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Microstructural analysis of cooked sausages with spelt flour

Larysa Bal-Prylypko*, Volodymyr Khomych, Svitlana Usenko, Valentyna Israelian, Maryna Nazarenko

National University of Life and Environmental Sciences
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine

Abstract. In a market economy, it is especially important to produce and provide the population with marketable, high-quality, and safe food products. Given its valuable chemical composition, spelt flour is a promising raw material of vegetable origin intended for improving meat products. Therefore, the purpose of the study is to clarify the features of the structure of boiled sausages and the microstructure of their components that arise during technological processing when spelt flour is added to minced sausage, using histological research methods that substantiate the microstructural analysis of control and experimental samples. The study highlights the results of the examination of microstructural analysis of sausages with the addition of spelt flour, which affects the structure formation of boiled sausages during technological processing. The study presents drawings of sections of control and experimental samples under a microscope. The main components of rubbed minced meat, which contains spelt flour, were examined and analysed to introduce new high-tech solutions that will be competitive not only in the Ukrainian, but also in the European market. Studies of histology specimens of control samples of rubbed minced meat and stained with hematoxylin and eosin identified that minced meat is represented by an inhomogeneous mass of pink-red colour with numerous vacuoles of various sizes and shapes. Sections of the samples show inclusions of spelt flour, which are located in vacuoles very similar to vacuoles with tissue fluid, but unlike the latter, they have a fibrous structure. It is established that through histological studies, which form the basis of microstructural analysis, it is possible to clearly identify all the components of minced meat from which sausages are made. The obtained results allow for expanding the range of sausages, and the use of spelt flour — enriching the finished product with biologically active substances such as dietary fibre, natural antioxidants, micro- and macronutrients

Keywords: sausages, spelt flour, histological studies, minced meat, microstructural analysis

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**Corresponding author*

Relevance

In the context of rapid growth in the world population, the problem of providing it with a sufficient amount of food products is becoming more acute. The state of nutrition of the population of Ukraine is characterised by a deficiency of many essential nutritional factors, accompanied by an imbalance in the main nutrients (proteins, fats, carbohydrates) and a pronounced deficiency of macro- and microelements, vitamins, etc. Therefore, modern food technologies provide for the creation of products that are characterised not only by high organoleptic properties but also by a balanced amino and fatty acid composition, enriched with the content of omega-three fatty acids, macro- and microelements, vitamins, and dietary fibre [1], [2].

The advantage of boiled sausage products is their high nutritional and biological value. However, the conventional technology of their manufacture is characterised by a high cost of raw materials.

Analysis of Recent Studies and Papers

Increasing the efficiency of the production of boiled sausages due to cheap plant raw materials without changing the quality indicators is a very urgent problem [3]. High-protein plant crops are now used to solve it: soy, peas, lentils, barley, etc. The modern food market offers a wide range of various additives of plant origin intended for the production of meat products [4].

Considerable attention should be paid to the appearance of new ingredients with improved functional properties, which include spelt flour [5].

Spelt is known for its healing properties. Flour is made from grain grown without the use of chemical exposure in the western and south-eastern regions of Ukraine. It preserves all the useful components contained in the grain: vitamins A, E, Group B, and the entire complex of amino acids, macro- and microelements [6], [7].

Spelt flour is a fine cream powder with a neutral taste and a light nutty smell, with a dry, uniform texture. The grinding sise according to DSTU 46.004 is 99.2%.

Spelt is characterised by a high protein content – 17.4%. The total content of dietary fibre in spelt is 14.3%, but the cellulose content is much lower – 2.1%, compared to conventional types of plant raw materials [8]. The rich vitamin and mineral composition of spelt can be explained by its specific ability to absorb nutrients from the soil better than free-threshing wheat [9], [10].

Currently, histological methods of composition identification are most widely used to control the quality of meat products. The use of such methods allows giving both a qualitative and quantitative assessment of the raw components of meat products, which form the basis of microstructural analysis [11].

The purpose of the study is to identify the features of the structure formation of boiled sausages and the microstructure of their components that arise during technological processing in the case of adding spelt flour to minced sausage by methods of histological studies, which substantiate the microstructural analysis of control and experimental samples.

Materials and Methods

The material for the research was 2 types of samples of boiled sausages (4 samples each). Control samples contained, in addition to

minced meat, pink salmon caviar, nori seaweed, vegetable components, salt, and spices (TS U 10.1 – 37792346-002:2021). Spelt flour was added to the test samples.

