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# USE OF OILSEED POLYFUNCTIONAL SUPPLEMENTS IN THE MANUFACTURE OF MEAT PRODUCTS

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**Abstract.** Nowadays, meat production is developing towards a wider range of products. Their components are optimised and combined in such a way as to increase the nutritional value, to preserve the most valuable components of raw materials, to make for some lacking macro- and micronutrients by including the functional ingredients in the recipe. A possible way to improve the meat products technology is making purposeful changes in the formulation of the product. This involves selecting certain types of raw materials and additional components in ratios providing the required nutritional value of the finished product. New functional ingredients having the desired physiological effects on the human body should be combined with new, modern means of processing raw materials that will provide the necessary technological characteristics, the quality and safety of the final product. Home-manufactured vegetable supplements obtained from seeds of different crops are a promising direction of research. Their unique chemical composition and functional properties allow achieving the expected nutritional value of the finished product in accordance with modern nutritional standards. This article presents the results of analysing and studying of oilseeds aimed at creating a balanced multifunctional supplement to be used in recipes of functional meat products. It has been studied how the functional and technological parameters of seeds change depending on the degree of their grinding. The organoleptic evaluation has allowed determining the optimum ratio of plant components in the mixture. The quality parameters of the supplement developed, its biological value, vitamin and mineral composition have been determined. The organoleptic characteristics and structural and mechanical parameters of meat model systems have been analysed, which has made it possible to recommend the right percentage of the composite oilseed mixture in the recipes of meat products, namely, pates and chopped semi-finished products.

**Keywords:** oilseeds, mixture, meat model systems, pate, chopped semi-finished products.

# ВИКОРИСТАННЯ ПОЛІФУНКЦІОНАЛЬНОЇ ДОБАВКИ З НАСІННЯ ОЛІЙНИХ КУЛЬТУР У ВИРОБНИЦТВІ М'ЯСНИХ ПРОДУКТІВ

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**Анотація.** Сучасне виробництво м'ясопродуктів розвивається у напрямку розширення асортименту продукції, комбінування й оптимізації компонентного складу з метою підвищення харчової цінності, збереження найцінніших складових сировини, компенсації нестачі ряду макро- і мікронутрієнтів шляхом включення в рецептуру функціональних інгредієнтів. Одним з можливих шляхів удосконалення технології м'ясних продуктів є аргументовані зміни рецептурного складу виробу, що передбачає підбір певних видів сировини та додаткових компонентів у співвідношеннях, які забезпечують досягнення прогнозованої харчової цінності готового виробу. Використання нових функціональних інгредієнтів з метою забезпечення бажаного фізіологічного впливу на організм людини доцільно поєднувати з новими, сучасними засобами обробки сировини, які сприятимуть забезпеченню необхідних технологічних, якісних характеристик та безпечності кінцевого продукту. Рослинні добавки вітчизняного виробництва на основі насіння різних культур є перспективним напрямом наукових досліджень, оскільки завдяки унікальному хімічному складу та функціональним властивостям вони здатні забезпечити досягнення прогнозованої харчової цінності готового виробу згідно з сучасними вимогами нутриціології. У даній статті представлено результати аналізу та дослідження насіння олійних культур з метою створення збалансованої багатофункціональної добавки для використання у рецептурах функціональних м'ясних продуктів. Вивчено динаміку зміни функціонально-технологічних показників насіння залежно від ступеню його подрібнення. За результатами органолептичної оцінки підібрано оптимальне співвідношення рослинних компонентів у складі суміші. Визначено якісні показники створеної добавки, біологічну цінність, вітамінний та мінеральний склад. Проведено аналіз органолептичних та структурно-

механічних показників м'ясних модельних систем, на підставі якого зроблено висновки щодо рекомендованого відсоткового вмісту композиційної суміші насіння олійних культур у рецептурах м'ясних продуктів, а саме паштетів та посічених напівфабрикатів.

