

Наводяться результати досліджень розроблених м'ясо-містких напівфабрикатів та проведено аналіз результатів, які підтверджують можливість комбінування м'яса качки і м'яса прісноводної риби в рецептурі м'ясо-містких напівфабрикатів шляхом повної заміни в рецептурах свинини і яловичини. Комбінування в рецептурах м'ясо-містких напівфабрикатів м'яса качки та м'яса прісноводної риби дозволило отримати модельні фарші з високими функціонально-технологічними властивостями: значення волого зв'язуючої здатності до 81,54 %, вологоутримуючої здатності до 76,47 %, емульгуючої здатності до 98,0 %, стабільності емульсії до 69,49 %, що є вищими в порівнянні з напівфабрикатами на основі традиційних видів м'яса. Сенсорна оцінка якості розроблених напівфабрикатів підтвердила високу якість органолептичних показників та відповідність вимогам, що регламентуються стандартам для традиційних січених напівфабрикатів, згідно характеристик даного сегменту продукції. Введення до складу рецептур м'яса качки та м'яса прісноводної риби не вплинуло негативно на мікробіологічну безпеку комбінованих виробів, що підтверджується показниками КМАФАМ та відсутністю БГКП у готовій продукції. За комплексом показників для подальшого вивчення обраний зразок № 2, який містив м'ясо качки та м'ясо сріблястого карася.

Сполучення різних видів сировини регіонального походження в рецептурі м'ясо-містких посічених напівфабрикатів дозволяє отримати продукт з високим вмістом незамінних амінокислот. Січені напівфабрикати з комбінуванням м'яса качки та сріблястого карася мають значення амінокислотного скору, який за вмістом троніну, триптофану, фенілаланіну+тирозину, лейцину і ізолейцину перевищує «еталонний» білок і знаходиться у межах 115,75–156,01 %.

Ліпіди м'ясо-містких комбінованих напівфабрикатів характеризуються високою біологічною ефективністю жирно кислотного складу завдяки високому вмісту МНЖК та ПНЖК, та оптимальному співвідношенню  $\omega$ -3 і  $\omega$ -6 ПНЖК (1:7)

Ключові слова: комбінування, прісноводна риба, м'ясо качки, м'ясо-місткий напівфабрикат, функціонально-технологічні показники

# DEVELOPMENT OF MEAT-CONTAINING MINCED SEMI-FINISHED PRODUCTS BASED ON THE LOCALLY PRODUCED RAW MATERIALS

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## 1. Introduction

One of the most important issues that require solution in the sector of meat industry is to improve the quality of products under conditions of utilizing the raw materials that are supplied for processing at constant changes in their composition and properties [1]. Application of new, as well as more extensive use of known types of raw materials, efficient utilization of regional raw materials in the formulations of meat and meat-containing products is an important task aimed to achieve the high quality, nutrient and biological value of products.

The promising types of the protein-containing raw materials of animal origin in Ukraine is the meat of waterfowl, and freshwater fish, whose production in different regions of Ukraine has been developing steadily [2, 3].

Rising prices for pork and beef, as well as the reduction of the production of these types of meat, predetermine the relevance of the development of new types of meat-containing foods based on the raw materials produced locally, and maintaining the traditional indicators of functional and technological indicators, specific to meat-containing products with the use of traditional meat raw materials. The application of raw materials alternative to

meat-containing products, produced in the regions, would make it possible to obtain products of high biological value with satisfactory functional-technological and consumer indicators.

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## 2. Literature review and problem statement

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In recent years Ukraine has seen a reduction in the number of cattle and pigs. On the other hand, the market for poultry meat in 2017 increased. As of June 1, 2017, the number of poultry of all kinds in Ukraine was thousand goals [4]. Ukraine has at its disposal a huge area of water reservoirs that are used for the cultivation of marketable fish [5], which has the potential for the industrial fish production to receive a sufficient volume of freshwater fish, a source of valuable protein.

These factors create prospects for the new combined products with a high content of valuable protein based on a given raw material.

The mass fraction of protein in duck meat is somewhat lower than that in other types of slaughter poultry. The content of protein in the chest muscles and shins of the duck is 20.8 and 19.6 %, respectively [6, 7], in chicken breasts and thighs it ranges from 23.6 to 24.8 % and from 20.1 to 21.7 %, respectively. In turkey meat, protein content in breasts and thighs is 25.0 and 21.0 %, respectively [7, 8].

