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PROPERTIES OF MODEL MIXED MEAT AND MEAT-CONTAINING SEMI-FINISHED PRODUCTS DEPENDING ON THE AMOUNT OF STRUCTURING AGENT

Statement of the problem. According to demographers, by 2050 the world's population will reach 9.7 billion, which requires solving problems related to food availability and food security. In the coming decades, the production of protein food must be significantly increased in order to provide it in sufficient quantities to keep up with population growth. However, animal products, especially meat, have a significant impact on the environment in terms of water and land use, greenhouse gas emissions, and energy consumption. Meat production requires a significant amount of vegetable protein. On average, 6 kg of vegetable protein are required for 1 kg of meat protein. The required amount of feed varies between 3,3, 6,4 and 25 kg for poultry, pork or beef, respectively[1]. Most people consume meat because it is perceived as tasty, healthy and nutritious and is deeply rooted in many cultures.

Analysis of recent research and publications. There are many varieties of plant-based diets for complete or limited consumption of animal protein foods: pescetarianism (abstaining from meat but consuming fish), vegetarianism (abstaining from meat and fish, but consuming animal products such as milk and eggs), lacto-vegetarianism (avoiding all animal products except milk),

1 Alexander, P., Brown, C., Arneth, A., Finnigan, J. & Rounsevell, M. D. A. (2016). Human appropriation of land for food: The role of diet. *Global Environmental Change*, 41, 88–98, https://doi.org/10.1016/j.gloenvcha.2016.09.005.

ovo-vegetarianism (avoiding all animal products except eggs), and veganism (complete rejection of products of animal origin). Flexitarianism is a more flexible and varied system of nutrition that does not have strict rules, but the basic idea is that the diet consists mainly of plant foods, but occasionally contains meat and fish.

Modern technologies for the production of meat products provide for the replacement of animal proteins with the use of processed products of plant origin. Thus, the actual meat content in finished products is reduced, which leads to a decrease in meat consumption. The share of meat-containing products in the assortment of meat-processing enterprises is dynamically increasing. A meat-containing product is a food product whose composition contains less than 60 % but not less than 15 % deveined meat or is made from offal and (or) blood.

Recently, another group of products has appeared – meat analogues[2]. These are products that can replace meat in terms of their functionality, being similar in terms of product properties and sensory characteristics.

The technologies for manufacturing meat-containing products and plant-based meat analogues require an understanding of the functional and technological properties of not only the protein source, but also the fibers and other bioactive ingredients. Although the synergistic effect caused by the combination of different ingredients makes it difficult to accurately predict behavior, it is important to pay attention to some properties characteristic of specific components. In the case of proteins, preference is given to high emulsifying ability, water solubility and amino acid composition[3]. The decisive factors in the selection of dietary fibers are gel-forming ability and viscosity, as well as moisture-retaining and emulsifying ability.

The choice of protein source plays an important role in shaping texture, color, flavor, and affects weight loss during cooking. The preference for plant-based protein sources (soy, wheat, peas, and potatoes) is largely due to their amino acid composition.

Soy protein has been one of the main sources of plant-based protein for meat alternatives and its history dates back to ancient China. Soy derivatives, such as soy flour, soy protein concentrate and soy protein isolates, are recognized as

2 Kołodziejczak, K., Onopiuk, A., Szpicer, A. & Poltorak, A. (2022). Meat Analogues in the Perspective of Recent Scientific Research: A Review. *Foods*, 11(1), 105, https://doi.org/10.3390/foods11010105.

3 Kyriakopoulou, K., Keppler, J. K. & van der Goot, A. J. (2021). Functionality of Ingredients and Additives in Plant-Based Meat Analogues. *Foods*, 10(3), 600, https://doi.org/10.3390/foods10030600.

a cheaper alternative with high nutritional value and technological properties and are used in the technology of meat and meat-containing products[4].

