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COMPARATIVE ANALYSIS OF STRUCTURAL-MECHANICAL AND FUNCTIONAL-TECHNOLOGICAL PROPERTIES OF ORGANIC AND NON-ORGANIC BEEF FOR SAUSAGE PRODUCTION

Abstract. This study aims to compare the structural-mechanical and functional-technological properties of organic and non-organic beef, focusing on parameters such as shear stress and viscosity, to determine their suitability for sausage production. Using a Structurometer ST2, we measured the shear stress and viscosity of longissimus dorsi muscle samples from both organic and non-organic beef. Additionally, the water holding capacity (WHC) was assessed using the Grau-Hamm method, and pH changes were monitored over five days. Our results revealed that organic beef exhibited significantly higher shear stress (90.32 to 121.30 Pa) and viscosity (180.64 to 242.6 Pa·s) compared to non-organic beef (shear stress: 88.24 Pa, viscosity: 176.48 Pa·s). These differences indicate that organic beef has greater toughness, density, and better emulsion properties, contributing to enhanced texture and juiciness in sausage products. Furthermore, organic beef showed a higher WHC of 75% compared to 60% for non-organic beef, along with a stable pH range of 5.6-5.7, which is crucial for maintaining meat quality during storage and processing. The findings suggest that organic beef, due to its superior mechanical properties and moisture retention capabilities, is more suitable for producing high-quality sausage products.

Keywords: shear stress, viscosity, water holding capacity, organic beef, sausage.

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Introduction. To achieve high-quality finished products, it is essential to consider the structural-mechanical and functional-technological properties of meat raw materials. In a study conducted by Poleti et al., the biological mechanisms associated with intramuscular fat deposition in the longissimus dorsi muscle were investigated, significantly influencing parameters such as meat juiciness and tenderness [1]. Hughes et al. examined the effect of pH on muscle structural changes and light scattering properties, demonstrating that darker muscles have a

higher final pH, affecting overall brightness and fiber width [2]. Research by Ba and colleagues showed that the level of marbling and aging during cooling significantly impact the technological and sensory characteristics of beef, including shear stress and taste [3]. The study of the structural-mechanical properties of the longissimus dorsi muscles reveals significant differences between organic and non-organic beef, which is a crucial factor in ensuring the high quality of finished products.

To investigate the structural-mechanical properties, the shear stress and viscosity of organic and non-organic beef were determined. Determining the shear stress and viscosity of meat raw materials is critically important to ensure the quality and stability of finished sausage products. These parameters directly affect texture, juiciness, and water retention, ultimately influencing the consumer characteristics of the product.

Shear stress is an indicator of the mechanical strength of meat, helping to determine its tenderness and texture. The viscosity of meat raw materials affects their ability to retain water and fats and the stability of emulsions during sausage production. High viscosity promotes better moisture and fat retention, improving the texture and juiciness of the finished product. Studies have shown that different types of meat have varying viscosity levels, which is important to consider when selecting raw materials for sausages [2]. Emulsion stability is a critical aspect of sausage production. It depends on the viscosity and the meat's ability to retain water and fats. Research indicates that using functional additives, such as hydrocolloids, can improve viscosity and emulsion stability, thereby enhancing sausage product quality [4]. Determining the shear stress and viscosity of meat raw materials plays a key role in ensuring the quality and stability of finished sausage products. These parameters influence texture, juiciness, and water retention capacity, making them essential for the selection and processing of meat raw materials in production.

Materials and methods. The objects of the research are samples of organic and non-organic beef taken from the longissimus dorsi muscles. The beef samples were obtained from certified organic and conventional farms, ensuring compliance with production and storage standards.

Determination of Shear Stress. To measure the shear stress of the meat samples, a Structurometer ST2 (Labreaktiv, Russia) was used. Meat samples measuring 1x1x3 cm were prepared and placed in the device chamber. Measurements were taken at a constant shear rate of 2 mm/s. The shear stress readings were recorded and analyzed to identify differences between organic and non-organic beef. This method allows for the assessment of the mechanical strength of the meat, which is crucial for determining its tenderness and texture.

Determination of Viscosity. The viscosity of the meat raw materials was also measured using the Structurometer ST2 (Labreaktiv, Russia). The meat samples were ground to a paste-like consistency and placed in the cylindrical chamber of the device. Measurements were taken at a constant spindle rotation speed, providing the viscosity values of the samples. High viscosity indicates a better ability of the meat to retain water and fats, which is important for sausage production.