**Ключові слова:** насіння олійних культур, суміш, м'ясні модельні системи, паштет, посічені напівфабрикати.




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## Introduction. Formulation of the problem

The ecological deterioration observed in the recent years in our country and globally results in higher morbidity rates. Besides, today, there is a tendency to a more hurried lifestyle, which tells on an average Ukrainian's dietary regimen and quality of nutrition. So, it seems necessary to modernise today's meat production technologies by improving their quality, expanding the range of products, and using raw materials more effectively.

A promising direction of research that allows implementing all the above is enriching meat with vitamins, minerals, and other substances that people generally lack for a balanced diet. To this end, appropriate functional ingredients should be purposefully selected. Particularly noteworthy are oilseeds due to their high nutritional value and specific functional and technological properties [1-5].

## Analysis of recent research and publications

Meat is a high-value protein-containing edible raw material. However, there are cases when it needs enriching with vitamins, minerals, and other substances the lack of which makes a diet unbalanced. The problem is of theoretical and practical interest, and a great number of domestic and foreign studies prove it is still important. The results of the studies allow concluding that meat products with a well-balanced fatty acid, vitamin, and mineral content can be obtained by introducing raw material of plant origin (primarily oils and flours) into their formulation [6-8].

A thorough analysis of reference materials and research papers presenting the results of experimental studies has shown that a promising raw material to enrich traditional meat products (in particular, pâtés and chopped semi-finished products) is the seeds of pumpkins, sunflowers, sesame, and flax, which are unique in their chemical composition and pharmacological properties [9-11].

Thus, pumpkin seeds are a source of valuable bioactive agents. They have been proved to contain a lot of proteins (35%), fats (40–55%), essential oils, phytosterol cucurbitol, cucurbitin (0.5%), phytin, organic acids (salicylic, malic), vitamins (carotene, carotenoids, ascorbic acid, and Group B vitamins – B1, B2, PP) – up to 0.2 % [7,12-16].

The percentage of the main nutrients in ripe sesame seeds: soluble carbohydrates – 16–20%, proteins – 19–27%, sesame oil – 53–65%, ash – 5%, phytosterols, sitosterols, phytin, amino acids, tocopherols, choline [14, 17-20].

The percentage of the main nutrients in ripe flax-seeds (Linum usitatissimum): proteic substances – 18–33%, mucilage – 5–12%, carbohydrates – 12–26%, nitrogen-free extractives – 22%, fatty oils – 30–50%, fatty acid triglycerides: linolenic – 30–45%, linoleic – 25–59%, oleic – 18–20%, glyceride stearic – 8–9%, palmitic, arachidic, myristic, and α-tocopherol. The seeds contain phytosterols, enzymes, vitamins C, A, F. In flax seed coats, high-molecular compounds were found, which, when hydrolysed, release linocinamarin. Its action is similar to that of pilocarpine and carbachol, so flax seeds stimulate gastrointestinal activity [14,17,21,22].

Laboratory studies show that ripe sunflower seeds contain the following substances: vitamin A, Group B vitamins (B1, B2, B5, B6, PP, B9), vitamins E, D; β-carotene and carotenoids; choline; mineral substances (selenium, manganese, magnesium, calcium, sodium, potassium, phosphorus, iron, zinc, copper); starch; mono and disaccharides; fatty acids; amino acids; phytosterols; dietary fibre; essential and fatty oils. These seeds provide the body with more than 100% of vitamins E it needs, and with 70% of Group B vitamins. The nutritional and caloric value of 100 g of the product is: proteins – about 20.2 g; fats – about 53.5 g; carbohydrates – about 10.6 g; food energy – about 605 kcal [23-25].

The papers by H. Simakhina, V. Pasichny, N. Slobodyanyuk, Yu. Sukhenko, L. Avdeyeva and others deal with the theory and practice of using plant-based functional supplements in the technologies of manufacturing chopped semi-finished products and forcemeat [1,2,12,13]. N. Stetsenko's papers, as well as those by a number of foreign researchers, focus on studying oilseeds as a promising source of bioactive dietary supplements [14,15,17,18,21]. Besides, vitaminised oil blends were once used in meat pâtés [22]. Thus, there are unsystematised data on how some supplements of plant origin (among them oilseed-based ones) effect on meat raw material and finished meat products. However, we can find no information as for the systemic approach to developing oilseed-based complex supplements to be used in the forcemeat products technology. So, it should be studied and scientifically reasoned whether it is practical to combine different oilseeds when making a dietary supplement to be added to forcemeat products.