Meat does not contain carbohydrates, but the technology of meat products involves their use, especially in emulsified and formed processed meat products. Meat analogues and meat-containing products, on the other hand, almost always contain carbohydrates. Carbohydrates contained in meat products can come from different ingredients and perform various functions. Carbohydrate ingredients can be classified as starch or flour, which are used to improve the texture and consistency of the product, or binding ingredients or gums, such as methylcellulose, acacia gum, xanthan gum, carrageenan, and many others, which are used to improve the stability and shape of the product. From a functional perspective, these ingredients are designed to improve the interaction between the protein and lipid components and the moisture of the food system. These ingredients help to catalyze these components and form a stable structure. From a nutritional perspective, carbohydrates can be viewed as health-promoting in the form of more dietary fiber or harmful to health in the form of more refined starches or sugars. Typically, a combination of dietary fiber, starch, and sugars is included in the formulation of both meat analogues and processed meat products[5].

From a technological point of view, dietary fibers can affect the functional properties of food products related to texture, due to the ability to retain moisture and fat, the ability to gel and swell, emulsion stability, increased viscosity. The viscosity of dietary fibers is due to the physical interaction between fiber particles, closely related to the fiber microstructure[6].

Setting the task. The aim of the work is to compare the effect of a mixture of dietary fibers on the active acidity and structural and mechanical properties of minced meat and meat-containing semi-finished products of model protein

4 Singh, P. & Krishnaswamy, K. (2022). Sustainable zero-waste processing system for soybeans and soy by-product valorization. *Trends Food Sci. Technol.*, 128, 331–344, https://doi.org/10.1016/j.tifs.2022.08.015; Strashynskyi, I., Marynin, A., Perhat, O. ta Baida, Ya. (2023). Teksturovani roslynni bilky yak alternatyva miasu. *Materialy 89 Mizhnarodnoi naukovoi konferentsii molodykh uchenykh, aspirantiv i studentiv "Naukovi zdobutky molodi – vyrishenniu problem kharchuvannia liudstva u XXI stolitti"*, 3–7 kvitnia 2023 r., (ch. 1, s. 289). Kyiv: NUKHT; Krintiras, G. A., Göbel, J., van der Goot, A. J. & Stefanidis, G. D. (2015), , p. 289. Production of structured soy-based meat analogues using simple shear and heat in a Couette Cell. *Journal of Food Engineering,* 160, 34–41, https://doi.org/10.1016/j.jfoodeng.2015.02.015.

5 Hrechko, V. V., Strashynskyi, I. M. ta Pasichnyi, V. M. (2019). Kharchovi volokna yak funktsionalnyi inhrediient u miasnykh napivfabrykatakh. *Tekhnichni nauky ta tekhnolohii*, 2(16), 154–164, https://doi.org/10.25140/2411-5363-2019-2(16)-154-164; Fernandes, A., Mateus, N. & de Freitas, V. (2023). Polyphenol-Dietary Fiber Conjugates from Fruits and Vegetables: Nature and Biological Fate in a Food and Nutrition Perspective. *Foods*, 12(5), 1052, https://doi.org/10.3390/foods12051052.

6 Marvizadeh, M. M. & Akbari, N. (2019). Development and Utilization of Rice Bran in Hamburger as a Fat Replacer. *Journal of Chemical Health Risks*, 9(3), 245–251, https://doi.org/10.22034/jchr.2019.668190.

systems based on beef, soy protein texturate and soy protein isolate. In accordance with the aim of the research, the following tasks were set:

– conduct a patent information search on the topic of the work;
– develop formulations of model systems with raw materials of animal and plant origin, as prototypes of chopped meat and meat-containing semi-finished products;
– to investigate the effect of a mixture of dietary fibers in amounts of 1,5 %, 3 % and 4,5 % on model systems based on beef, soy protein texturate and soy protein isolate;
– determine active acidity and texture of the studied model systems before and after heat treatment.

The object of research is a technology of chopped meat and meat-containing semi-finished products.

The subject of research is a mixture of food fibers, meat raw materials, soy protein texturate and soy protein isolate, pre-prepared model protein systems of chopped meat and meat-containing semi-finished products.

The work investigated the effect of a mixture of dietary fibers (VIVAPUR ® MGV 100 JRS, Germany) on protein systems of animal and plant origin.

