UDC: 637.562:633.854.78:637.521.47

USING SUNFLOWER PROTEIN AS A COMPONENT OF FORCEMEATS FOR FROZEN SEMI-PROCESSED MINCED MEAT PRODUCTS

DOI: https://doi.org/10.15673/fst.v14i4.1915

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Article history

Received 27.05.2020
Reviewed 22.06.2020
Revised 08.11.2020
Approved 08.12.2020

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Cite as Vancuver style citation

Zhelieva T, Kamsulina N, Pavlova O. Using sunflower protein as a component of forcemeats for frozen semi-processed minced meat products. Food science and technology. 2020;14(4):52-61. DOI: https://doi.org/10.15673/fst.v14i4.1915

Цитування згідно ДСТУ 8302:2015

Zhelieva T., Kamsulina N., Pavlova O. Using sunflower protein as a component of forcemeats for frozen semi-processed minced meat products // Food science and technology. 2020. Vol. 14, Issue 4. P. 52-61. DOI: https://doi.org/10.15673/fst.v14i4.1915

Abstract. The problem of how to remediate protein deficiency in the human diet can be solved by using new raw material sources or by consuming vegetable proteins, in particular, sunflower protein, more efficiently. Sunflower is high in biologically complete proteins with a wide range of functional properties. This makes it practical to use sunflower protein as a component of forcemeats for frozen semi-processed minced meat products. As this task is highly topical and promising, it has determined the direction of further research. The purpose of the research is to establish how sunflower protein affects the qualitative characteristics of forcemeat for frozen semi-processed minced meat products, and to specify the rational norms of using it in their composition. It has been studied how sunflower protein effects on the moisture-holding capacity of forcemeat. The results have shown a sharp increase in this parameter after introducing sunflower protein. It has been established that sunflower protein affects the processes of freezing and defrosting in forcemeat systems. However, it has no pronounced cryoprotective properties independent of its concentration in a system, and the loss in weight during freezing the samples is but insignificant. Studying the effect of sunflower protein powder on the sensory, functional, and technological properties of forcemeat reveals positive dynamics and direct relationship between these characteristics and the concentration of sunflower protein. The losses in the weight of the semi-processed products during heat treatment have been analysed. The data obtained have shown that this parameter decreases by 1.9 times when sunflower protein is used. Sensory evaluation of the samples has allowed establishing that the rational norm for sunflower protein as a forcemeat component is up to 10%. Thus, the research conducted prove that it is practical to use sunflower proteins as components of forcemeats for frozen semi-processed minced meat products. This will make the products more nutritious, allow controlling their amino acid composition, curtail the expenditure of raw meat, help control the rheological parameters, and expand the range of products.

Key words: sunflower proteins, frozen semi-processed minced meat products.

Introduction. Formulation of the problem

With years, people need more and more proteins and protein-containing products. Protein satisfies the human body's need of total nitrogen for nonessential amino acid biosynthesis and of other nitrogenous endogenous bioactive substances. Underconsumption of protein unbalances the metabolic processes that involve proteins: breakdown of a cell's own proteins becomes the prevailing feature, which exhausts the body. The priority areas of research are, thus, the ones that focus on providing people with the necessary protein components, improving the chemical composition of food by supplementing it with protein and other substances, and the efficient use of appropriate protein-containing raw materials. Research in this direction will make it possible to remediate protein deficiency in the human diet [1-5]. The problem can be solved by using new raw material sources or by increasing the efficiency of consuming traditional vegetable proteins, in particular, sunflower protein.

Analysis of recent research and publications

A rational diet implies combining foods of animal and plant origin to keep the amino acid balance. Besides, plant proteins lack many essential amino acids, so they cannot be used as a full-function substitute for those of animal origin. However, plant

proteins have a positive effect on the sensory parameters of food: appearance, colour, taste, and texture. This determines how plant proteins are applied, which of their types are chosen, and what percentage of them is used in a product [2,6].

