ANIMAL SCIENCE AND FOOD TECHNOLOGY

Journal homepage: https://animalscience.com.ua/en
Animal Science and Food Technology, 17(2), 18-31
Received 03.01.2026 Revised 23.04.2026
Accepted 21.05.2026 Published 29.05.2026

UDC 637.05
DOI: 10.31548/animal.2.2026.18

ISSN 2706-8331
e-ISSN 2706-834X

A study of changes in the functional-technological properties of minced meat systems based on hake and broiler chicken meat mince

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Abstract. The relevance of the research stems from increased consumer interest in combined meat products, which necessitates determining the optimal formulation combinations of raw materials of different origins. The aim of the study was to determine changes in the functional-technological and rheological properties of minced systems depending on the ratio of meat and fish raw materials and the carrageenan content. Four formulations based on broiler chicken

Suggested Citation:
Pasichnyi, V., Bondarenko, L., Svyatnenko, R., & Shubina, Ye. (2026). A study of changes in the functional-technological properties of minced meat systems based on hake and broiler chicken meat mince . *Animal Science and Food Technology*, 17(2), 18-31. doi: 10.31548/animal.2.2026.18

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meat were investigated with the addition of 0 or 10% hake mince and 2.8-5.2% carrageenan. The samples were heat-treated to 70 °C followed by determination of moisture content, water-holding capacity, pH, plasticity, and rheological properties. The moisture content ranged from 71.21 to 74.85%. After heat treatment, moisture losses were 3.06-5.75%, with lower losses observed in samples containing higher levels of carrageenan, indicating the formation of a more stable gel structure. The highest water-holding capacity was observed in samples containing fish raw material. The pH increased to 6.21-6.32 with a further slight increase after heating. Rheological studies demonstrated pseudoplastic behaviour of the systems, with viscosity decreasing as the applied load increased. The addition of fish raw material increased the effective viscosity but reduced the yield shear stress. The obtained results confirm the feasibility of combining meat and fish raw materials with carrageenan to regulate the functional-technological properties and to form stable structures of minced systems. In addition, a decrease in plasticity after heat treatment and a change in yield shear stress were established, indicating the transition of the systems from a viscoplastic to an elastically structured state and the formation of a denser structure in the minced systems. The obtained results may be applied in the production of meat products with the addition of fish raw materials for the targeted regulation of functional-technological properties and the formation of a stable protein-polysaccharide structure of the finished product

Keywords: semi-finished meat products; hydrobionts; combined meat products; hydrocolloids; rheological properties; functional properties

Introduction

Modern approaches to the formation of food product assortments are increasingly focused on the scientifically substantiated combination of ingredients of different natural origins in order to achieve a balanced chemical composition, increase nutritional value, and improve the functional-technological properties of finished products. Such a strategy for the development of food technologies is based on the principles of rational nutrition, functional food design, and reducing the negative effects of excessive consumption of certain nutrients. According to the results of sociological studies conducted in European countries by researchers M. Banovic *et al*. (2022) and A.M. Barone *et al*. (2021), the majority of consumers positively perceive the creation of so-called hybrid products that combine meat, fish, and plant raw materials within a single formulation, particularly when familiar organoleptic characteristics are preserved.

This approach opens broad opportunities for the targeted regulation of the nutritional and biological value of products, particularly through optimisation of the amino acid composition of the protein fraction, reduction of the total saturated fat content, increase in the proportion of polyunsaturated fatty acids, as well as enrichment of products with biologically active components of natural origin. At the same time, the use of combined raw materials contributes to the improvement of technological indicators, including structural-mechanical and rheological characteristics, increased stability of emulsion systems, reduction of syneresis, and improvement of water- and fat-binding capacity, which is critically important for ensuring the stable quality of finished products throughout their shelf life. The development of the modern meat-processing industry is largely determined by the need to optimise product formulations in accordance with the principles of rational and functional nutrition, particularly balance in proteins, fats, carbohydrates, and micronutrients. Particular attention is also paid

to reducing the energy value of products without loss of their technological and consumer qualities. One of the effective approaches to such improvement, according to the research of S.Y.J. Sim *et al*. (2021), is the combination of raw materials of different origins, which makes it possible to purposefully regulate the nutritional and biological value of products, as well as to increase their functionality through the synergistic interaction of components within the food system.