The **purpose** of the study is giving scientific reasons and creating a multifunctional dietary supplement, which is a mixture of different oilseed varieties, to be further used in the technology of meat pâtés and chopped semi-finished products. For this purpose, the following **objectives** have been set and achieved:

– considering whether oilseeds can be used in the meat products technology;

– modelling the seed mixture composition;

– studying the quality characteristics of the supplement obtained;

– determining and giving reasons for the optimum proportion of the mixture in the recipes of meat pâtés and chopped semi-finished products.

## Research materials and methods

The objects of the study were products of the brand *Sto pudiv* (Kharkov, Ukraine), namely: flax-seeds (country of origin – Ukraine, nutritional value of 100 g of the product: proteins – 21.8 g, fats – 39.5 g, carbohydrates – 27.8 g), sunflower kernels (country of origin – Ukraine, nutritional value of 100 g of the product: proteins – 20.8 g, fats – 51.4 g, carbohydrates – 20.1 g), sesame seeds (country of origin – India, nutritional value of 100 g of the product: proteins – 20.0 g, fats – 40.0 g, carbohydrates – 28.1 g), pumpkin seeds (country of origin – Ukraine, nutritional value of 100 g of the product: proteins – 24.0 g, fats – 33.1 g, carbohydrates – 4.7 g).

The seeds were ground with a technological laboratory mill LMT-2 (made by LLP OLIS, Ukraine) equipped with an automatic grain supply measurer and with replaceable calibrated screens (mesh sizes 0.8 mm, 0.57 mm, 0.4 mm, and 0.35 mm).

Model forcemeat systems were prepared by mincing the meat raw material (50 % of beef and 50 % of chicken) in a laboratory mincer (the hole plate diameter 8 mm).

Physico-chemical, functional and technological properties were determined by standard methods [26].

## Results of the research and their discussion

At the first stage of the research, an analysis of scientific literature allowed selecting four oilseed varieties, namely sesame, flax, sunflower, and pumpkin seeds, as they were promising raw materials for bioactive supplements to meat products due to their valuable chemical composition and functional properties.

In meat products manufacturing technology, plant raw material can be pre-processed in different ways, and the most common preparatory operation is grinding, or crushing [27]. Destroying the dispersed structure allows controlling its structural and mechanical properties. Besides, as complex conformational and destructive transformations of plant raw material biopolymers take place, the digestion of nutrients accelerates [28]. So, to improve the functional and technological characteristics of the samples, they were ground into particles as big as 800 to 350 µm, and the changes in the properties depending on the fineness of grinding were determined. In a similar way, model meat systems were studied, with the crushed seeds content 10 % of the weight of the forcemeat. It has been determined that the more finely the seeds are ground, the higher is the water-binding capacity of meat systems. The highest water-binding capacity was observed in the samples where seeds had been added ground into 350 µm particles (Fig. 1).