The main plant protein types are produced from peas, maize kernels, wheat grains, soya beans, and potatoes. They differ, primarily, in the amount of protein, amino acid content, and functionality. Soya beans and products of processing them have become the most widely used raw material to manufacture functional protein supplements [6,7]. The amino acid composition of soya protein is considered the closest to that of animal proteins. Soya is high in complete protein and contains some essential amino acids. However, using it has a negative effect, too. This is due to its composition: to the high content of natural toxins that hinder the action of trypsins and other enzymes needed to digest proteins, to the large amount of phytic acid that blocks absorption of minerals, to phytoestrogens causing serious hormonal disorder. Besides, much of soya is genetically modified, and it has one of the highest levels of pesticide contamination [1,2,7].

Today, a good alternative and competitor to soya protein can be plant protein obtained from sunflower seeds. Sunflower is rich in bioactive substances, and its protein content averages 22–26%. This is why sunflower can be viewed as an abundant plant protein resource [8-10]. The conditions of its preprocessing and methods of its fractionation significantly tell on the fractional composition of its proteins, which varies quite widely. Its seeds contain a full set of amino acids, except for lysine. Sunflower proteins are valuable mostly due to reserve proteins, which make 80–94% of the total protein content. According to Osborne's classification, the bulk of reserve proteins is made up of globulin (36.8%) and albumin (18.4%) fractions. Prolamins and glutelins make up, respectively, 1.6 and 8.2% [9,11,12].

Sunflower proteins are good foam-formers, emulsifiers, fat and moisture-binders, with low gelling power. The functional and technological properties of proteins vary widely depending on the ways of preparing protein-containing products, methods of evaluating their functionality, presence of accompanying substances [13-19]. The wide functional range of sunflower proteins allows using them in different branches of the food industry [20,21]. Table 1 sums up the results of modern theoretical and research studies from Ukraine and abroad, and shows possible applications of such products of processing sunflower seed kernels as press cake, solvent-extracted cake, flour, and isolates. The list includes the branches of all directions, the range of mixed food products and supplements, that can be reproduced in multicomponent products, both food-purpose and functional.

Scientists have developed a technology of cheese produced by heat-acid coagulation with the use of cold-pressed sunflower oilcake obtained from husked seeds. It has been found rational to add press cake to standardised or skimmed milk in the amount 1.5% at 50°C. This technology increases the protein mass fraction in a milk-and-plant mixture and the moisture content in a cheese coagulum, reduces the strength of the coagulum's protein framework, slows down whey exudation during synaeresis of the coagulum, increases the yield of cheese [22].

Z. Khodyreva suggested using sunflower kernels in the technology of ice cream to control and balance its chemical composition and enrich it with plant protein. The sunflower kernels were processed at 85±2°C for (20±0.5)·60sec, ground to the particle size $0.67 \cdot 10^{-3}$m and $1.4 \cdot 10^{-3}$m, and added, in the amount 5–7%, at the freezing stage. The heat treatment of sunflower kernels allowed obtaining a supplement with high sensory characteristics. It contained about 19% of plant protein and had good emulsifying properties. Adding sunflower kernels contributed to a 9-15% increase in the product's creaming power [23].

Patent of invention No. 84809 UA certifies that the researchers V. Drobot and L. Mykhonik developed a technology of health-improving wheat bread. Its recipe includes using whole-grain wheat flour *Zdorovya*, with addition of oat-flakes, dehydrated wheat gluten, soya flour, and sunflower kernels (1.7–3.7% of the flour weight).

Table 1 – Applications of products of processing sunflower seed kernels as food components

Food product or supplement	Sunflower-based supplement	Weight fraction of the supplement, %
Meat industry		
Forcemeat for sausages	Modified protein supplement from solvent-extracted oilcake	3–10
Cooked sausages	Sunflower protein isolate	2.1–2.2
Baked meat pâté	Sunflower kernel flour	64–76
Milk industry		
Heat-acid meat cheese	Press cake from sunflower kernels	1.5
Coagulation whey	Press cake from sunflower seeds	3
Confectionery industry		
Sponge cake	Modified protein supplement from solvent-extracted oilcake	3–10
Pralines	Press cake from sunflower seeds	10–15

In their utility patent No. 42095 UA, H. Lysyuk, S. Oliynyk, and S. Tymchuk present a method of manufacturing wheat bread with increased biological value. Its recipe includes whole or crushed sunflower kernels. They are added in the amount 5-20% of the flour weight in the course of kneading the dough after the second punch.