Determination of Water Holding Capacity by the Grau-Hamm Method. The water holding capacity of the meat raw materials was assessed using the Grau-Hamm method. Meat samples weighing 5 g were placed between two layers of filter paper and subjected to pressure for 10 minutes at 25°C. The diameter of the moisture spot formed on the filter paper was then measured. The smaller the

diameter of the spot, the higher the water holding capacity of the meat. This method evaluates the ability of meat raw materials to retain moisture, which is a crucial parameter for the texture and juiciness of finished products.

All measurements were performed in triplicate to ensure the reliability of the results. Statistical data analysis included the use of analysis of variance (ANOVA) methods to identify significant differences between organic and non-organic beef.

Research results. An experiment was conducted to measure the shear force values for both organic and non-organic beef (Fig. 1, 2). The results indicated that organic beef exhibited higher shear force, shear stress, and viscosity values compared to non-organic beef.

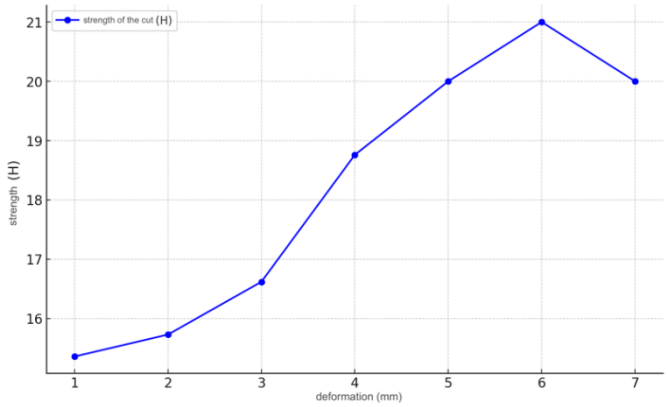

Fig. 1. The cutting power of organic beef

This finding suggests that organic beef has superior mechanical properties, potentially leading to better texture, juiciness, and overall quality in the final meat products.

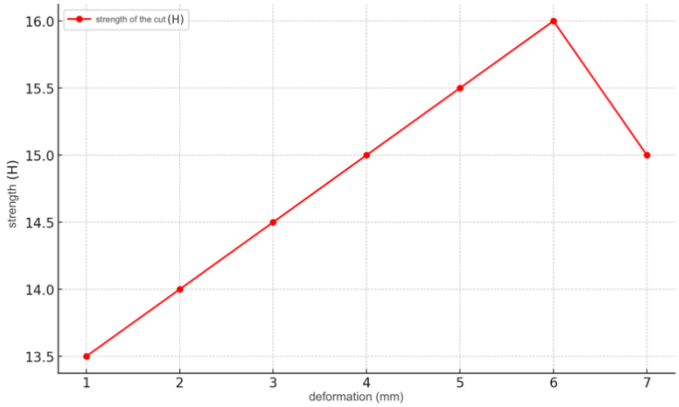

Fig. 2. The strength of the cut of inorganic beef

The higher shear force and stress values imply that organic beef is tougher and more resilient, while the increased viscosity indicates a greater ability to retain moisture and fats, which is crucial for the production of high-quality sausage products.

Based on the obtained data on shear force, deformation, and shear rate, the shear stress and viscosity of the meat raw materials were determined. The study

revealed significant differences in the mechanical properties of organic and non-organic beef (Fig. 3).

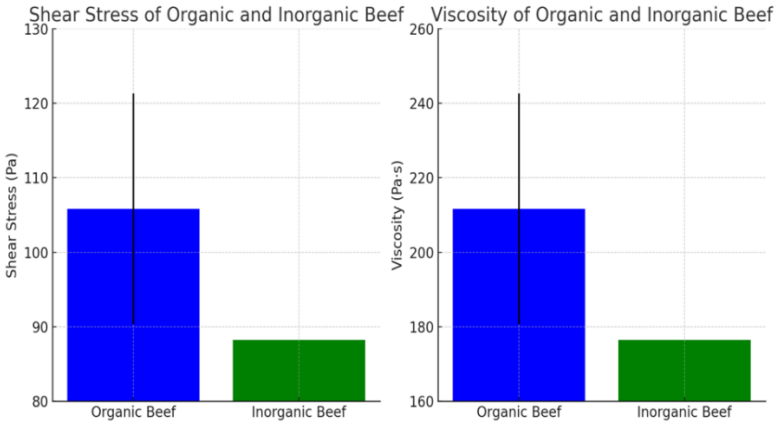

Fig. 3. Shear stress and viscosity of meat raw materials

The study revealed significant differences in the mechanical properties of organic and non-organic beef. Samples from the longissimus dorsi muscle of organic beef exhibited higher shear stress values ranging from 90.32 to 121.30 Pa and viscosity values from 180.64 to 242.6 Pa·s compared to non-organic beef, which had a shear stress of 88.24 Pa and viscosity of 176.48 Pa·s.