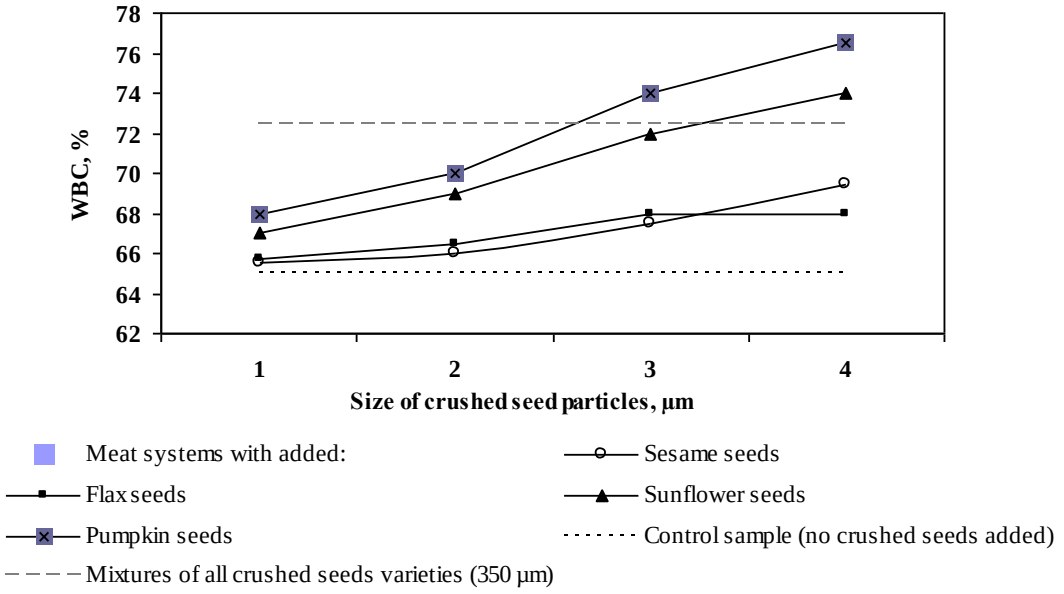


**Fig. 1. Changes in the water binding capacity of meat systems containing seeds of different crops, depending on the size of the vegetable component particles**

The results can be explained by fibre microcrystallisation that takes place while grains are finely crushed. During this process, there is an increase in fibre's water-absorbing capacity and in its ability to form stable colloidal gel.

It has also been established that seeds crushed into 350 μm particles, when added to meat systems, increase their fat holding capacity (Fig. 2). This is important for the technology, as this parameter is responsible for the product's delicate and smooth texture, prevents fat separation, and reduces the weight loss during heat treatment.

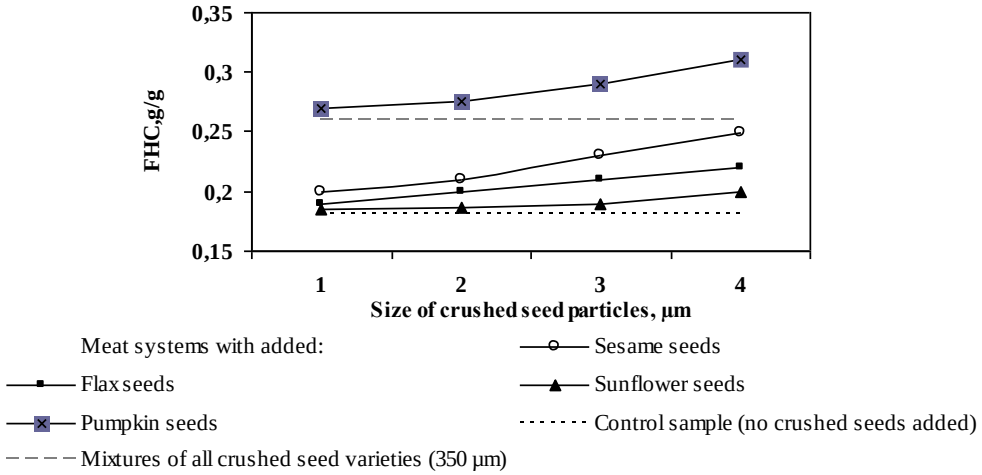


**Fig. 2. Changes in the fat holding capacity of meat systems containing seeds of different oil crops, depending on the size of the vegetable component particles**

Besides, it has been observed that the output of the finished product increases by 3–5%. This parameter is the highest for the samples with crushed pumpkin seeds added. The increased output reduces the loss of valuable water-soluble dietary and bioactive substances while water is lost during heat treatment.