The research was conducted in the histological laboratory of the Department of Animal Anatomy, Histology, and Pathomorphology named after academician V.G. Kasyanenko of the National University of Life and Environmental Sciences of Ukraine.

Histological studies were performed according to the generally accepted methodology [12]. Samples with a length of 1.5-2 cm were cut out of the selected material, labelled, and fixed in an 8% aqueous solution of neutral formalin for 6 days. The recorded samples were washed with running tap water for 4 hours and dehydrated in ethyl alcohol of increasing concentration (60%, 70%, 80%, 95%, and 100%). In each solution, they were kept for 12 hours [13]. The dehydrated material was compacted with paraffin and blocks were made, from which sections with a thickness of 6-11 microns were made using an MS-2 sledge microtome. The latter were placed on slides. The sections were stained with hematoxylin and eosin, Van Gieson's stain, and placed into balsam [14], [15]. The resulting histology specimens were examined using an Olympus light microscope.

Research Results

Studies of histology specimens of control samples of rubbed minced meat and stained with hematoxylin and eosin identified that it is represented by a heterogeneous mass of pink-red colour (crushed muscle tissue) with numerous vacuoles of various sizes and shapes. They can be rounded, oval, heart-shaped, or slit-shaped. Most vacuoles are filled with air (Fig. 1), and some of them contain a pink-red substance (tissue fluid) (Fig. 2) and filamentous nori algae (Fig. 3). Most of the identified algae have a pronounced membrane and are formed by oval, square, or rectangular cells (Fig. 4).

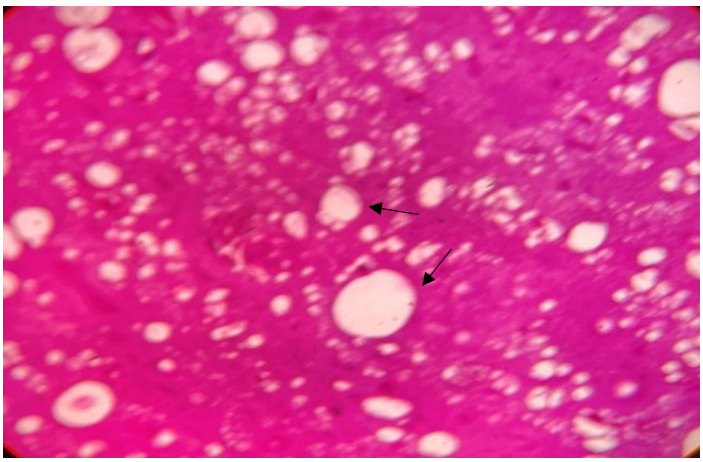

Figure 1. Vacuoles with air in the sausage of the control sample (shown by arrows). Hematoxylin and eosin dyeing. Magnification ×100

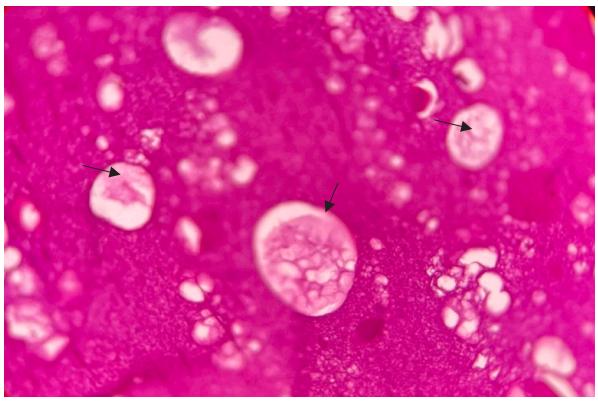

Figure 2. The substance is pink-red in the vacuoles of the sausage of the control sample (shown by arrows). Hematoxylin and eosin dyeing. Magnification ×100