Organic beef demonstrated higher shear stress and viscosity values, indicating greater toughness and density compared to non-organic beef. These differences are important to consider in the production of finished meat products, as they can affect the texture and quality of the final product (Fig. 4).

The differences in texture are undoubtedly related to the conditions of raising, feeding, and processing the animals. Organic beef was subject to more natural and less intensive methods of raising and feeding, which affected the structure of muscle fibers and connective tissue.

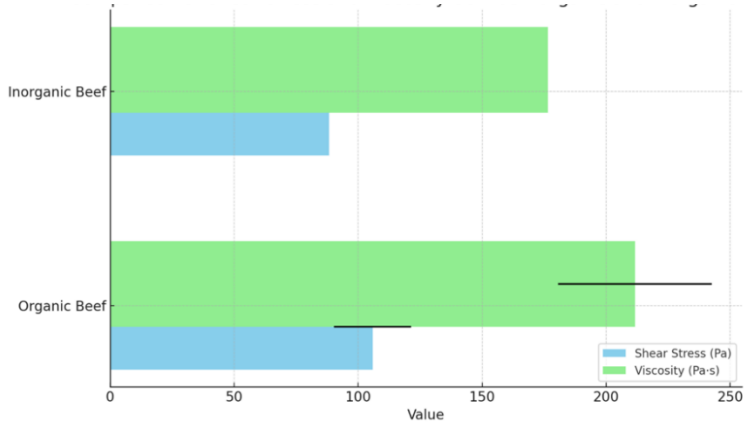

Fig. 4. Comparative analysis of the structural and mechanical properties of meat raw materials

Higher shear stress and viscosity of organic beef indicate its greater toughness and density. This means that sausage products made from organic beef

will have a more stable texture, which is particularly important for maintaining the shape and structure of the product during storage and transportation [5].

The high viscosity values of organic beef contribute to better water and fat retention, improving the emulsion properties of the mince. This results in a more stable sausage consistency, reducing the likelihood of separation and syneresis, ultimately enhancing the quality stability of the product throughout its shelf life [6]. Additionally, the greater density and toughness of organic beef can enhance the organoleptic properties of sausage products, such as juiciness and texture, making them more appealing to consumers. This can contribute to increased consumer demand and loyalty to the product.

To study the functional-technological properties of the meat, water holding capacity (WHC) was determined using the Grau-Hamm method, along with pH changes over 5 days. The water holding capacity (WHC) of meat determines its visual appeal, weight loss, technological yield, and sensory characteristics upon consumption. Various factors such as animal age, pre-slaughter stress, and storage temperature can significantly influence meat WHC [7]. The high water holding capacity of organic beef may be associated with more favorable raising conditions and less stress for the animals before slaughter [8].

The water holding capacity of meat is a critically important quality indicator as it affects water retention during storage and cooking, as well as the final organoleptic properties of meat products (Fig. 5). The pH level of the meat is also important for ensuring the stability of its quality and texture.

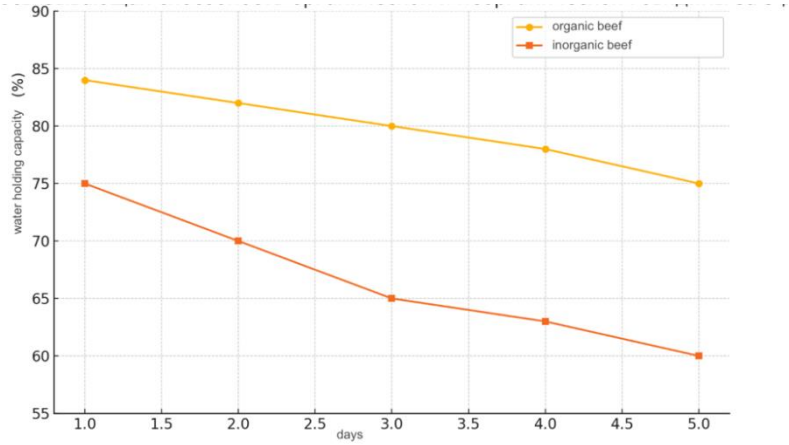

Fig. 5. Change in the BCC of meat raw materials for 5 days

The study showed that organic beef has a higher moisture binding capacity of 75% compared to non-organic beef of 60%, which indicates its better ability to retain water during storage and cooking.