The percentage of lipids and the metabolism in oxidative energy in duck meat is larger than that in the meat of land birds. That affects the physical-chemical and sensory properties of manufactured products during storage [9].

Peking and musk duck meat is the source of EAA, especially lysine and methionine. Studying the fat acid composition (FAC) of different parts of carcasses of ducks showed the presence of a high concentration of the monounsaturated acid S18:1 – 26.89–40.24 % of the total content of fatty acids and polyunsaturated fatty acids (PUFA) – arachidonic and linoleic [10].

Fish is rich in high-quality proteins, PUFA, especially ( $\omega$ )-3 and ( $\omega$ )-6, as well as micro elements. The proteins of fish are more affordable source of protein than other proteins [11]. This opens up prospects for the development of freshwater aquaculture in the regions of Ukraine.

Paper [12] shows that the muscle tissue of crucian contains 17.3–17.9 % of protein while the content of lipids is 3.31–5.93 %. Studying the amino acid composition revealed that meat of the fish under consideration contains a full set of essential amino acids (EAA).

Author of [13] found that the high content of linoleic ( $\omega$ )-6 and linolenic ( $\omega$ )-3 fatty acids in the lipids of carp and silver carp characterizes this fish as a raw material of high biological effectiveness. The protein of carp and silver carp is fully valuable and contains all EAA, however there are limits to methionine+cystine and tryptophan.

At present, it is a relevant task to develop the combined meat products that contain in their composition, along with meat raw material, other kinds of raw materials of animal and vegetable origin. To extend the range of products, scientists have conducted studies into the feasibility of technologies for full-fledged products [14–16] and foodstuffs with a preventative effect that include the alternative raw materials [17].

These developments are aimed at expanding the use of poultry meat in order to improve the biological effectiveness and enhance the food functionality of products through the

introduction to the minced meat systems of the developed protein-containing and protein-fat formulations [14, 15], as well as to strengthen their resistance to the spoilage of fats. There are no studies regarding the products based on the combination of waterfowl meat and fish on defining their compatibility in the composition of meat-containing products.

The combined products can satisfy human needs in a balanced rational nutrition. Especially popular are the multi-component meat-containing frozen semi-finished products, with raw materials of local origin, which have a longer shelf life.

Research into development of semi-finished products based on waterfowl duck meat [18, 19], and using fish as well [20–22], has shown that in terms of their functionally-technological and organoleptic characteristics these products are not inferior to those traditional based on pork and beef. However, a possibility for combining these raw materials of regional origin in the formulation of semi-finished products has not been investigated.

Thus, at present, the development of new combined food products that contain in their composition local raw materials, waterfowl meat and freshwater hydrobionts, is an important task.

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## 3. The aim and objectives of the study

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The aim of this study is the scientific substantiation of the possibility to combine the meat of freshwater fish and the meat of duck of local origin in the composition of meat-containing semi-finished products in order to improve their functional and technological indicators and biological efficiency while maintaining the qualitative organoleptic characteristics of the traditional technology for meat-containing minced semi-finished products.

To accomplish the aim, the following tasks have been set:

- to explore the impact of combining the meat of duck and the meat of freshwater fish in the formulation of meat-containing semi-finished products on the technological-functional and organoleptic indicators;
- to run a comparative analysis of the functional-technological, organoleptic indicators, and to identify a possibility to ensure microbiological stability of the meat-containing semi-finished products based on the developed formulations;
- to analyze the biological value and biological efficiency of the developed meat-containing semi-finished products.

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## 4. Materials and methods to study a set of indicators for the developed meat-containing semi-finished products

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To solve the set tasks, we chose «Home Cutlets» [19] as the formulation for an analog to substantiate the possibility of replacing the basic meat raw material with the alternative raw materials of local origin in meat-containing products.

In the course of the study we used minced meat made from Peking duck and freshwater fish, which was received by separating the meat from bones and shredding it at a chopper with a diameter of grid holes of 2–3 mm.

Variants of formulations are given in Table 1.

Materials and methods applied in the research into a set of indicators for the developed meat-containing semi-finished products are described in detail in paper [23].