The next stage of the work was modelling a composite oilseed mixture to be further used as a dietary supplement. Analytically, on studying the literature, it has been established that all the oilseed varieties under analysis are high in their nutritional value and functional and technological characteristics. As a most important parameter that allows evaluating whether a supplement can be used is its sensory properties depending on its individual compositional features, the content of certain components has been determined, primarily, by sensory evaluation. To this end, sesame, flax, sunflower, and pumpkin seeds, ground as fine as into 350 μm particles were mixed together in different proportions. The content of certain components varied 10 to 50% (Table 1).

On analysing the sensory evaluation results (Fig. 3), it has been decided in favour of the equal ratio of the four seed varieties in the composition of the complex supplement.

The qualitative characteristics of the experimental supplement are given in Tables 2 and 3.

The studies evidence that the gustatory and aromatic features of the whole supplement and of its individual components are quite pronounced. Nevertheless, at a certain concentration, they do not affect the sensory characteristics of finished products.

The biological value of any functional supplement is as important. It is known that oilseed proteins are high in various essential amino acids. Table 4 presents the amino acid composition of the supplement under analysis.

It has been established that the supplement can be a source of high quality protein (21–22 %). A considerable carbohydrate content, where starch and fibre prevail, results in the complex supplement's water and fat binding capacity. Besides, it has a positive effect on its emulsifying efficiency and gel-forming capability.

**Table 1 – Selection of the components of the oil crops composite mixture**

| **Variant combination of the components of the oil crops composite mixture** | | | |
|---|---|---|---|
| Variant 1 | | Variant 2 | |
| Seed variety | Percentage when added | Seed variety | Percentage when added |
| sesame | 10 % | sesame | 30 % |
| flax | 30 % | flax | 10 % |
| sunflower | 30 % | sunflower | 30 % |
| pumpkin | 30 % | pumpkin | 30 % |
| Variant 3 | | Variant 4 | |
| sesame | 30 % | sesame | 30 % |
| flax | 30 % | flax | 30 % |
| sunflower | 10 % | sunflower | 30 % |
| pumpkin | 30 % | pumpkin | 10 % |
| Variant 5 | | Variant 6 | |
| sesame | 25 % | sesame | 20 % |
| flax | 25 % | flax | 20 % |
| sunflower | 25 % | sunflower | 10 % |
| pumpkin | 25 % | pumpkin | 50 % |

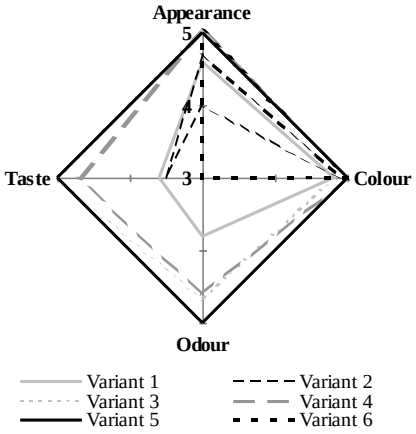


**Fig. 3. Profile chart of the sensory evaluation of variant combinations of the oil crops composite mixture components**

**Table 2 – Physico-chemical and functional and technological characteristics of the experimental supplement**

| Physico-chemical characteristics | | Functional and technological characteristics | |
|---|---|---|---|
| Mass fraction of moisture, % | 8.30 | Water holding capacity, g water/g product | 2.8 |
| Mass fraction of protein, % | 21.40 | Fat holding capacity, g fat/g product | 0.8 |
| Mass fraction of fat, % | 44.70 | Emulsifying efficiency, % | 89 |
| Mass fraction of carbohydrates, % | 22.50 | Critical gelation concentration, % | 45 |
| in particular, fibre, % | 2.10 | Hydromodulus at 20 °C | 1:3 |
| Mass fraction of ash, % | 1.00 | pH | 5.8 |

**Table 3 – Sensory characteristics of the experimental supplement**

| Parameter | Description |
|---|---|
| Appearance | Friable loose-textured powder |
| Colour | Light creamy, with brown flax inclusions |
| Odour | No off-odours, no mouldy or stale smell |
| Taste | Taste of raw seeds, with a specific tinge of flavour |