The pH level of organic beef is stable in the range of 5.6-5.7 for 5 days, which contributes to better meat quality and texture, whereas the pH of inorganic beef, in the range of 5.7-5.8, is less stable and can negatively affect moisture retention. The data obtained are consistent with the results of the study of structural and mechanical properties. Thus, organic beef, having a higher shear stress, demonstrates a better moisture binding ability, which makes it the preferred choice for consumers looking for high-quality and natural products.

Discussion. The organic beef samples from the longissimus dorsi muscle exhibited higher shear stress values ranging from 90.32 to 121.30 Pa and viscosity

values from 180.64 to 242.6 Pa·s compared to non-organic beef, which had a shear stress of 88.24 Pa and viscosity of 176.48 Pa·s. These findings suggest that organic beef is tougher and denser, which has significant implications for the production and quality of finished meat products.

Higher shear stress and viscosity in organic beef indicate greater mechanical strength and cohesiveness, crucial for maintaining the texture and structural integrity of sausage products during storage and transportation. This stability is vital for ensuring product quality and consumer satisfaction. Additionally, the higher viscosity of organic beef enhances its ability to retain water and fats, improving the emulsion properties of the meat mixture. This results in a more consistent sausage product, reducing the risk of separation and syneresis, ultimately enhancing product quality throughout its shelf life [9].

The differences in texture between organic and non-organic beef are likely due to variations in raising, feeding, and processing methods. Organic beef, raised under more natural and less intensive conditions, exhibited superior muscle fiber and connective tissue structure, contributing to its enhanced mechanical properties. This is consistent with findings from other studies, which have demonstrated that organic farming practices can positively affect meat quality [10].

To further investigate the functional-technological properties of the meat, we assessed the water holding capacity (WHC) using the Grau-Hamm method and monitored pH changes over five days. WHC is a critical indicator of meat quality, affecting visual appeal, weight loss, technological yield, and sensory characteristics. Factors such as animal age, pre-slaughter stress, and storage temperature significantly influence WHC [11]. Organic beef demonstrated a higher WHC of 75% compared to 60% in non-organic beef, indicating better water retention during storage and cooking. This improved WHC is likely due to the favorable raising conditions and reduced stress experienced by organically raised animals [12].

The pH levels of the meat also played a crucial role in determining quality and texture stability. Organic beef maintained a stable pH range of 5.6-5.7 over five days, contributing to better meat quality and texture. In contrast, the pH of non-organic beef, ranging from 5.7-5.8, was less stable, potentially affecting moisture retention negatively.

The data obtained in this study are consistent with the results of other studies on structural-mechanical properties of meat. For instance, similar research has shown that organic beef exhibits better textural qualities and moisture retention due to its higher shear stress and viscosity values [13]. These findings underscore the importance of considering both structural-mechanical and functional-technological properties in meat production to ensure the development of superior finished products that meet consumer expectations.

Conclusion. This study demonstrated significant differences in the structural-mechanical and functional-technological properties between organic and non-organic beef. Organic beef samples from the longissimus dorsi muscle exhibited higher shear stress and viscosity values, indicating greater toughness and density. These properties are crucial for maintaining the texture and structural integrity of sausage products during storage and transportation. The higher viscosity and shear stress of organic beef contribute to better water and fat retention, enhancing the emulsion properties and overall consistency of the sausage mixture. Additionally, organic beef showed superior water holding capacity (WHC) and stable pH levels over five days, further supporting its suitability for sausage production. These characteristics ensure better moisture retention and

quality stability, which are essential for producing high-quality meat products. The findings align with previous studies, reinforcing the notion that organic farming practices positively influence meat quality. In conclusion, organic beef, with its enhanced mechanical properties and improved functional-technological characteristics, is a more suitable choice for sausage production compared to non-organic beef. Its ability to retain moisture and fats, along with its stable pH levels, makes it an ideal ingredient for creating high-quality sausage products that meet consumer expectations.