Table 1

Formulations of the examined samples of semi-finished products

No.	Ingredients	Control	Sample 1	Sample 2
1	Pork	30.5	–	–
2	Beef	30.5	–	–
3	White carp	–	30.5	–
4	Silver Prussian carp	–	–	30.5
5	Duck meat	–	30.5	30.5
6	Wheat bread	12.0	12.0	12.0
7	Breadcrumbs	4.0	4.0	4.0
8	Onion	1.5	1.5	1.5
9	Ground pepper	0.06	0.06	0.06
10	Eggs	2.0	2.0	2.0
11	Salt	1.2	1.2	1.2
12	Water	18.3	18.3	18.3
Total		100	100	100

5. Results of studying a set of indicators for the developed meat-containing semi-finished products

In the process of research, we studied the functional-technological parameters of model minced meat of semi-finished products containing the meat of duck and freshwater fish. The results obtained are given in Table 2.

The results given in Table 2 show that the formulation for the meat-containing semi-finished product in sample 2 has the best functional-technological indicators. Moisture content in sample 2 is at the level of  $82.42 \pm 1.16\%$ , which is 16% higher compared to control sample and 13.17% higher in comparison with sample 1 containing the meat of silver carp.

The values of  $MBA_a$  (moisture-binding ability) for minced meat, in order to ensure high-quality for semi-finished products, must reach the level of 85%. The data in Table 2 indicate that the largest values of  $MBA_a$  and MRA (moisture-resistant ability) were demonstrated by the minced meat in meat-containing semi-finished products of formulation 2 containing the minced meat of silver Prussian carp.

Analysis of results confirms that the combination of duck meat and freshwater fish meat in formulations improves indicators of  $MBA_a$ , MRA and SE.

Table 2

Functional-technological properties of the examined samples of minced meat

Indicators	Minced meat samples		
	Control	Sample 1	Sample 2
Moisture content, %	$71.04 \pm 0.80$	$72.83 \pm 0.57$	$82.42 \pm 1.16$
$MBA_a$ , %	$69.41 \pm 0.90$	$70.43 \pm 0.50$	$81.54 \pm 0.16$
MRA, %	$63.06 \pm 0.00$	$62.85 \pm 0.00$	$76.47 \pm 0.05$
EA, %	$97.00 \pm 1.41$	$98.00 \pm 0.00$	$98.00 \pm 0.00$
SE, %	$63.43 \pm 3.11$	$67.03 \pm 0.51$	$69.49 \pm 2.56$

Fig. 1 shows a profilogram of the organoleptic estimation of the prepared cutlets, Fig. 2 shows the samples of cutlets for tasting.

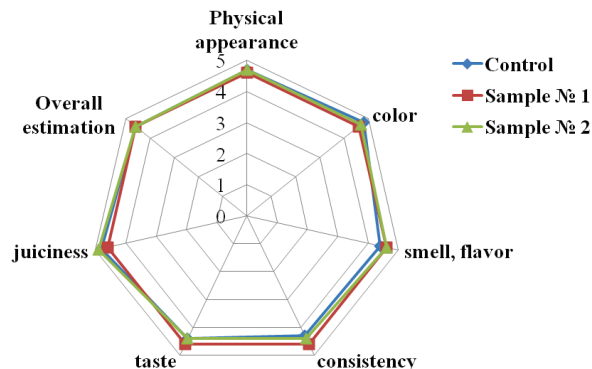


Fig. 1. Profilogram of quality estimation of the examined samples of meat-containing minced semi-finished products

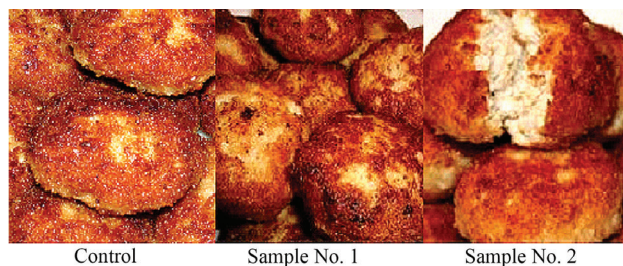


Fig. 2. Examined samples of cutlets

In terms of organoleptic estimation, the developed meat-containing minced semi-finished products are inferior to control sample only in color.

Combining the non-traditional raw materials in minced semi-finished products poses the risk of microbiological spoilage, which is why we investigated the microbiological safety of ready meat-containing minced semi-finished products with the results given in Table 3.