According to OECD/FAO (2025), the production of meat and fish products demonstrated a stable growth trend during 2020-2025, driven both by increasing global demand for protein products and by the gradual expansion of the range of food products with added technological value. At the same time, according to the studies of researchers C. Barcenilla *et al.* (2022) and S. Sheffield *et al*. (2024), meat products remain one of the key and most accessible sources of complete protein, essential amino acids, B-group vitamins, and a number of minerals necessary for the normal functioning of the human body. As noted in the work of M.W.M. Kharl *et al*. (2025), fish is a valuable functional food product characterised by a high content of complete protein with high biological value, a significant amount of polyunsaturated fatty acids (particularly the omega-3 fraction), as well as a wide range of vitamins and minerals that positively affect metabolic processes and overall health. Owing to this, fish raw material is regarded as an important component for the creation of combined protein systems with increased nutritional value.

Particular attention among fish raw materials is attracted to hake, which, according to the studies of M.J. Santos *et al.* (2022), is one of the most widespread commercial fish species in Europe and has stable industrial significance. Its meat is characterised by a white colour, dense and fibrous consistency, low fat content, and favourable functional-technological properties, which determines the feasibility of its use in the production of combined meat-fish products. In addition, researchers R. Mendes *et al.* (2021) established that the physicochemical and structural properties of fish meat change significantly depending on storage conditions and methods, particularly chilling or freezing, which must necessarily be taken into account when designing processing technologies. In modern meat technologies, polysaccharides of natural and modified origin are regarded as functionally active ingredients capable of significantly influencing the structural-mechanical and rheological properties of minced systems. According to the findings of J. Shao *et al*. (2025), their action is due to the ability to form spatial hydrocolloid structures as a result of interaction with the aqueous phase, proteins, and lipids, thereby increasing moisture-retention capacity, stabilising the emulsion system, and reducing weight losses during heat treatment.

Studies conducted by N.E. Masiques *et al.* (2025) demonstrate that the use of hydrocolloid mixtures in meat products also significantly affects protein bioavailability and its subsequent digestion within the body. It was determined that κ-carrageenan and xanthan gum may modify protein digestion processes, influence the composition of the intestinal microbiota, regulate inflammatory pathways, and affect the intensity of oxidative processes in diets high in red meat. Such effects are associated both with changes in the structure of the food matrix and with the slowing down or modification of enzymatic protein hydrolysis in the gastrointestinal tract. The aim of the study was to determine changes in the functional-technological and rheological properties of minced systems based on broiler chicken white meat, hake mince, and carrageenan in various ratios.

Materials and Methods

The studies were carried out under laboratory conditions at the Department of Meat and Meat Products Technology of the National University of Food Technologies during 2025-2026. In

accordance with the developed experimental design, the experimental samples were formed by varying the content of structure-forming agents and the composition of the protein base, resulting in four formulation compositions. White meat of broiler chickens was selected as the main raw material for all samples. Carrageenan, previously hydrated at a ratio of 1:40, was used as the structure-forming component. According to the literature review data, the choice of carrageenan was due to its pronounced gel-forming ability. Its content in the formulations varied from 2.8% to 5.2%. The second variable component was fish raw material – hake mince, which was either excluded from the formulation (0%) or added in an amount of 10%. According to the analysis of literature sources, hake mince is one of the most widespread types of fish raw material, which makes the use of such raw material particularly relevant. As a result, four formulation variants were developed, differing in the combinations of carrageenan content and the presence of fish raw material. Such an approach made it possible to assess the effect of compositional changes on the functional-technological properties of the minced systems. The obtained formulations are presented in Table 1.

Table 1. *Formulation composition of minced systems with fish raw material*

Raw material	Sample 1	Sample 2	Sample 3	Sample 4
Broiler chicken fillet	94.8%	97.2%	84.8%	87.2%
Hake mince	0%	0%	10.0%	10.0%
Hydrated carrageenan	2.8%	5.2%	2.8%	5.2%

Source: compiled by the authors

Grinding of the meat raw materials was carried out using an HKN-22SS meat grinder. Mixing of the mince was performed in a Sirman IP 10 M meat mixer. The obtained minced systems were baked in a SIEMENS HB537A2S00 oven to an internal product temperature of 70°C. Moisture content was determined by the gravimetric drying method. For this purpose, a sample weighing 5.00 g (with an accuracy of 0.01 g) was taken and evenly distributed in a previously dried and weighed weighing dish. Drying was carried out in a drying oven at a temperature of 105 ± 2°C until a constant mass was achieved, which was monitored by repeated weighing at intervals of 30-60 minutes. Moisture content was calculated from the loss of mass after drying relative to the initial sample mass, and the result was expressed as a percentage. All measurements were performed in triplicate with subsequent averaging of the results to increase the reliability of the obtained data.