**Table 4 – Amino acid composition of the supplement (per 100 g protein)**

| Essential amino acids, g | | Non-essential amino acids, g | |
|---|---|---|---|
| Lysine | 5.40 | Alanine | 4.37 |
| Valine | 5.26 | Arginine | 11.59 |
| Methionine + cystine | 1.93 | Aspartic acid | 9.26 |
| Isoleucine | 4.26 | Histidine | 2.54 |
| Threonine | 3.94 | Glycine | 6.4 |
| Leucine | 6.90 | Glutamic acid | 19.17 |
| Phenylalanine + tyrosine | 4.00 | Oxyproline | 0.00 |
| Tryptophan | 1.60 | Proline | 4.30 |
| **Total** | **33.29** | Serine | 4.56 |
| | | **Total:** | **62.19** |
| **Total amino acids** | | | **95.48** |

However, the presence of all essential amino acids in the composition of protein is not enough to make it nutritionally valuable. Protein is only complete when all its amino acids are present in the amounts and ratio optimum for the body's normal functioning. That is why, to determine the biological value of the supplement, the amino acid score has been calculated – the percentage of each amino acid compared to its content in protein taken as standard (ideal protein). The amino acid score calculated for the experimental supplement is shown as a chart (Fig. 4).

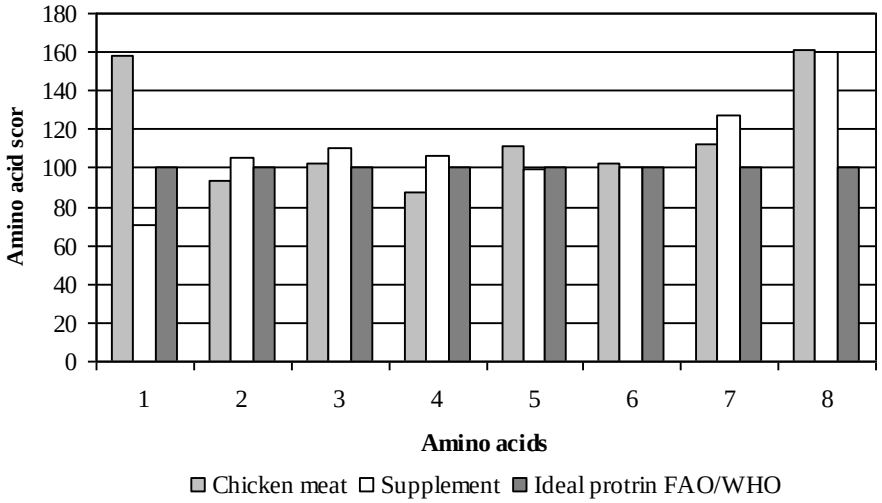


**Fig. 4. Amino acid score (%) of the supplement, of chicken meat (category 1), and of 'ideal protein'**
1 – Lysine, 2 – Valine, 3 – Methionine + cystine, 4 – Isoleucine, 5 – Threonine, 6 – Leucine, 7 – Phenylalanine + tyrosine, 8 – Tryptophan

The calculation of the amino acid score allows determining the limiting amino acid that is responsible for how much the whole protein is assimilated by the body. This is due to the fact that amino acids ingested with food in excessive quantities as compared to the limiting one do not take part in protein biosynthesis. They quickly decompose in the course of metabolism and excreted from the body. All amino acids necessary for protein biosynthesis must be easily available in a cell and present all at the same time.

In the experimental supplement, the limiting amino acid is lysine, which is typical of proteins contained in seeds. This disadvantage can be cancelled out by combining the supplement with proteins of animal origin (in particular, with chicken meat) or with animal fat. As the amino acid compositions of vegetable and animal proteins complement each other, it can make the protein well-balanced, and the biological value of the composite product can become adequate for the body's needs.

At the next research stage, the vitamin and mineral composition of the experimental supplement was determined. The results are presented in Table 5.