Patent of invention No. 55112 UA describes a method of producing sunflower paste to be used as a filling agent in bakery products. The paste is based on 31.1–34.0% of sunflower kernels crushed with addition of citric acid, powdered sugar, cocoa powder, milk powder, vanillin, sunflower oil, and an antioxidant. The product's sensory characteristics are the brown colour, pleasant sweet taste with a nutty shade, vanillin aroma, and pasty consistency.

In utility patent No. 41168 UA, the researchers S. Plokhinsky, S. Novikov, and O. Skvortsova suggested a method of manufacturing an extruded grain product, crispbreads, based on groats of different cereals and other supplements, with sunflower kernels added in the amount up to 10% or in the glaze.

Patent of invention No. 51395 UA is for a method of mayonnaise production. Its technology and formulation involves replacing all powdered eggs and skim milk powder with sunflower kernels (20–25%), which is the basis to prepare the emulsion.

The authors of patent of invention No. 52385 UA M. Ikhno and A. Kotelevska developed the technology of an emulsion-type food product based on large-fruited sunflower kernels, in the amount 32.3–48.5%, crushed with the addition of sugar, salt, lactic acid, and water.

In utility patent No. 60206 UA, Yu. Lukanova suggested preparing food products based on slightly roasted sunflower kernels with addition of vegetable oil, salt, a flavouring agent, and peanuts.

In the confectionery industry, sunflower kernels have found wide application in manufacturing pastries and sugar confections. H. Lysyuk, O. Shydakova-Kamenyuka, and I. Fomina developed the recipe and technology of butter sponge cake with sunflower kernels added (8 and 16% of the total recipe mixture). A peculiarity of this technology is whisking the crushed kernels with the egg yolk and sugar mixture and adding it to the egg white and sugar mixture that has been whipped earlier. It was noted that using sunflower kernels increased protein in the finished products by 17–18%, and fat by up to 12%. The amounts of vitamins and minerals increased, too. The research carried out by the authors allowed them to develop the formulation and the technology of shortcrust dough using 14.8±0.2% of whole sunflower kernels and thus reducing the wheat flour content by 5%, and to create biscuits based on it. It is worth noting that the levels of protein and fat increased by 31.4 and 27.7%, compared to the traditional dough. Also, the authors suggested antioxidant-containing palm-oil coating for products with extended shelf life made with the use of sunflower kernels [24].

The author of utility patent No. 23881 UA suggested manufacturing oatmeal biscuits with additional introduction of dough at the end of preparation and topping the semi-finished biscuits with sunflower kernels in the amount 1.1–18.3% of the dough weight.

Utility patent No. 22706 UA describes how to make zefirs, marshmallow-like confections, with 1.0–12.3% of crushed sunflower kernels added to the semi-finished marshmallow mass at the end of its preparation, or with 2.6–11.0% added to the semi-finished marshmallow mass as topping.

There is a method of making dragée from 50-60% of roasted sunflower kernels (patent of invention No. 5461 UA). The method involves treating kernels with a natural antioxidant based on dry malt extract. This ensures the long shelf life of the finished product.

In patent of invention No. 25379 UA, H. Bondar, Yu. Yegorov, and M. Bakhmutchenko described the technology of a food product based on wheat germs with sunflower kernels added in the amount 12–16%. To produce it, the preprepared components are ground to obtain homogeneous pasty mass. The product is supposed to be used in the confectionery industry as filling for sweets and wafer biscuits, or as a health-promoting product in its own right in the diet of people of different social backgrounds.

The authors of utility patent No. 58780 UA presented a method of making brittle using sunflower kernels or their mixtures with cereal crops, nuts, other oily raw materials, in the amount 30–70% of the weight of the finished product. In the course of preparing brittle, melted sugar was supposed to be mixed with roasted sunflower kernels or their mixture with other components.

Patent of invention No. 6656 UA suggests making the pasty mass for praline sweets substituting nuts with high-protein sunflower kernels. The nuts to sunflower kernels ratio varies from 1:4 to 1:1. The mixture of roasted nuts and kernels is pulverised, with other praline mass components added, and is used to mould sweets.

Patent of invention No. 37156 UA describes the technology of dragée from roasted sunflower kernels contained in the amount 28.8–29.0%. The product is coated with sugar, syrup, and cocoa powder, and glazed.