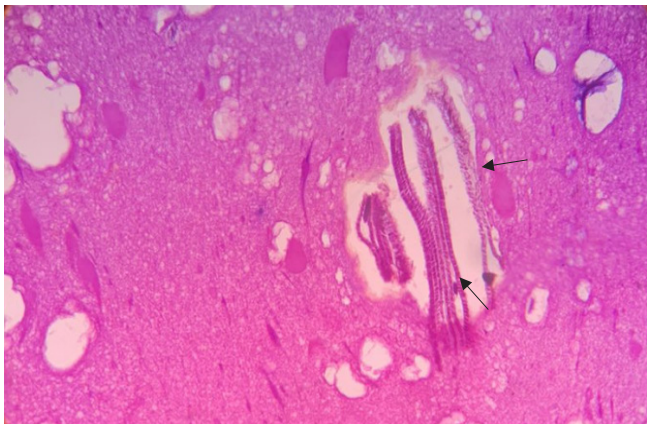

Figure 3. Filamentous nori algae (arrows) in the sausage of the control sample. Hematoxylin and eosin dyeing, ×100

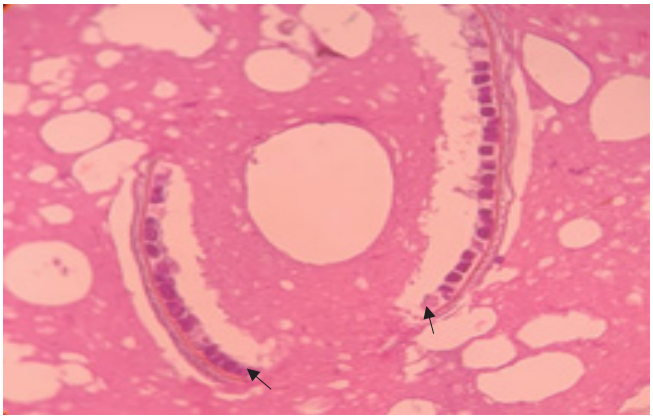

Figure 4. Nori algae cells (arrows) in the sausage of the control sample. Hematoxylin and eosin dyeing. Magnification ×200

In some cells, purple nuclei are visible. Also in this minced meat, individual fragments of completely non-destroyed muscle fibres are noticeable, which are cut along and across the transverse striation and the nuclei are not pronounced in them (Fig. 5).

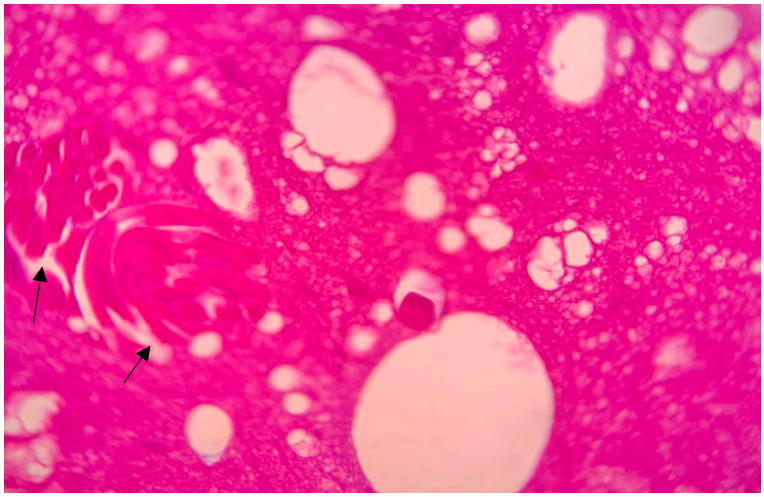

Figure 5. Fragments of muscle fibres (arrow) in the sausage of the control sample. Hematoxylin and eosin dyeing. Magnification ×100

In some vacuoles, eggs of rounded, oval, square, and diamond shapes are noticeable, which are intensely coloured dark red, and surrounded by fibrous structures of pink colour.

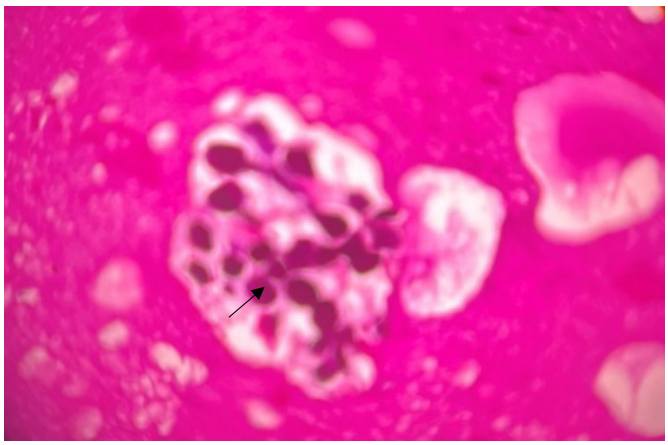

Figure 6. Group of eggs (arrow) in the sausage of the control sample. Hematoxylin and eosin dyeing. Magnification ×100

In some histology specimens of control samples, fragments of bundles of fibrous structures (bundles of collagen fibres) are detected, which, in the case of Van Gieson's staining of sections, turn red (Fig. 7). In the histology specimens of sausages of control samples, flavouring additives are detected.