In the conducted studies, active acidity was compared by determining pH using a certified pH meter (pH 50 VIO lab, measurement accuracy ± 0.02, manufacturer – XS Instruments, Italy).

The texture profile of the samples was examined by hardness characteristics on a Shimadzu EZ-LX texturometer (Japan).

The obtained data are presented as mean ± standard deviations after triplicate determination. Statistical analysis was performed using Microsoft Excel 2007. Differences in the obtained results were considered valid at a significance coefficient of $\alpha = 0,95$ [7].

Presentation of the main material. Research was conducted in the production laboratory of LLC "FOODTEK" and the Problem Research Laboratory of the National University of Food Technologies.

As a source of animal protein, beef of the 2nd grade (pH value 5,59 ± 0,02) was used for the research. Soy protein texturate (SOYTEX 5006PC, China) and soy isolate (ISOPRO 510A, China) were used as vegetable proteins. The formulations

7 Strashynskyi, I. M. ta Hrytsai, M. S. (2024). Rozrobka kompleksu nefosfatnykh volohoutrymuiuchykh dobavok na osnovi aktyvnykh stabilizatoriv miasnykh system. *Visnyk Lvivskoho torhovelno-ekonomichnoho universytetu*, 37, 71–79, https://doi.org/10.32782/2522-1221-2024-37-12.

of the studied model systems are given in Table 1. At the first stage, emulsions were prepared based on beef fat and a mixture of dietary fibers of 1,5 %, 3 % and 4,5 %, respectively. Hydration of the mixture of dietary fibers was carried out with food ice and water in a ratio of 1:4 to a homogeneous mass, the temperature at the end of the cutting was 18±2°C. The ratio of components according to the recipes 1 M, 2 M,3 M– with meat beef grade 2, control samples, experimental samples 1 T, 2 T, 3 T– with soy protein texturate and 1 Is, 2 Is,3 Is – with soy protein isolate.

Table 1

Formulations of the studied model systems

Raw material / Sample No	Grade 2 beef	Soy protein texturate	Soy protein isolate	Dietary fiber blend	Beef fat	Moisture for hydration
	Content, %					
1 M	66	–	–	1,5	15	17,5
2 M	59,5	–	–	3	15	22,5
3 M	53,2	–	–	4,5	15	27,3
1 T	–	25,8	–	1,5	15	57,5
2 T	–	23,3	–	3	15	58,7
3 T	–	20,8	–	4,5	15	59,7
1 Iз	–	–	19,3	1,5	15	64,2
2 Iз	–	–	17,5	3	15	64,5
3 Iз	–	–	15,6	4,5	15	64,9

At the second stage, preliminary preparation of soy proteins was carried out according to the technological instructions for their use. For texturate, it was carried out by hydration (soaking in water, ratio 1:2 at a temperature of 6±2°C for 2 hours) and subsequent grinding into 2-3 mm flakes. Soy protein isolate was used after hydration (ratio 1:3), prolonged cutting to form soy granules (achieving a gel temperature of 36±2°C), after which it was cooled for 12 hours at a temperature of 4±2°C).

Beef was ground into a powder with a diameter of 2-3 mm, a phosphate-free complex of active stabilizers (1,4 % by weight of meat) and 15 % moisture by weight of raw materials were added[8].

8 Chauhan, S. S., LeMaster, M. N., Clark, D. L., Foster, M. K., Miller, C. E. & England, E. M. (2019). Glycolysis and pH Decline Terminate Prematurely in Oxidative Muscles despite the Presence of Excess Glycogen. *Meat and Muscle Biology*, 3(1), p. 74, https://doi.org/10.22175/mmb2019.02.0006.

At the third stage, experimental model systems were prepared according to the recipes by mixing on a mixer until the components were evenly distributed. 1,2 % of table salt was added to all samples. Salt increases the solubility of proteins, and added moisture is a solvent for salt and proteins, forming the textural properties of minced meat and finished products. The prepared minced meat was left for exposure for 20–30 min.

The work investigated the effect of heat treatment on experimental samples of model minced meat in a cooled state with a temperature in the middle of the product not higher than 8°C. The temperature of culinary readiness in the middle of the product of the products for meat and meat-containing chopped semi-finished products was 90°C.