In utility patent No. 65652 UA, S. Khodachenko shows how to manufacture candyfloss of improved nutritional value. The technology involves producing sugar strands, forming a single mass of them, and covering it with a food additive, in particular, sunflower kernels, whole or crushed (100% of the weight of candyfloss).

Utility patent No. 54823 UA presents a spread intended for people subject to a lot of physical exertion or psychoemotional stress, like sportspeople. For them, it can be an extra source of energy and polyunsaturated fatty acids. The paste-like spread is based on dairy

products, with the addition of chocolate, nuts, a functional composition, and crushed sunflower kernels (up to 11.4% of the weight of raw materials).

In utility patent No. 28787 UA, N. Iordateva, N. Romaneskul, and L. Poplavska described methods of producing breakfast cereal compositions, muesli. The fatty component of plant origin in it was sunflower kernels (0.3–1.0% of the total weight of the mixture).

In the meat industry, sunflower seeds are used far less widely. However, things are changing with years. To enrich meat products and confections with protein, O. Shyrokoryadova [25-27] studied the biochemistry of protein fractions from sunflower seeds and developed modified protein supplements from solvent-extracted sunflower oilcake. These supplements were of enhanced biological value, with fat-holding and water-holding capacity.

In patent of invention No. 2028061 RU, N. Filchakova developed a cooked sausage technology that uses protein isolate in the forcemeat composition (2.1–2.2% of the raw material weight) and an energy nutrient supplement.

In patent of invention No. 63911 UA, O. Topchiy and A. Davydyuk suggested using sunflower kernel flour in low-calorie baked meat pâté for a protective diet. The formulation containing meat raw materials and auxiliary components was supplemented with sunflower kernel flour (3–10% of the mixture's total weight). This resulted in a finished product with high sensory qualities, increased nutritional and biological value, and improved rheological characteristics.

There is a food concentrate developed to be used when preparing forcemeat for cutlets and pâtés (patent of invention No. 75627 UA). As food protein in the forcemeat formulation, the developers suggested using protein flour from sunflower kernels (64.0–76.0% of the concentrate's weight), along with buckwheat, vegetables, and spice.

There is a method of making sausages for hotdogs that is based on plant proteins from sunflower and peas, which allows classing the product as vegetarian food. This composition of the sausages is the first allergen-free alternative to soya and wheat [28,29].

This analysis of literary sources allows us to state that the high content of biologically complete proteins in the sunflower and a wide range of their functional properties make its use in meat products very promising. Since there has been no comprehensive research into using sunflower proteins as components of forcemeat to manufacture frozen semi-processed minced meat products, this direction of research is topical and highly practical.

The purpose of the research is determining how sunflower protein affects the qualitative characteristics of forcemeat for frozen semi-processed minced meat products and establishing the rational standards of using it in their composition. To achieve the purpose, the following **objectives** were formulated:

– to determine the effect of sunflower protein on the moisture-holding power of forcemeat for frozen semi-processed minced meat products;

– to study the effect of sunflower protein on the processes of freezing and defrosting in forcemeat systems, and on their weight loss during freezing;

– to study the effect of sunflower protein powder on the sensory, functional, and technological properties (moisture content, moisture-binding capacity) of forcemeat for frozen semi-processed minced meat products;

– to establish the effect of sunflower protein on the changes in the weight loss of forcemeat for frozen semi-processed minced meat products during heat treatment;

– to make a sensory assessment of the frozen semi-processed minced meat products containing sunflower protein as a component of their forcemeat, and to establish the recommended norms of using it.

Research materials and methods

The research was carried out in a laboratory of the Meat Technology Department of Kharkiv State University of Food Technology and Trade. The materials under study were forcemeats based on beef and pork. The forcemeats were prepared by the traditional technology (control samples) and with sunflower protein added. Prior to this research, the experts from the Meat Technology Department of the University had already studied the functional and technological properties of sunflower protein [30]. The main characteristics of the physicochemical and functional properties of sunflower protein are listed in Table 2.