Table 3

Microbiological indicators for the developed minced semi-finished products

Indicators	Samples of products		
	Control	Sample 1	Sample 2
NMAFAM, CFU/g, not larger	$1.7 \cdot 10^2$	$4.1 \cdot 10^2$	$3.4 \cdot 10^2$
BGEC per 0.001 g	Not detected	Not detected	Not detected

Table 3 shows that in the samples of cutlets containing duck meat and freshwater fish meat, the quantity of mesophilic aerobic and facultative anaerobic microorganisms (NMAFAM) is higher than that in control, and the values of these parameters do not exceed the norm, which is  $1.0 \cdot 10^5$  [24]. Examination of the number of bacteria from Escherichia coli group did not reveal any specified microorganisms in any of the samples.

Data on the biological value based on EAA value and on the biological efficiency based on FAC of the model meat-containing semi-finished products containing the meat of duck and the meat of silver Prussian carp are given in Tables 4, 5.

The research conducted into EAA of the minced meat-containing semi-finished products of formulation 2 made it

possible to identify all EAA. Data from the Table indicate that in terms of EAA the high content is demonstrated by leucine, phenylalanine+tyrosine, and threonine. Evaluation of the quality of protein based on the amino acid score (AS) showed that the sulfur-containing amino acid methionine, whose content is 0.08 g per 100 g of product, proved to be limiting. AS of methionine was 22.37 %. This indicator for other amino acids ranged from 102.7 for valine to 156.01 % for threonine. In addition, AS for tryptophan was 145.95 %, meaning that these minced semi-finished products can be considered a source of this EAA.

Table 4

Results of studying the biological value of proteins in meat-containing semi-finished products containing the meat of duck and silver Prussian carp

No.	Title	Reference (FAO/WHO)	Concentration, g/100 g of product	Amino acid score, %
Essential amino acids				
1	Valine	5.0	1.02	102.7
2	Methionine	1.8	0.08	22.37
3	Isoleucine	4.0	0.92	115.75
4	Leucine	7.0	1.61	115.75
5	Phenylalanine + Tyrosine	6.0	1.56	130.85
6	Lysine	5.5	1.14	104.31
7	Threonine	4.0	1.24	156.01
8	Tryptophan	1.0	0.29	145.95

Table 5

Results of studying the fat acid composition of meat-containing semi-finished products containing the meat of duck and silver Prussian carp

Title	Concentration, g/100 g of product
<b>Saturated fatty acids (SFA)</b>	
Lauric acid (C 12:0)	0.16
Myristic acid (C14:0)	1.46
Pentadecanoic acid (C15:0)	0.34
Palmitic acid (C16:0)	21.93
Margarine acid (C17:0)	0.29
Stearic acid (C18:0)	5.36
Arachnid acid (C20:0)	0.75
Lignoceric acid (C24:0)	0.83
<b>Total SFA</b>	<b>31.12</b>
<b>Monounsaturated fatty acids (MUFA)</b>	
Myristoleic acid (C14:1)	0.17
Palmitoleic acid (C16:1)	5.21
Oleic acid (C18:1) <b>trans</b>	0.42
Oleic acid (C18:1) <b>cis</b>	38.97
<b>Total MUFA</b>	<b>44.77</b>
<b>Polyunsaturated fatty acids (PUFA)</b>	
Linoleic acid (C18:2)	18.39
$\alpha$ -Linolenic acid (C18:3)	2.66
Arachidonic acid (C20:4)	0.89
Docosadienoic acid (C22:2)	0.22
<b>Total PUFA</b>	<b>22.16</b>

An analysis of FAC in the meat-containing semi-finished product of formulation 2 confirms that a given formulation's concentration of the cis-isomer of oleic acid in cutlets is at the level of 38.97 g/100 g of fat. The total amount of PUFA is 22.16 g/100 g of fat; we also observed a high content of linoleic acid (18.39 g/100 g), which belongs to the family of  $\omega$ -6.

## 6. Discussion of results of studying a set of indicators for the developed meat-containing semi-finished products

According to the acquired data, the level of mass share of moisture in the examined samples was within 71.04–82.42 % and depended on the composition of the formulation. The least amount of moisture was demonstrated by the «Home-made cutlets» with pork and beef (control) and cutlets with the meat of duck and the meat of silver carp in equal proportions. Sample 2, a formulation composition with the meat of duck and silver Prussian carp (1:1), had a 10-% larger value.

The respective trend is demonstrated by such indicators as  $MBA_a$  and MRA. This is predetermined by the presence in the meat of fish of myofibrillar proteins in the amount of 75 to 80 % of the total protein content. These salt-soluble proteins are characterized by high biological value and high  $MBA_a$ . The high content, compared to the meat of slaughtered animal, of the salt-soluble proteins explains the slight loss of moisture during thermal processing of products with the meat of fish, as well as causes high juiciness and the yield of finished products [25–29].