The values of active acidity are given in Table 2. A significant difference in pH was observed between the samples from meat raw materials and samples with plant proteins studied. The lower pH value in samples with dietary fibers in the amount of 1,5 %, 3 % and 4,5 % compared to the pH of the raw materials was probably associated with glycolytic changes in the meat raw materials[9].

Table 2

pH values of samples of model systems

Sample No	**Dietary fiber mixture content, %**	**pH before heat treatment**	**pH after heat treatment**
1 M	1,5	5,54	5,71
2 M	3	5,35	5,63
3 M	4,5	5,52	5,51
1 T	1,5	6,34	6,43
2 T	3	6,51	6,60
3 T	4,5	6,35	6,77
1 Iз	1,5	6,28	6,35
2 Iз	3	6,61	6,68
3 Iз	4,5	6,88	7,08

According to the current study, samples using soy protein texturate and soy protein isolate showed a pH of more than 6. The higher pH in these samples

9 Anjum, F. M., Naeem, A., Khan, M. I., Nadeem, M. & Amir, R. M. (2011). Development of texturized vegetable protein using indigenous sources. *Pakistan Journal of Food Science*, 21(1), 33–44.

may be due to the alkalinity of the protein preparations containing vegetable protein (pH 7,42–7,43) compared to the controls, which are made from beef.

Similar research results were obtained by scientists in[10], who also noted that the addition of soy protein isolate at a level of 25 % significantly increases the pH in meat sausages, which is similar to the results of this study.

Figure 1 shows the measurement of the hardness of a beef sample on a Shimadzu EZLX texturometer. According to Ayadi et al.[11], hardness is an instrumental parameter for assessing the texture of meat products.

Fig. 1. Shimadzu EZ-LX texturometer (Japan).

Textural properties are crucial for meatcontaining products, since texture is an important factor in simulating organoleptic characteristics, including taste properties of finished products. The hardness values before heat treatment of meat and meat-containing systems with a content of 1.5 %, 3 % and 4.5 % of the dietary fiber mixture in the samples are presented in Figure 2.

10 Ahmad, S., Rizawi, J. A. & Srivastava, P. K. (2010). Effect of soy protein isolate incorporation on quality characteristics and shelf-life of buffalo meat emulsion sausage. *Journal of Food Science and Technology*, 47(3), 290–294, https://doi.org/10.1007/s13197-010-0045-x; Sukhenko, Yu. H., Zheplinska, M. M., Pasichnyi, V. M. ta Tymoshenko, I. V. (2019). Optymizatsiia vyrobnychykh protsesiv: [Navchalnyi posibnyk]. Kyiv: Firma «INKOS», p. 292.

11 Ayadi, M. A., Kechaou, A., Makni, I. & Attia, H. (2009). Influence of carrageenan addition on turkey meat sausages properties. *Journal of Food Engineering*, 93(3), 278–283, https://doi.org/10.1016/j.jfoodeng.2009.01.033.

The hardness of samples using meat raw materials was significantly higher compared to samples with soy protein texturate and soy protein isolate.