Table 2 – Physicochemical and functional properties of sunflower protein

Parameter	Value
pH	7.2
Fat-emulsifying capacity, %	31.5
Fat-holding capacity, %	89.5
Moisture-holding capacity, %	250
Moisture content, %	8.2
Emulsion stability, %	82 maximum (for protein concentration 20%)
Solubility, %	82

To study in detail the effects of sunflower protein on the weight loss during heat treatment, on the sensory test results, and on determining its rational norms, a frozen semi-processed minced meat product (cutlets *Domashni*) was chosen. Its recipe composition is presented in Table 3 [31]. Sunflower protein was introduced into the forcemeat by reducing the weight content of the minced beef in the recipe by 5% (Sample 1), 10% (Sample 2), and 15% (Sample 3) and replacing it with the same weight content of sunflower protein that had been hydrated to a concentration of

20%. Pure forcemeat was the control sample. The quality and safety of the raw materials used in the research complied with the regulatory documents and the manufacturers' certificates of conformity, and were authorised in Ukraine by an executive body responsible for health care and food safety.

Table 3 – Recipe composition of the cutlets *Domashni*

Raw material	Net weight
Minced beef	28
Desinewed fat pork	29.7
Wheat flour bread	13
Bread crumbs	4
Peeled bulb onion	2
Black pepper	0.1
Eggs	2
Table salt	1.2
Drinking water	20
Total	100

The effect of sunflower protein on the processes of freezing and defrosting in forcemeat systems was established according to the main principles of the physicomathematical model of the crystallisation process in meat systems, using the methods [32] to calculate the parameters of the temperature dependence of effective specific heat capacity. The research was carried out on a laboratory test installation equipped with an eight-channel multifunctional measuring controller OVEN TRM 138-R with an automatic interface converter OVEN AS 4. The study procedure consisted in producing thermograms in the temperature range from -30°C to 30°C, until the temperature in the centre of a sample was no lower as -20°C. The temperature was measured automatically in steps of $\Delta\tau$=1×60 sec. The results of the experiment were processed using the software Owen Process Manager.

To determine the rational concentration of sunflower protein included in the forcemeat, a semi-processed product was prepared. In it, the raw meat material was mixed together with hydrated sunflower protein, with addition of other components according to the recipe [31]. The resulting mass was thoroughly stirred and moulded, and then the product was crumbed, frozen, and fried by the main method.

When analysing the semi-processed minced meat products containing sunflower protein, the quality of the meat and meat products was controlled by the conventional methods [33], using appropriate equipment. The moisture-binding capacity of the forcemeat was checked by pressing. The moisture-holding capacity of the semi-processed products was checked with a butyrometer. The moisture content was determined using the referee method, by drying a sample to constant weight (DSTU (State Standard of Ukraine) ISO 1442:2005). The formulations of the semi-processed minced meat products were developed according to DSTU 3946-2000. The development testing of the recipe and technology was carried out in small batches and repeated in triplicate, with the estimated output of the finished products 0.5kg.

The losses during freezing and heat treatment were calculated by the standard method of weighing (GOST (State Standard) 31988-2012. For the sensory evaluation of the quality of the finished food, the analytical descriptive method was used (GOST 4288-76). The sensory evaluation was done by a taste panel, who based on their own opinions and on objective quality indicators to characterise different parameters of the samples.

Results of the research and their discussion

Quite an important quality characteristic of semi-processed minced meat products is the juiciness of the finished products, namely, their moisture-holding capacity. That is why the first stage of the research was determining the effect of sunflower protein on the moisture-holding capacity of the semi-processed products (Fig. 1).

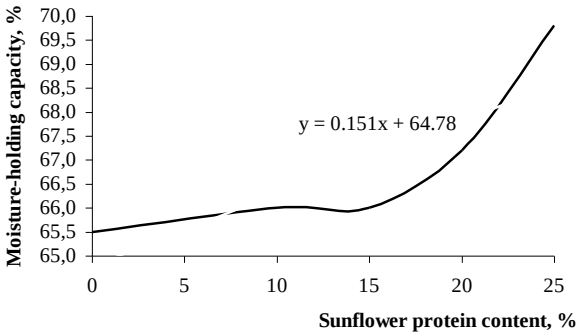

Fig. 1. Moisture-holding capacity of the semi-finished products

The results obtained (Fig. 1) make it clear that the moisture-holding capacity of the semi-processed products is directly proportional to the sunflower protein content. It has been established that the more sunflower protein, the higher the moisture-holding capacity of the products is. It should be noted that a sunflower protein level higher than 15% results in a sharp increase in the moisture-holding capacity. Thus, after adding 10% and 15% of hydrated sunflower protein, the values of the moisture-holding capacity were almost identical (about 66%), and the increase in them was 0.5%. However, with 20% of sunflower protein added, the moisture-holding capacity increased by 1.8%, and with 25%, by 4.2%.