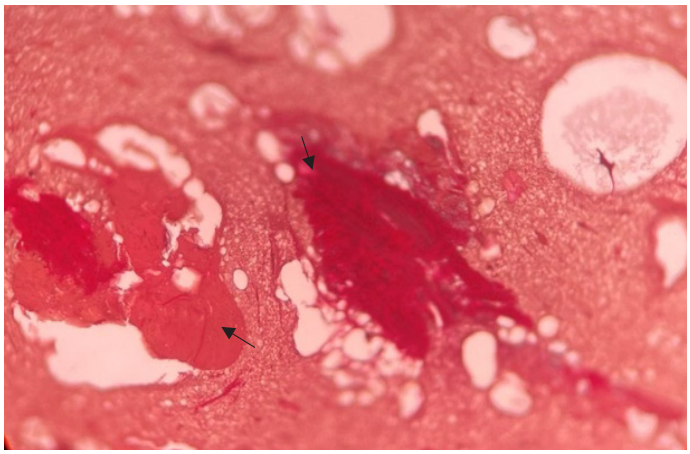

Figure 7. Bundles of fibrous structures (arrows) in the sausage of the control sample. Van Gieson's staining. Magnification ×100

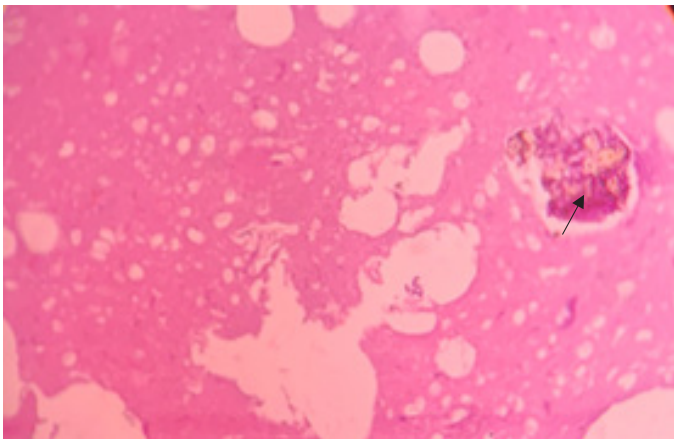

Figure 8. Pepper fragments (arrow) in the sausage of the control sample. Hematoxylin and eosin dyeing. Magnification ×100

The general plan of the microstructure of minced meat of experimental samples is similar to the same minced meat of control samples. In addition to the structures described above, it contains inclusions of spelt flour. They come in many shapes and sizes. Some of the inclusions

are located in vacuoles, and some – outside of them. In one field of view of the microscope, there can be 4-7 of them. On sections stained with hematoxylin and eosin, inclusions of spelt flour, which are located in vacuoles, are very similar to vacuoles with tissue fluid (Fig. 9), but unlike the latter, they have a fibrous structure. In the case of Van Gieson's staining of sections of experimental samples, the fibres of spelt flour inclusions acquire a specific colour. They have a gray-black colour (Fig. 10), which allows clearly differentiating them.

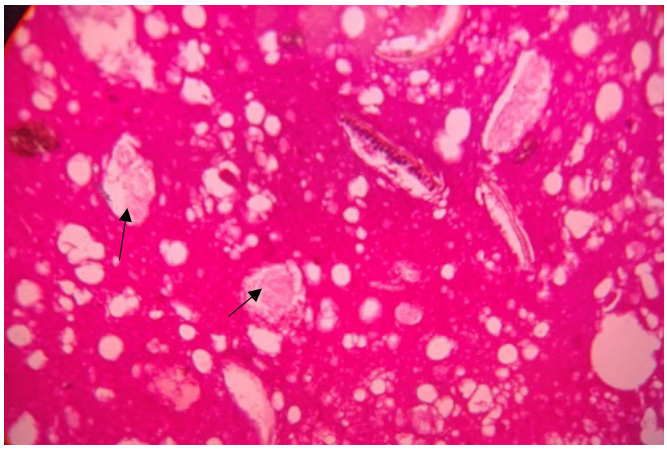

Figure 9. Inclusion of spelt flour (arrows) in the sausage of the experimental sample. Hematoxylin and eosin dyeing. Magnification ×100