Water-binding capacity (WBC) was determined by the pressing method, which is based on the ability of the minced system to retain moisture under external pressure. For the analysis, a mince sample weighing 0.30 g was placed on filter paper and subjected to a standard load for 10 minutes. WBC was calculated in two ways: relative to the total moisture content in the sample (WBCa), which characterises the proportion of bound water; and relative to the sample mass (WBCm), which reflects the ability of the system to retain moisture per unit mass of the product. The obtained indicators make it possible to evaluate the structural-mechanical properties of the mince and the degree of water binding by protein components. Active acidity (pH) was determined by the potentiometric method using an MP511 laboratory pH meter. Prior to measurements, the pH meter was calibrated using standard buffer solutions with pH values of 4.00 and 7.00, and the electrode was cleaned and rinsed with distilled water between measurement series to prevent cross-contamination.

Effective viscosity and yield shear stress were determined using a Volarovich viscometer,

the operating principle of which is based on measuring the resistance of the material to shear under applied mechanical loading. Effective viscosity was determined as the ratio of shear stress to shear rate under specified flow conditions. Yield shear stress was established as the minimum stress required to initiate system flow. Measurements were carried out at a controlled temperature of 20 ± 1°C and within a range of regulated loads, which ensured reproducibility of the rheological characteristics. Each determination was performed in at least triplicate. The obtained indicators characterise the consistency of the mince, its plasticity, and its moulding ability, which are critically important for technological processing operations. Statistical processing of the results was carried out using determination of the mean value and standard deviation; the significance of differences between samples was assessed using Student's t-test at a significance level of $p < 0.05$

Results and Discussion

The developed minced systems, created using fish raw materials and specially selected structure-forming components, were subjected to comprehensive investigation according to the main physicochemical and rheological indicators. Such studies were carried out for a more detailed and objective assessment of their functional-technological properties, as well as to determine the stability of the formed structures in model systems. In order to establish the effect of heat treatment on the quality characteristics of the finished product, the obtained minced masses were formed into standard-shaped meat loaves. The samples were then baked under controlled temperature conditions until reaching a temperature of 70°C in the central part of the product, which ensured complete and uniform heat treatment. After cooling, the finished products were additionally analysed according to the main physicochemical indicators in order to assess the changes occurring in the structure and composition of the product during thermal processing.

The amount of bound moisture in minced systems, as well as its subsequent change after thermal treatment, is regarded as an important indicator of the level of structural organisation of the product. Variations and dynamics of this indicator make it possible to assess the effectiveness of interactions between ingredients, the degree of spatial network formation, and the overall stability of the system during technological processing. The results of determining the moisture content in the product are presented in Figure 1.

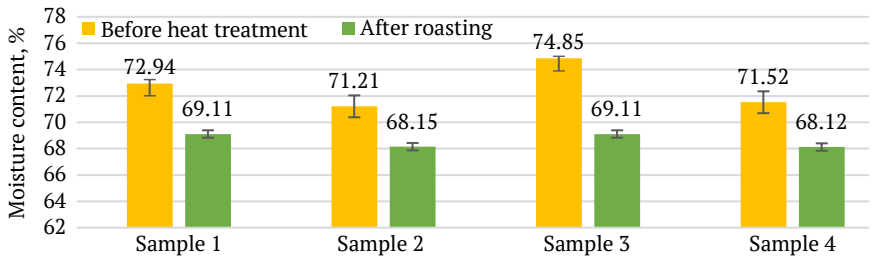

Figure 1. Changes in moisture content in minced systems before and after heat treatment
Source: compiled by the authors