So, it can be concluded that using 20% of sunflower protein and more causes a sharp increase in the moisture-holding capacity of the semi-processed products. It is quite possible that among raw meat proteins, collagen particles, and sunflower proteins, bonds are formed, electrostatic by nature. They strengthen the structure of meat system gel, which

allows obtaining semi-processed products of different structure.

It is known that the emulsion stability sharply decreases after adding more than 20% of powdered sunflower protein [30]. So, in the further studies of the forcemeat, 5%, 10%, and 15% of the meat raw material (Samples 1, 2, and 3 respectively) were replaced with the same percentages of sunflower protein that had been hydrated to a concentration of 20%.

Manufacture of frozen semi-processed meat products involves low-temperature treatment of a forcemeat system accompanied by physical, histological, colloid-chemical, and biochemical changes due to deterioration of the finished product. The specific character of this manufacture requires selecting carefully the forcemeat ingredients that can stabilise its structure and properties in a wide temperature range. That is why the next direction of the research is studying the effect of sunflower protein on the processes of freezing and defrosting of a forcemeat system (Fig. 2 and 3, Table 4), and on the weight loss during freezing (Table 5).

Analysis of the data obtained (Fig. 2 and 3) makes it clear that in the curves of both freezing and defrosting of the semi-processed products, there are three easily distinguishable stages, irrespective of the sunflower protein content. Our main interest is in the second stage of the processes of freezing and defrosting, namely, crystal formation and melting.

It should be noted that the crystal formation stage should be passed as quickly as possible, because this will result in the formation of smaller ice crystals, more evenly distributed. With sunflower protein added, the duration of crystal formation ranges in the semi-processed products is shorter by 1.4 times than it is in the control.

It has also been established that during freezing, sunflower protein added to the forcemeat systems lowers (by 1.2–1.3 times) the values of the temperature range of moisture crystal formation (Samples 1 and 3), or results in no changes in it (Sample 2), compared with the control. During defrosting, the range of moisture melting temperatures becomes smaller. The lowest value is observed in Sample 1.

Thus, the data obtained prove that sunflower protein affects the processes of freezing and defrosting of semi-processed products, but it has no pronounced cryoprotective properties independent of its concentration in a system. The weight losses in the samples during freezing have appeared to be slightly decreasing as compared with the control, which is within the limits of a possible error.

Table 4 – Characteristics of the freezing and defrosting processes in the semi-processed products (n=3, p≤0.05)

Parameter	Control	Sample 1	Sample 2	Sample 3
Freezing				
Time of reaching the cryoscopic point (the supercooling process), min	12	13	14	16
Temperature range of crystal formation of moisture, °C	7.6	5.7	7.6	6.3
Duration of the crystal formation range, min	69	50	67	59
Duration of freezing, min	197	175	197	195
Defrosting				
Range of moisture melting temperatures, °C	2.3	0.5	2.3	1.3
Duration of defrosting, min	71	62	70	65