The analysis of the vitamin composition has shown that the newly-developed supplement contains all Group B vitamins (except for B12). Besides, there is tocopherol (E), β-carotene, ascorbic acid (C), folic acid, niacin (PP), and micro and macroelements essential for human life. Besides, by the computational method, it has been determined that a complex seed-based supplement can be a good source of polyunsaturated fatty acids, as all the four components (sesame, flax, sunflower, and pumpkin seeds) are high in Omega-3 and Omega-6 fatty acids.

When using structure-forming dietary supplements, one should know their hydromodulus (proportion of water), as gel-formation is only possible at a certain concentration of proteins and polysaccharides. To determine the optimum hydromodulus for the experimental supplement, a series of experiments has been carried out, with different mass fractions of moisture at 20ºC. The results of the experiments have shown that one part of the supplement can strongly bind 3–3.5 parts of water. That is why, the recommended hydromodulus is 1:3. Besides, the experiments made it possible to determine the optimum resting time of gel and the dependence of its viscosity on the temperature. The results are presented as a graph in Fig. 5.

**Table 5 – Vitamin and mineral content (in 100 g supplement)**

| **Vitamins, µg** | | **Macroelements, mg** | | **Microelements, µg** | |
|---|---|---|---|---|---|
| B-carotene | 0.502 | Potassium | 171.93 | Iron | 2.14 |
| Tocopherol (E) | 2.258 | Calcium | 71.25 | Manganese | 0.74 |
| Ascorbic acid (C) | 0.237 | Magnesium | 102.12 | Copper | 0.51 |
| Vitamin B6 | 0.146 | Sodium | 8.43 | Nickel | 0.03 |
| Biotin (H) | 0.417 | Sulphur | 22.62 | Tin | 0.20 |
| Nicotinic acid (PP) | 1.22 | Phosphorus | 181.93 | Zinc | 1.57 |
| Pantothenic acid (B5) | 0.155 | Chlorine | 23.62 | – | – |
| Riboflavin (B2) | 0.060 | – | – | – | – |
| Thiamine (B1) | 0.184 | – | – | – | – |
| Folacin (folic acid) | 0.030 | – | – | – | – |
| Choline (B4) | 13.9 | – | – | – | – |

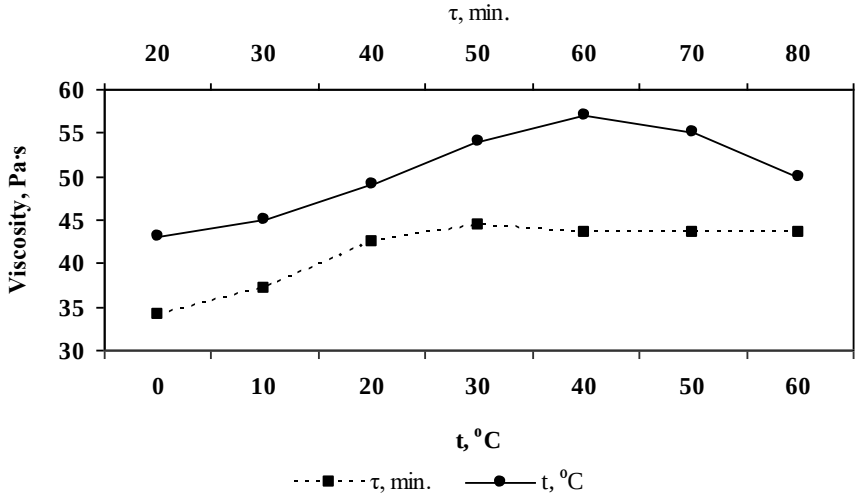


**Fig. 5. Dependence of gel viscosity on the temperature and resting time**

The study has shown that gel's optimum resting time is 30 minutes. Within this interval, gel stabilises, and during the further resting time, it gets no stronger. As seen in Fig. 3, when gel is heated to 60ºC, its viscosity increases, and if the temperature rises, this parameter decreases, which can be explained by protein denaturation.