According to the results presented in Figure 1, changes in moisture content in the developed minced systems showed that all experimental formulations had this indicator within the range of 71.21-74.85%. The highest moisture content was determined in Sample 3, which is explained by the higher content of hake mince. After heat treatment, the moisture con-

tent in the samples decreased by 3.06-5.75%. Lower losses were observed in the samples containing 5.2% carrageenan, indicating the formation of a stable gel matrix in these samples. Samples 3 and 4, which contained 10% hake mince, showed significant differences between each other, with decreases of 5.75% and 3.4%, respectively. This confirms the feasibility of enhancing structure formation in formulations containing fish raw material in order to ensure stability and reduce moisture losses. Similar trends are described in studies of hydrocolloid systems by T. Udo *et al*. (2023), where it was established that heat treatment promotes the formation of a denser spatial network, which partially displaces unbound moisture. As noted in the work of the research group led by M. Woo *et al.* (2025), the use of polysaccharides in meat products is effective for improving juiciness in low-fat products, which correlates with the obtained data. Lower moisture losses in samples with increased carrageenan content confirm its ability to form a stable gel matrix. Similar results were obtained in studies of meat-fish minced systems by A.M. Geredchuk *et al.* (2023) and N.M. Stukalska *et al.* (2024), where the addition of polysaccharides ensured increased water-retention capacity through the formation of a three-dimensional network that retains water in a capillary-bound state. In addition, increasing the content of fish raw material (hake) contributed to an increase in overall moisture content, which is explained by the higher hydration capacity of fish proteins compared with meat proteins. Similar conclusions were presented in the study by N. Bozhko *et al.* (2021), where it was shown that fish mince forms less dense but more moisture-saturated structures. In addition to assessing overall moisture content, determining the degree of moisture binding is also important. This indicator makes it possible to evaluate the stability of the formed dispersed system. The obtained results are presented in Figure 2.

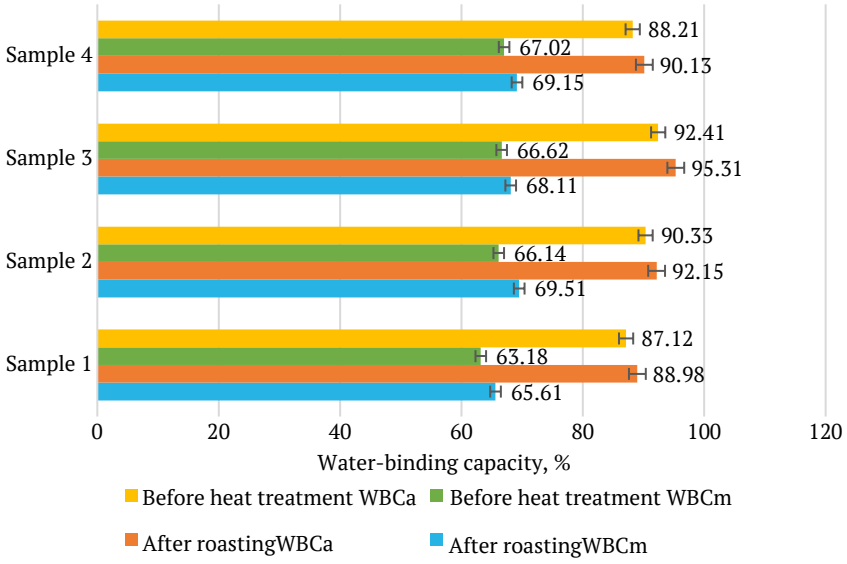

Figure 2. Water-binding capacity of the developed minced systems

Source: compiled by the authors

In accordance with the planned research programme, the water-binding capacity (WBC) of the obtained minced systems and its changes after roastingwere determined. The calculation

