0	24.0
Corn oil	5.0	5.0	5.0	5.0	5.0	5.0
Wheat fiber hydrated	–	–	–	–	–	–
Phytocomplex germinated grains	5.0	10.0	15.0	20.0	25.0	30.0
Dry milk	5.0	5.0	5.0	5.0	5.0	5.0
Whey	5.0	5.0	5.0	5.0	5.0	5.0
Bow	2.0	2.0	2.0	2.0	2.0	2.0
Salt	1.99	1.99	1.99	1.99	1.99	1.99
Pepper	0.01	0.01	0.01	0.01	0.01	0.01

The best organoleptic evaluation is received by sample No. 3, the worst – No. 5 and No. 6. Further research is carried out with samples No. 1 through No. 4. Physical and chemical indicators of the finished pastes are given in Table 8.

Samples No. 3 and No. 4 have the highest pH value (6.63). The smallest protein content is sample No. 4 and is 15.1 %, which is within the amount of protein for

top grade according to DSTU. The greatest amount of mineral substances contains sample No. 3 (2.96 %), which is 0.36 % more than in the control sample (2.6 %). The lowest fat content in the finished pastes is contained in the sample from No. 3 and contains 12.1 % (within the limits of the amount of fat according to DSTU). The best indicators of moisture content shows sample number 3, respectively, 69.7 %.

Table 8

Physical and chemical indicators of pastes

No. of sample	pH	Protein, %	Ash, %	Fat, %	Moisture, %
Sample No. 1	6.61	15.9±0.31	2.0±0.31	12.6±0.36	69.0
Sample No. 2	6.62	15.4±0.28	2.32±0.30	12.9±0.34	69.1
Sample No. 3	6.63	15.9±0.30	2.96±0.28	12.1±0.30	69.7
Sample No. 4	6.63	15.1±0.27	2.30±0.27	13.0±0.29	69.2

Functional and technological indicators of pastes: water-binding (WBA), water-retaining (WRA) and fat-retaining (FRA) abilities and plasticity of the developed pastes are given in Table 9.

Table 9

Functional and technological indicators of finished pastes

Sample No.	WRA, %	FRA, %	WBA, %	Plasticity, cm ² /g
Sample No. 1	62.6±0.5	73.9±0.25	79.2±0.4	5.92±0.35
Sample No. 2	61.0±0.3	74.8±0.25	78.3±0.2	5.74±0.25
Sample No. 3	62.7±0.8	74.6±0.25	81.2±0.5	5.67±0.27
Sample No. 4	57.6±0.7	74.3±0.15	79.8±0.6	5.90±0.38

The content of water-binding and water-retaining capacity reduces the loss of raw materials during heat treatment, increases the yield, creates a delicate, rich consistency of the finished product and improves the digestibility degree. Sample No. 3 has the highest value of the water-holding and water-binding capacity of ready-made pastes and is 62.7 % and 81.2 %, respectively. The grease capacity of sample No. 3 is 0.3 % higher than in the control sample (11.4 %) and corresponds to DSTU values. The highest plasticity value in sample No. 1 is 5.92 cm²/g.

When analyzing the results of studies of functional and technological indicators, it is found that the plasticity, water-binding and water-retaining capacity of minced meat developed pastes correlated with the control. During heat treatment, the maximum absorption occurs and

the content of the aqueous phase of the polymers in the constituents of the product allows to obtain a paste with a high yield.

7. SWOT analysis of research results

Strengths. New formulations of the developed pastes containing meat and by-products from poultry, vegetable raw materials: common oyster mushrooms and champignons, hydrated wheat fiber are proposed. The results of the organoleptic evaluation of model products show their pleasant taste and aroma, uniform, delicate, ointment-like consistency. Microbiological studies of pastes have shown the absence of pathogenic microflora. The possibility of recommending pastes for nutritional nutrition is tested and gave results:

- no negative effects of the product on the patients' health, blood test values, liver and kidney tests, sugar metabolism are detected;
- a positive effect on cholesterol levels is revealed.

Weaknesses. The weaknesses of the introduction of new formulations of pastes include the need, in some cases, to make changes in the production lines and to reconfigure the equipment.

Opportunities. The introduction of new recipes in the production of pastes will lead to an expansion of the range of meat products from chicken and, as a result, will contribute to the growth of chicken production.

Threats. The introduction of new formulations of chicken paste into production will necessitate additional investments in the modernization of production. It is also necessary to take into account the risk factors associated with market conditions, for example, depends on the epidemiological situation in the poultry industry.

8. Conclusions

1. Formulations of functional pastes are developed using oyster mushrooms in the amount of 15 %, mycelial biomass of *Pleurotus ostreatus* fungi (oyster mushroom) – 3 % and phytocomplex of cereals in the amount of 15 %. Analysis of the data shows that replacing meat with vegetable raw materials in minced pastes does not reduce the nutritional value of the products. The protein content in the samples using biomass of oyster mushrooms is at the level with the control. In pastes, the replacement of animal fat with flaxseed oil does not detract from the total fat content, but this is offset by the presence of polyunsaturated fatty acids, including linoleic (Omega-3), α - and γ -linolenic and oleic. Due to the decrease in the energy value, pastes with mushrooms, kcal/100 g: 194.08, 188.94 and 204.21 can be recommended for people who are overweight.

2. Formulations of experimental samples and conducting research of model pastes on organoleptic, physicochemical, and functional-technological parameters are developed. Paste from phytocomplex of cereals in the amount of 15 % has high levels of protein content (15.9 %) and mineral

substances (2.96 %). As well as the lowest in fat content (12.1 %), as compared with other studied samples, as well as high in functional and technological parameters: WRA – 62.7 %, FRA – 74.6 %, WBA – 81.2 %.

The results of the organoleptic evaluation of model products show their pleasant taste and aroma, uniform, delicate, greasy consistency. This makes it possible to recommend for mass production three developed formulations of the «Mushroom», «Spicy» and «Special» pastes.

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