Today, the manufacture of meat products is rather empirical: recipes are based on sensory data, and the technology is traditional in its structure, in the set and sequence of operations using traditional equipment. The optimum amount of the mixture in the formulations of pâtés and chopped semi-finished products has been determined by sensory evaluation of model forcemeat systems. The content of the supplement varied 5 to 25%. The results are visually represented in Fig. 6 and 7.

To evaluate the quality of a product, sensory analysis has an advantage as it allows determining quite quickly whether a product is safe to consume. The parameters like colour, taste, odour, consistency give a general idea of the product and help make the right choice of the main ingredients and their ratio. The research results make it possible to conclude that the supplement's percentage in the formulations of chopped semi-finished products should not be more than 20%, and in those of meat pâtés, not more than 15%, as a higher percentage of the supplement results in worse sensory characteristics.

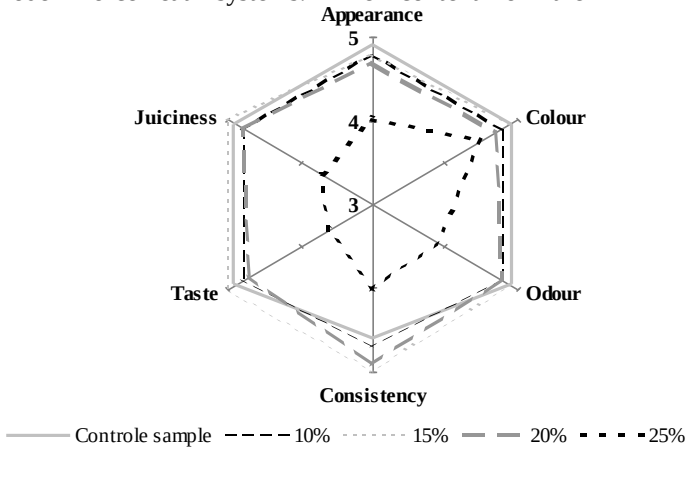


**Fig. 6. Profile chart of the sensory evaluation of the experimental samples of chopped semi-finished products with different percentages of the supplement**

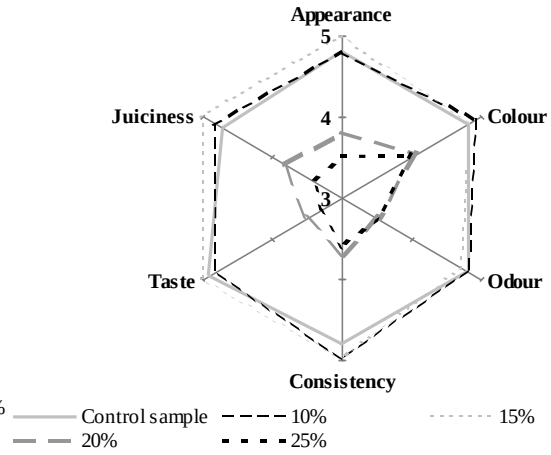


**Fig. 7. Profile chart of the sensory evaluation of the experimental samples of meat pâtés with different percentages of the supplement**

## Conclusion

Based on an analysis of research papers and reference materials, the properties of different oilseed varieties have been studied. Four oilseed varieties have been selected as the most promising to be used in meat product technologies, namely, sesame, flax, sunflower, and pumpkin seeds. A model of the seed mixture composition has been created. It has been established that the equal ratio of the seed varieties in the composition of the complex supplement is the optimum. On analysing the functional and technological properties of the four varieties of the seed raw material, it has been established that the oilseed crops can be modified by mechanodestruction. It has been shown that crushing seeds effects positively on such parameters as water binding and fat holding capacities, as well as on forcemeat output. Experimentally, it has been determined that the optimum hydromodulus for the supplement developed is 1:3, with the gel resting time 30 minutes at 60 ºC.

The model samples of meat pâtés and chopped semi-finished products have been organoleptically evaluated. The evaluation results have made it possible to recommend including 15–20% of the oilseed mixture into the composition of these meat products.

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