was carried out relative to the total moisture mass (WBCa) in the experimental sample and relative to the sample weight (WBCm) used for the analysis. The results for Sample 1 indicate the possibility of obtaining sufficiently high values with minimal addition of the structure-forming polysaccharide to broiler chicken meat mince. Sample 2 increased the WBCm values by 3.9% and WBCa by 3.17% due to the higher hydrocolloid content. After roasting, the studied indicators decreased, indicating the formation of a dense gel matrix capable of retaining moisture. Sample 3 demonstrated the highest WBCa value at 95.31%, despite moderate WBCm values of 68.11%. However, the combination of the polysaccharide-based hydrocolloid and fish raw material allowed only a slight decrease in the indicators by 2.92% and 1.49%, respectively. The highest amount of bound moisture in the finished product confirms the possibility of forming a thermally stable system as a result of the synergy between meat and fish proteins with the carrageenan-based hydrocolloid. As noted in the study by T.M. Prylipko *et al*. (2024), the combination of fish mince and plant protein components makes it possible to obtain improved structural characteristics of the product due to enhanced water binding. The obtained results of combining hake mince and broiler chicken meat indicate that the addition of fish raw material does not have a pronounced effect on water-binding capacity. The decrease in WBC values after heat treatment is consistent with the findings of T. Udo *et al.* (2023), who associate this with the transition of the system into a more ordered gel state, in which part of the water becomes less available for determination.

The obtained data show that the combination of fish raw material and hydrocolloid provides better stability of the indicators after heating. This is explained by the synergy between fish myofibrillar proteins and the polysaccharide matrix, which has been confirmed in studies of combined minced systems by N. Bozhko *et al.* (2021) and A.M. Geredchuk *et al*. (2023). At the same time, an excess of carrageenan (Sample 4) leads to a decrease in the efficiency of water binding after heat treatment, which is consistent with the findings of L. Montes *et al.* (2022) regarding possible oversaturation of the system with hydrocolloid and the formation of a fragile structure. Determining changes in active acidity during the development of a combined product makes it possible to assess the interaction of ingredients of different origins. The results of the conducted studies are presented in Figure 3.

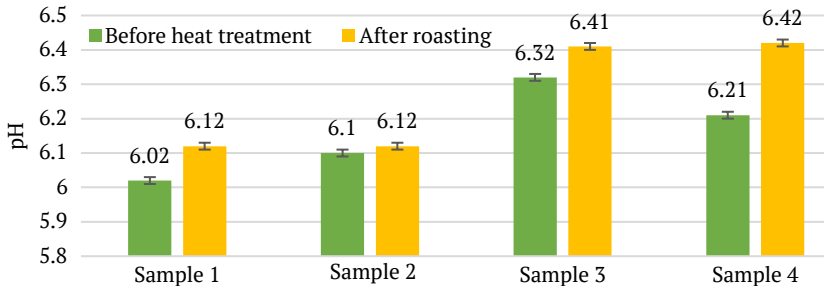

Figure 3. Changes in active acidity in minced systems before and after heat treatment
Source: compiled by the authors

The active acidity values in combined meat-fish systems primarily depend on the quantitative ratio of the raw materials. In the minced systems before heat treatment, a clear pattern was observed: the addition of hake meat contributed to a shift in pH towards the

alkaline range (6.21-6.32), which is explained by the specific biochemical composition of fish tissue and its higher intrinsic acidity level. After heat treatment to 70°C, a further increase in pH values was recorded in all experimental samples by 0.02-0.21 pH units, which is the result of thermal denaturation causing the disruption of hydrogen bonds. Considering the previously presented data, it can be stated that an increase in pH in the model minced systems promotes the formation of a stable gel matrix and improves moisture binding. The increase in pH after heat treatment is associated with protein denaturation and the destruction of hydrogen bonds, leading to the release of functional groups. A similar effect was described by T. Udo *et al.* (2023) for protein-polysaccharide systems, where heating alters the charge of protein molecules and promotes their interaction. Importantly, the increase in pH correlates with improved water-retention capacity, which is confirmed both by the obtained results and by literature data indicating that moving away from the isoelectric point enhances protein hydration. An important indicator for evaluating combined minced systems is the determination of rheological characteristics. Such indicators reflect the features of the structural organisation of the minced system and its behaviour under mechanical loading. One of the key indicators is plasticity, which determines the ability of the system to undergo deformation without destruction of the structure. The results of the conducted studies are presented in Figure 4.