To obtain the finished products of high quality from the multicomponent polydisperse systems, the values of EA and SE are important. The study shows that the model minced meat has high values of EA and SE, which makes it possible to form a protein matrix that ensures the introduction of fat to its structure, thereby obtaining a stable fat emulsion in water. In this case, at high values of EA for all formulations, the best values of EA were demonstrated by formulation 3. Combining the meat of duck and the meat of silver Prussian carp made it possible to improve the stability of minced-meat emulsion by 9.55 %. This is predetermined by the formation of a more stable framework to stabilize the fatty phase at the expense of water- and salt-soluble proteins in the meat of fish, whose content in the meat of silver carp is 19.5 g/100 g, and in the meat of silver Prussian carp is 17.3–17.78 % [12]. The results of organoleptic assessment of meat-containing minced semi-finished products showed that the examined samples of cutlets are not inferior to conventional ones in terms of the overall combined estimation, which was 4.58–4.62 points.

An indispensable part of the comprehensive assessment of quality and safety of food products is determining the microbiological indicators. To verify compliance of the minced meat-containing semi-finished products containing the meat of duck and fish with the requirements of the standard, all samples were investigated for NMAFAM and BGEC. Results of examining the microbiological indicators of the developed semi-finished products containing the meat of duck and fish, which is unstable in terms of sanitary-hygienic safety [30], meet the regulatory standard, thereby confirming their microbiological safety.

The amino acid composition of the minced semi-finished product containing the meat of duck and silver Prussian carp testifies to that a given product is a valuable source of all EAA, except for methionine. The semi-finished product contains a significant proportion of leucine, which prevents the de-



struction of muscle protein and tryptophan, which regulates the functions of the endocrine system, prevents anemia, regulates blood pressure, enables the synthesis of hemoglobin [31].

FAC of meat-containing minced semi-finished product is represented, mainly, by palmitic (21.93 %), stearic (5.36 %) and myristic (1.46 %) acids, the unsaturated – by oleic (38.97 %), linoleic (18.39 %),  $\alpha$ -linolenic (2.66 %), arachidonic and docosodienic acids. The high content of PUFA poses the risk of the development of oxidizing processes in a product during storage. To prevent the oxidizing of fats, they use natural antioxidants, such as rosemary extract, grape seed extract, and other compositions [32]. It was experimentally established that in the lipids of meat-containing semi-finished products containing the meat of duck and silver Prussian carp the level of MUFA is 44.77 %, PUFA – 22.16 %, saturated – 31.12 %. The biological efficacy of lipids in food products is characterized not only by the number of MUFA and PUFA, but also by the ratio of  $\omega$ -3 and  $\omega$ -6 of PUFA, which, based on the recommended norms [33], must be from 1:4 to 1:10. It was established experimentally that the meat-containing minced semi-finished product demonstrated that the specified ratio was 1:7 due to the introduction to the formulation of duck meat and freshwater fish meat, which are distinguished by the high content of PUFA. The content of  $\omega$ -3 and  $\omega$ -6 of PUFA per 100 g of the prepared semi-finished product satisfies the daily human need [34] by 100 % and larger.

## 7. Conclusions

1. It was established that by combining the meat of Beijing duck and meat of freshwater fish, specifically the meat of frozen silver Prussian carp, in the composition of frozen minced meat-containing semi-finished products, it is possible to produce products of a full nutritional value with high quality indicators.

2. Based on the analysis of functional- technological and organoleptic parameters, we confirmed the possibility of improving the functional-technological indicators of model minced meat for semi-finished products: MBA<sub>a</sub> – to 81.54 %, MRA – to 76.47 %, EA – to 98.0 %, SE – to 69.49 %. The developed semi-finished products with a combined composition demonstrate high organoleptic indicators and are safe in terms of microbiological indicators.

3. We have substantiated the technology and presented data on the qualitative and quantitative composition of the new meat-containing products and confirmed their high biological value in terms of the content of essential amino acids, as well as their biological effectiveness in terms of the content of fatty acids from the  $\omega$ -6 and  $\omega$ -3 family. That confirmed the possibility to combine the local aquaculture sources, meat of waterfowl, with traditional types of meat and vegetable raw materials to enhance the biological efficiency of meat-containing semi-finished products.

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