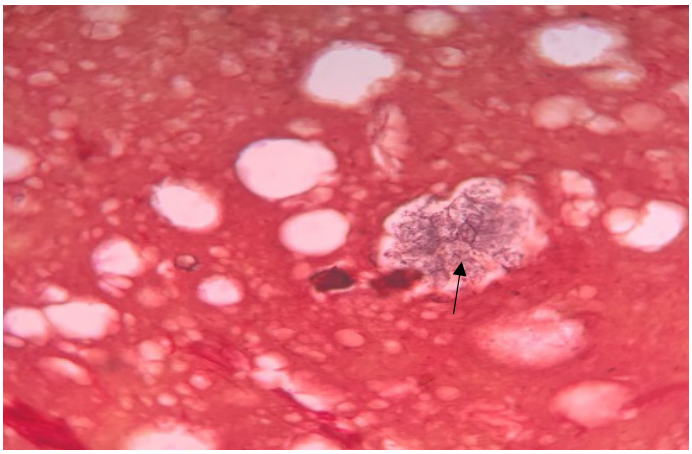

Figure 10. Inclusion of spelt flour (arrow) in the sausage of the experimental sample. Van Gieson's staining. Magnification ×100

Conclusions and Prospects

Histological studies, which form the basis of microstructural analysis, can clearly identify all the components of minced meat, from which sausages are made.

For more accurate identification of spelt flour in minced meat, which is used for making sausages, it is recommended to stain sections of histology specimens using Van Gieson's method.

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Мікроструктурний аналіз варених сосисок зі спельтовим борошном

Лариса Вацлавівна Баль-Прилипко, Володимир Тимофійович Хомич, Світлана Іванівна Усенко, Валентина Миколаївна Ісраелян, Марина Вікторівна Назаренко

Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна

Анотація. В умовах ринкової економіки особливо важливим є випуск і забезпечення населення конкурентоспроможною, якісною та безпечною харчовою продукцією. Зважаючи на цінний хімічний склад, спельтове борошно є перспективною сировиною рослинного походження, призначеною для вдосконалення м'ясних продуктів. Тому метою роботи було з'ясування особливостей структуроутворення варених сосисок та мікроструктуру їхніх складових, що виникають під час технологічної переробки при додаванні до ковбасного фаршу спельтового борошна, методами гістологічних досліджень, якими обґрунтовано мікроструктурний аналіз контрольних та дослідних зразків. У статті висвітлено результати досліджень мікроструктурного аналізу сосисок із додаванням спельтового борошна, яке впливає на структуроутворення варених сосисок, під час технологічної переробки. У статті наведено рисунки зрізів контрольних та дослідних зразків під мікроскопом. Вивчено та проаналізовано основні складові кутерованого фаршу, в якому міститься спельтове борошно, яке додавали з метою впровадження нових високотехнологічних рішень, які будуть конкурентними не тільки на українському, але й на європейському ринку. Проведеними дослідженнями гістопрепаратів контрольних проб кутерованного фаршу і зафарбованих гематоксиліном та еозином встановлено, що фарш представлений неоднорідною масою рожево-червоного кольору з численними вакуолями різноманітних розмірів і форм. На зрізах дослідних зразків виявляються включення спельтового борошна, які розташовані у вакуолях дуже подібні до вакуолей із тканинною рідиною, але на відміну від останніх вони мають волокнисту структуру. Встановлено, що за допомогою гістологічних досліджень, які складають основу мікроструктурного аналізу, можна чітко виявити усі складові м'ясного фаршу з якого виготовлені сосиски. Отримані результати досліджень дають змогу розширити асортимент сосисок, а використання спельтового борошна дозволяє збагатити готовий продукт такими біологічно-активними речовинами, як харчові волокна, природніми антиоксидантами, мікро- та макроелементами

Ключові слова: сосиски, спельтове борошно, гістологічні дослідження, фарш, мікроструктурний аналіз