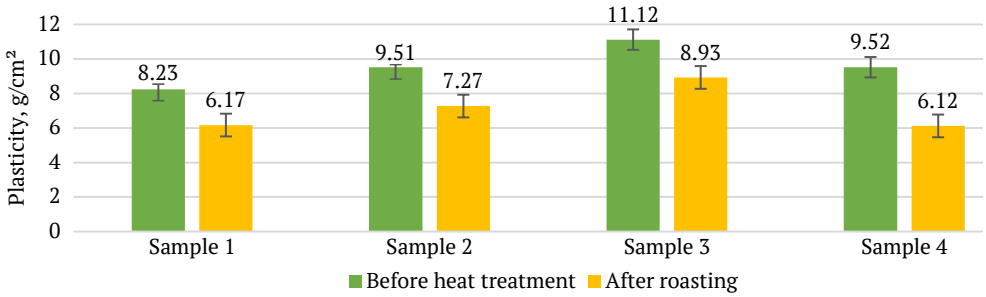

Figure 4. Plasticity of the studied minced systems

Source: compiled by the authors

Changes in plasticity in combined minced systems largely depend on the formulation composition and the state of moisture. According to the results presented in Figure 4, increasing the amount of hydrocolloid made it possible to increase the plasticity of the mince by 1.28 g/cm³. The increase in plasticity in Sample 3 correlates with the high moisture content in this sample and indicates greater flowability of the mince containing hake and a lower amount of hydrocolloid. After heat treatment, the plasticity of all experimental samples decreased by 2.06-3.4 g/cm³. Such a change is caused by the transition of the system from a viscoplastic state to an elastically mechanical state with the formation of a spatial framework that resists deformation. As can be seen from the obtained data, increasing the amount of carrageenan-based hydrocolloid intensifies the reduction in plasticity after heat treatment, despite the presence of fish raw material. The combination of 2.8% hydrocolloid and 10% fish raw material made it possible to maintain plasticity within 8.98 g/cm³, allowing the formation of a tender structure. At the same time, increasing the hydrocolloid proportion to 5.2% resulted in an excessively dense structure and a brittle consistency.

In the study by T. Udo *et al.* (2023) on hydrocolloids, it was shown that heating causes

a transition from a viscoplastic to an elastically resilient state due to the formation of a three-dimensional network. The increase in plasticity with the addition of fish raw material is consistent with the results of N. Bozhko *et al.* (2021), where it was noted that fish proteins form a softer and more plastic structure compared with meat proteins. At the same time, increasing the concentration of carrageenan leads to the formation of a more rigid structure, which is confirmed both by the obtained data and by literature sources, particularly the studies of G. Kalsi *et al*. (2025). An excess of hydrocolloid may result in the formation of an overly dense network, reducing plasticity and making the product brittle. Evaluation of effective viscosity and yield shear stress makes it possible to determine the resistance of the obtained system to structural breakdown and the characteristics of its internal flow under applied mechanical stresses. Taking into account the findings of H. Bao *et al.* (2025), it was established that carrageenan significantly affects the rheological behaviour of meat systems through the formation of a gel matrix in interaction with muscle proteins, while its effectiveness largely depends on the presence of protein components, particularly fish raw material, which enhances structure formation and stabilises the system. The results of the studies are presented in Figure 5.