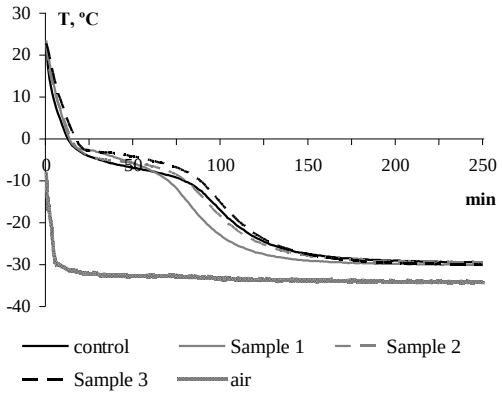

Fig. 2. Curves of freezing the product

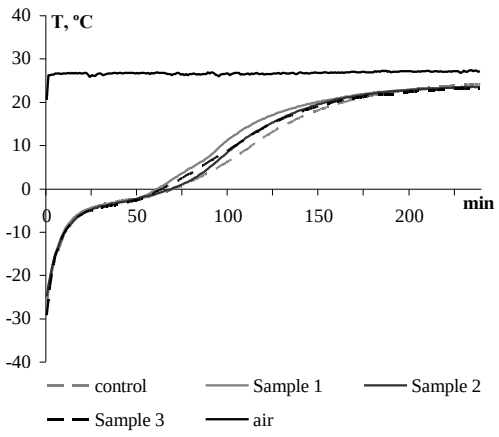

Fig. 3. Curves of defrosting the product

Table 5 – Weight loss during freezing of the product (n=3, p≤0.05)

Sample	Weight loss during freezing of the product, %
Control	5.95
Sample 1	4.81
Sample 2	4.93
Sample 3	5.71

Sensory properties belong to the most important indicators of the quality of meat products and characterise their technological and commercial efficiency. The sensory evaluation results have made it clear that it is impractical to add more than 10% of sunflower protein to the systems, since this protein concentration makes forcemeat systems too dark-coloured. So, the further research only dealt with forcemeat systems supplemented with 5% (Sample 1) and 10% (Sample 2) of hydrated sunflower protein.

At the next stage of the research, it was studied how sunflower proteins affected the functional and technological properties of forcemeat for semi-processed minced meat products. The results are given in Table 6.

Table 6 – Functional and technological properties of forcemeat for semi-processed minced meat products (n=3, p≤0.05)

Sample	Parameter	
	Moisture content, %	Moisture-binding capacity, %
Control	74.4	63.3
Sample 1	72.2	73.2
Sample 2	66.6	75.1

The data from Table 6 show that the moisture content in the forcemeat is inversely proportional to the sunflower protein concentration. With higher sunflower protein concentrations, the moisture content in the forcemeat is lower by 2.2% (in the samples with 5% of sunflower protein) and by 7.8% (in the ones with 10% of sunflower protein).

According to the research data on the moisture-binding capacity of forcemeat, it increases by 9.9% (with 5% of protein added) and by 11.8% (with 10% of protein added). Thus, as compared with the control, the values of the moisture-binding capacity of the samples containing sunflower protein are higher, and this increase is related to its concentration in the system. This may be due to the deficiency of moisture in the forcemeat and to the increased hydrophilicity of the sunflower powder.

To study in detail the effect of sunflower protein on the properties of forcemeat for semi-processed frozen meat products, the dynamics of the weight loss of the samples during their heat treatment have been considered. In the course of this study, the semi-processed products were fried by the main method. The results obtained are in Table 7.

The data on the weight loss during the heat treatment of samples with and without sunflower protein, when analysed, reveal the clearly definable regularity: a decrease in this parameter depends on the percentage of protein. This is a positive factor, because this can increase the output of finished products, which will result in a positive economic effect. Thus, using 10% of sunflower protein reduces the total weight loss during heat treatment by 1.9 times. Besides, moisture is retained in the products, and this increases their total moisture content and has a positive effect on the sensory characteristics.

Table 7 – Weight losses during heat treatment of the semi-processed products (cutlets *Domashni*) (n=3, p≤0.05)

Sample	Weight loss during heat treatment, %
When heated	
Control	6.9
Sample 1	6.7
Sample 2	3.0
When cooling down	
Control	0.77
Sample 1	0.74
Sample 2	0.09
Total	
Control	7.6
Sample 1	7.3
Sample 2	3.9

The research conducted has not allowed specifying the recommended norms of sunflower protein content in the forcemeat intended for semi-processed frozen meat products. That is why the finished products (heat-treated by frying in the standard way) underwent one more sensory evaluation.

The sensory evaluation results have made it possible to establish that replacing the raw meat material with up to 5% of sunflower protein effects on the quality characteristics of the semi-processed products but insignificantly. Replacing the raw meat material with more than 10% of sunflower protein makes the forcemeat and finished products darker in colour, and besides, the finished products become more resilient. Adding 10% of sunflower protein to the semi-processed products under study resulted in virtually no off-flavour and off-odour. The change in the colour remained within limits acceptable for consumers. The texture of the semi-processed products was characterised as softer than that of the control sample.