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ШҰЖЫҚ ӨНДІРІСІНДЕ ОРГАНИКАЛЫҚ ЖӘНЕ ОРГАНИКАЛЫҚ ЕМЕС СИЫР ЕТІНІҢ ҚҰРЫЛЫМДЫҚ-МЕХАНИКАЛЫҚ ЖӘНЕ ФУНКЦИОНАЛДЫҚ-ТЕХНОЛОГИЯЛЫҚ ҚАСИЕТТЕРІН ТАЛДАУ

Аңдатпа. Бұл зерттеу органикалық және органикалық емес сиыр етінің құрылымдық-механикалық және функционалдық-технологиялық қасиеттерін салыстыруға, олардың ығысу кернеуі мен тұтқырлығы сияқты параметрлерге назар аударуға, олардың шұжық өндіруге жарамдылығын анықтауға бағытталған. ST2 Структурометрін қолдана отырып, біз органикалық және органикалық емес сиыр етінен алынған longissimus dorsi бұлшықет үлгілерінің ығысу кернеуі мен тұтқырлығын өлшедік. Сонымен қатар, суды ұстау қабілеті Грау-Хамм әдісімен бағаланды және pH өзгерістері бес күн ішінде бақыланды. Біздің нәтижелеріміз органикалық сиыр етінің органикалық емес сиыр етімен (ығысу кернеуі: 88,24 Па, тұтқырлығы: 176,48 Па) салыстырғанда ығысу кернеуі (90,32-ден 121,30 Па) және тұтқырлығы (180,64-тен 242,6 Па·с) айтарлықтай жоғары екенін көрсетті. Бұл айырмашылықтар органикалық сиыр етінің қаттылығы, тығыздығы және эмульсиялық қасиеттері жоғары екенін көрсетеді, бұл шұжықтардың құрылымы мен шырындылығының жоғарылауына ықпал етеді. Сонымен қатар, органикалық сиыр етінің ылғал ұстау қабілеті 75% органикалық емес сиыр 60% етінің салыстырғанда жоғары болды, сонымен қатар тұрақты pH диапазоны 5,6-5,7 болды, бұл сақтау және өңдеу кезінде ет сапасын сақтау үшін өте маңызды. Нәтижелер органикалық сиыр етінің жоғары механикалық қасиеттері мен ылғалды сақтау қабілетіне байланысты жоғары сапалы шұжық өнімдерін өндіруге қолайлырақ екенін көрсетеді.

Тірек сөздер: ығысу кернеуі, тұтқырлығы, суды ұстау қабілеті, органикалық сиыр еті, шұжық.

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ СТРУКТУРНО-МЕХАНИЧЕСКИХ И ФУНКЦИОНАЛЬНО-ТЕХНОЛОГИЧЕСКИХ СВОЙСТВ ОРГАНИЧЕСКОЙ И НЕОРГАНИЧЕСКОЙ ГОВЯДИНЫ ДЛЯ ПРОИЗВОДСТВА КОЛБАСНЫХ ИЗДЕЛИЙ

Аннотация. Цель данного исследования – сравнить структурно-механические и функционально-технологические свойства органической и неорганической говядины, уделяя особое внимание таким параметрам, как напряжение сдвига и вязкость, чтобы определить их пригодность для производства колбасных изделий. Используя структурометр ST2, мы измерили напряжение сдвига и вязкость образцов длиннейшей мышцы спины как из органической, так и из неорганической говядины. Кроме того, с помощью метода Грау-Хамма была оценена влагоудерживающая способность (WHC), а изменения pH контролировались в течение пяти дней. Наши результаты показали, что органическая говядина обладает значительно более высоким напряжением сдвига (от 90,32 до 121,30 Па) и вязкостью (от 180,64 до 242,6 Па·с) по сравнению с неорганической говядиной (напряжение сдвига: 88,24 Па, вязкость: 176,48 Па·с). Эти различия указывают на то, что органическая говядина обладает большей твердостью, плотностью и лучшими эмульсионными свойствами, что способствует улучшению текстуры и сочности колбасных изделий. Кроме того, органическая говядина показала более высокий показатель полезного действия – 75% по сравнению с 60% у неорганической говядины, а также стабильный диапазон pH 5,6-5,7, что имеет решающее значение для поддержания качества мяса при хранении и переработке. Полученные результаты свидетельствуют о том, что органическая говядина, благодаря своим превосходным механическим свойствам и способности удерживать влагу, больше подходит для производства высококачественных колбасных изделий.

Ключевые слова: напряжение сдвига, вязкость, влагоудерживающая способность, органическая говядина, колбаса.