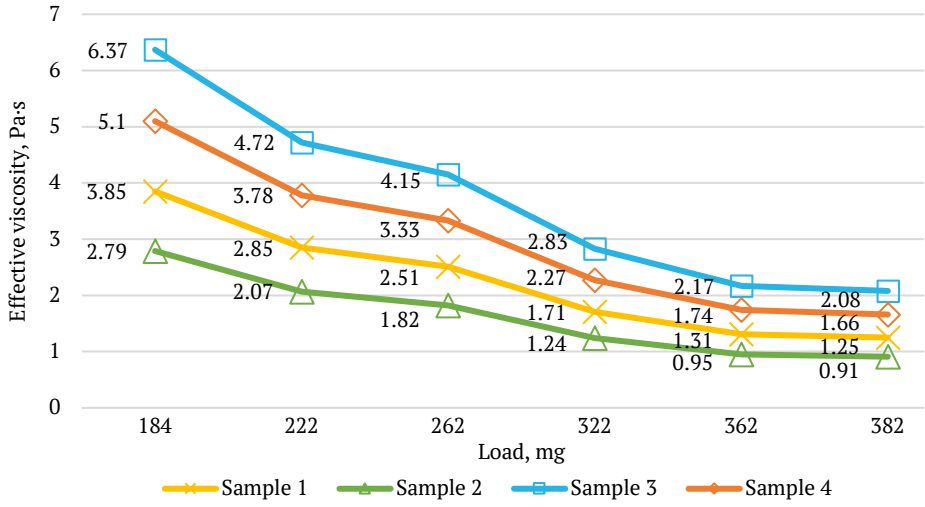

Figure 5. Effective viscosity of the developed minced systems

Source: compiled by the authors

In all samples, a decrease in effective viscosity was recorded with increasing load from 184 g to 382 g, which is typical for structured food dispersed systems and indicates the presence of pseudoplastic behaviour. This is associated with the destruction of the spatial structure of the protein-polysaccharide gel and the orientation of particles in the direction of flow. The lowest viscosity values were characteristic of Sample 2, whereas Sample 1 demonstrated slightly higher structural stability at low and medium loads, but also rapidly lost viscosity with increasing shear stress. This indicates that excessive addition of carrageenan without supplementary protein components does not ensure the formation of a more stable structural framework. In contrast, Samples 3 and 4, containing 10% hake mince, were characterised by significantly higher effective viscosity values throughout the entire load range. For example, at a load of 184 g, the values were 6.37 Pa·s and 5.10 Pa·s,

respectively, which is almost twice as high as the corresponding values in samples without fish raw material. This indicates enhanced interprotein interactions and the formation of a denser spatial matrix.

The increase in viscosity in samples containing fish raw material indicates strengthened intermolecular interactions. Similar results were obtained in the studies of N. Bozhko *et al*. (2021) and A.M. Geredchuk *et al*. (2023), where the addition of fish protein promoted the formation of more structured systems. At the same time, the low effectiveness of excessive carrageenan without a protein component confirms the findings of L. Montes *et al*. (2022), which state that protein-polysaccharide interaction is the key factor in the formation of a stable structure. The next stage of the research was the determination of yield shear stress, the results of which are presented in Figure 6.

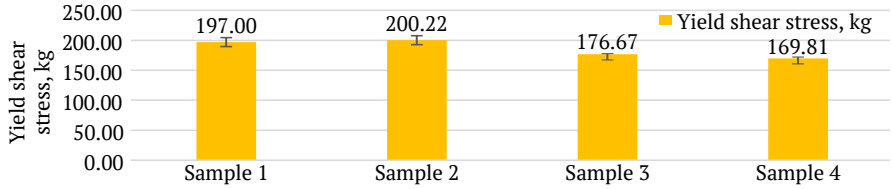

Figure 6. Yield shear stress of combined minced systems

Source: compiled by the authors

The obtained values of yield shear stress characterise the strength of the structural framework of the studied systems and their ability to resist destruction under external loading. The highest values were recorded for Sample 2 at 200.22 kg and Sample 1 at 197.00 kg, indicating a relatively stronger structure in systems without the addition of a fish component. This may be associated with a denser carrageenan gel matrix in the absence of additional protein-lipid phases that alter the nature of spatial interactions. In Samples 3 and 4, which contained 10% hake mince, a decrease in yield shear stress to 176.67 kg and 169.81 kg, respectively, was observed. This indicates a partial weakening of the structural framework, probably as a result of replacing part of the stronger muscle protein matrix of chicken with a more heterogeneous fish protein system that forms a less dense spatial network. This is consistent with the findings of G. Kalsi *et al.* (2025), where it was shown that carrageenan forms dense gels in the absence of external protein phases. The reduction in this indicator with the addition of fish raw material is explained by the more heterogeneous structure of the system. Similar results are described in studies of meat-fish minced systems by N.M. Stukalska *et al*. (2024) and H. Xie & L. Grossmann (2025), where the incorporation of fish protein reduces rigidity but improves textural characteristics.

Summarising the obtained results, it was established that the combination of broiler chicken meat, fish raw material, and carrageenan makes it possible to purposefully regulate the functional-technological and rheological properties of combined minced systems through the formation of a protein-polysaccharide spatial structure. The most pronounced structure-forming effect was observed in samples with an optimal content of carrageenan and fish raw material, which ensured a balance between viscosity, water retention, and the strength of the gel matrix. The obtained patterns confirm the possibility of controlled formation of the desired technological properties of combined minced systems and create a basis for further optimisation of formulations and technological production regimes.