Conclusion

This analytical research allows concluding that enriching meat products with plant (in particular, sunflower) proteins is topical and promising.

The experiments have allowed achieving the purpose of the research: to define how sunflower protein effects on the qualitative characteristics of forcemeat for frozen semi-processed minced meat

products, and to establish the rational norms of using it as their component.

It has been determined how sunflower protein effects on the moisture-holding capacity of forcemeat for frozen semi-processed minced meat products. The results have shown a sharp increase in this parameter after introducing sunflower protein. It has been established that among raw meat proteins, collagen particles, and sunflower proteins, bonds are formed, electrostatic by nature. They strengthen the structure of meat system gel, which allows obtaining semi-processed products of different structure.

It has been studied how sunflower protein effects on the processes of freezing and defrosting in forcemeat systems and on the loss in their weight during freezing. It has been established that sunflower protein affects the processes of freezing and defrosting of semi-processed products, but has no pronounced cryoprotective properties independent of its concentration in a system. The loss in weight when freezing the samples is but insignificant, compared with the control, and is within the limits of a possible error.

Studying the effect of sunflower protein powder on the sensory, functional, and technological properties of forcemeat reveals positive dynamics and direct relationship between these characteristics and the concentration of sunflower protein.

It has been shown that when sunflower protein is used the loss in the weight of the semi-processed products during heat treatment decreases by 1.9 times. This can increase the output of finished products, which will result in a positive economic effect.

Sensory evaluation of the semi-processed products has allowed establishing that the rational norm for sunflower protein as a component of forcemeat for frozen semi-processed minced meat products is up to 10%.

Thus, this research proves that it is practical to use sunflower proteins as components of forcemeats for frozen semi-processed minced meat products. This will make the products more nutritious, allow controlling their amino acid composition, curtail the expenditure of raw meat, help control the rheological parameters, expand the range of products, and make it possible to develop inexpensive products with new consumer properties.

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ВИКОРИСТАННЯ БІЛКІВ СОНЯШНИКУ В СКЛАДІ ФАРШІВ ДЛЯ ЗАМОРОЖЕНИХ М'ЯСНИХ ПОСІЧЕНИХ НАПІВФАБРИКАТІВ

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Анотація. Проблема подолання дефіциту білка в харчуванні людини може бути вирішена шляхом використання нових джерел сировини, або за рахунок підвищення ефективності використання рослинних білків, зокрема, білків соняшнику. Високий вміст в соняшнику повноцінних білків та широкого спектру їхніх функціональних властивостей визначає доцільність його використання в складі фаршів для заморожених м'ясних посічених напівфабрикатів. Враховуючи актуальність та перспективність цього питання, обрано напрям подальших робіт. Мета роботи – визначення впливу білка соняшнику на якісні характеристики фаршу для заморожених м'ясних посічених напівфабрикатів та встановлення раціональних норм його використання у їхньому складі. Результати досліджень впливу білка соняшнику на вологоутримувальну здатність фаршу дозволяють стверджувати про стрімке збільшення даного показника. Визначено, що білок соняшника впливає на перебіг процесів заморожування та розморожування фаршевих систем, однак не має чітко виражених кріопротекторних властивостей, які не залежать від його концентрації в системі, а втрати маси під час заморожування зразків незначні. Дослідження впливу порошку білка соняшнику на органолептичні та функціонально-технологічні властивості фаршу свідчать про позитивну динаміку та пряму залежність даних показників від концентрації білка соняшника. Згідно аналізу одержаних даних втрат маси напівфабрикатів під час теплової обробки, встановлено зменшення даного показника у 1,9 рази при використанні білка соняшнику. Органолептична оцінка зразків дозволила встановити раціональні норми використання білка соняшнику у складі фаршу до 10%. Отже, проведені дослідження свідчать про доцільність використання білків соняшнику в складі фаршів для заморожених м'ясних посічених напівфабрикатів, що забезпечить підвищення їхньої харчової цінності, регулювання амінокислотного складу, скорочення витрат м'ясної сировини, регулювання реологічних показників та розширення асортименту.

Ключові слова: білки соняшника, заморожені м'ясні посічені напівфабрикати.

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