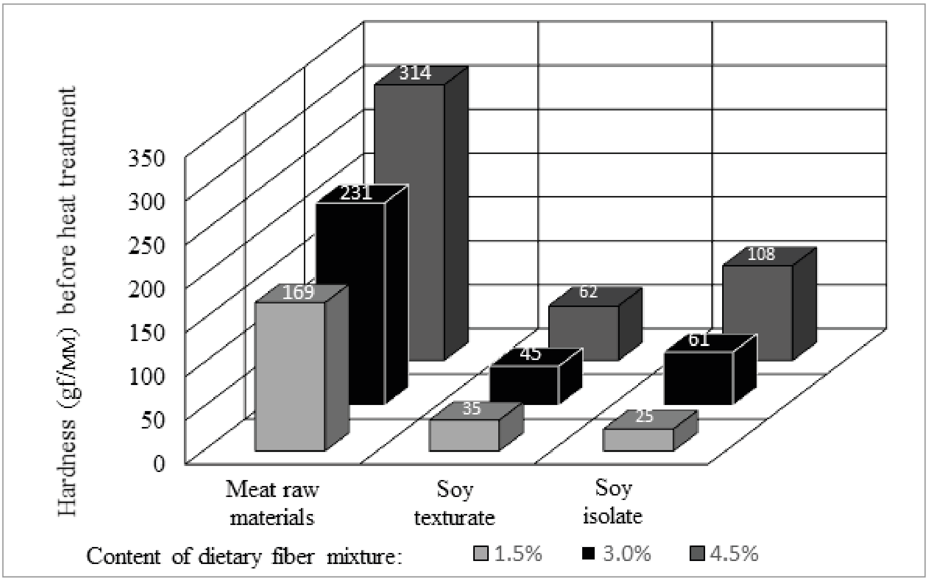

Fig. 2. Hardness (gf/mm) before heat treatment.

Figure 3 shows the hardness values of meat and meat-containing systems with different contents in the samples of the dietary fiber mixture after thermal processing.

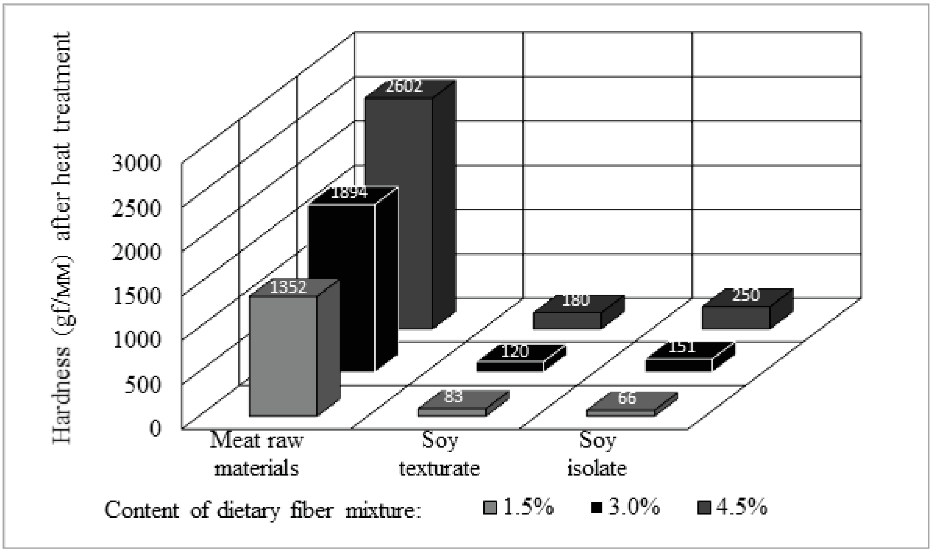

Fig. 3. Hardness (gf/mm) after heat treatment

The increase in hardness values in samples with beef grade 2 after heat treatment was expected due to denaturation of muscle proteins, which led to an increase in hardness in the meat system.

Increasing the content of the dietary fiber mixture in the formulations from 1,5 % to 4,5 % increases the hardness of all experimental model systems and shows that with an increase in the amount of binding agent, hardness values increased proportionally. Similarly, increasing the amount of carrageenan in the formulations from 0,5 % to 1,5 % increases the hardness of sausage products [15, p. 281]. The reason for the lower hardness values of the experimental samples with soy protein texturate SOYTEX 5006PC and soy protein isolate ISOPRO 510A was their high hydration, which leads to the fact that meat-containing systems become softer.

Conclusion. The use of 1,5 %, 3 % and 4,5 % of a mixture of dietary fibers in model systems of meat and meat-containing semi-finished products with beef of the 2nd grade for control and experimental samples of soy protein texturate SOYTEX 5006PC and soy protein isolate ISOPRO 510A shows that with an increase in the amount of dietary fibers, hardness values increase. In samples with texturate and soy protein isolate, the pH values is more than 6, which is due to the alkalinity of protein preparations pH 7,42–7,43. The results obtained, and the relevance of the identified scientific direction justify the need for further research to develop a structuring composition based on dietary fibers for meat-containing products.

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