Conclusions

As a result of the conducted study, it was established that the combination of broiler chicken white meat, fish raw material, and hydrated carrageenan significantly affects the formation of the functional-technological, structural-mechanical, and rheological properties of complex multicomponent minced systems. This effect is manifested both at the level of water-binding capacity and in the formation of a spatial protein-polysaccharide matrix, which determines product stability at all stages of the technological process, including preparation, heat treatment, and subsequent storage. It was established that the addition of carrageenan ensures the formation of a developed gel matrix that acts both as a structure-forming agent and as a stabiliser of the dispersed system. Through interaction with the protein components of the meat and fish raw materials, it increases the moisture-retaining capacity of the minced systems, reduces moisture and fat losses after heat treatment, and promotes a more uniform distribution of moisture within the structure of the finished product. The most stable moisture-retention values after roasting were characteristic of samples with an increased hydrocolloid content, indicating enhanced intermolecular interactions and more pronounced structure formation within the system, as well as the formation of a denser and more elastic gel.

It was demonstrated that the addition of 10% hake mince significantly alters the balance of structural interactions in the minced system. On the one hand, an increase in total moisture content and effective viscosity was observed, which is associated with the high water-binding capacity of fish proteins and their ability to form additional intermolecular bonds in the combined system. On the other hand, the incorporation of fish raw material resulted in a reduction in yield shear stress, which may indicate a certain weakening of the strength of the spatial protein framework compared with systems not containing a fish component, as well as a change in the nature of the structure from more elastic to more plastic. Overall, the obtained results indicate the feasibility and technological efficiency of using a combination of meat and fish raw materials with carrageenan for the targeted regulation of the functional-technological properties of combined minced systems. Such an approach makes it possible to develop products with predetermined structural-mechanical characteristics, increased stability of the emulsion and gel structure, and improved behaviour during heat treatment, which is important for achieving stable quality of finished products under industrial conditions. Prospects for further research include expanding the combination of carrageenan with other types of meat and fish raw materials of different functional compositions, as well as studying the influence of various heat-treatment methods (boiling, roasting, frying) on the formation of structural-mechanical and rheological properties of combined minced systems.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Дослідження зміни функціонально-технологічних показників фаршевих систем на основі фаршу м'яса хека та курчат-бройлерів

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Анотація. Актуальність досліджень зумовлена підвищеним зацікавленням споживача до комбінованих м'ясних продуктів, що зумовлює необхідність визначення оптимальних рецептурних поєднань сировини різного походження. Метою було визначення

змін функціонально-технологічних і реологічних показників фаршів залежно від співвідношення м'ясної та рибної сировини і вмісту карагенану. Досліджено чотири рецептури на основі м'яса курчат-бройлерів із додаванням 0 або 10 % фаршу хеку та карагенану 2,8-5,2 %. Зразки піддавали термообробці до 70 °С з подальшим визначенням вологи, вологоутримувальної здатності, pH, пластичності та реологічних показників. Вологовміст становив 71,21-74,85 %. Після термообробки втрати вологи були 3,06-5,75 %, менші втрати спостерігалися у зразках із вищим вмістом карагенану, що свідчить про формування більш стабільної гелевої структури. Найвищу вологоутримувальну здатність мали зразки з рибною сировиною. pH підвищувався до 6,21-6,32 з подальшим незначним зростанням після нагрівання. Реологічні дослідження показали псевдопластичну поведінку систем зі зниженням в'язкості зі зростанням навантаження. Додавання рибної сировини підвищувало ефективну в'язкість, але зменшувало граничне напруження зсуву. Отримані результати підтверджують доцільність поєднання м'ясної та рибної сировини з карагенаном для регулювання функціонально-технологічних властивостей і формування стабільних структур фаршевих систем. Додатково встановлено зниження пластичності після термічної обробки та зміну граничного напруження зсуву, що вказує на перехід систем від в'язко-пластичного до пружно-структурованого стану та формування більш щільної структури фаршевих систем у фарш. Отримані результати можуть бути застосовані у виробництві м'ясних продуктів з додаванням рибної сировини з метою цілеспрямованого регулювання функціонально-технологічних показників та формування стабільної білково-полісахаридної структури готового продукту

Ключові слова: м'ясні напівфабрикати; гідробіонти; комбіновані м'ясні продукти; гідроколоїди; реологічні показники; функціональні показники