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INFLUENCE OF PROTEIN-FAT EMULSION FROM TURKEY SKIN AND PLANT RAW MATERIALS ON THE QUALITY OF COOKED SAUSAGES

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The study examined the impact of a protein-fat emulsion (PFE) derived from turkey skin and green buckwheat flour on the quality of cooked sausages. The aim was to investigate how the addition of PFE affects various characteristics of the sausage. The experiments demonstrated that adding PFE up to 30% while stirring for up to 8 minutes at 10°C improved the sausage structure. This was evidenced by an increase in pH values to 6.5, water binding capacity to 71.2%,

and ultimate shear stress to 321.86 Pa. It was observed that stuffing temperature and mixing time influenced pH, water binding capacity, and ultimate shear stress. The study identified the optimal production conditions and determined the maximum amount of PFE that can be added to sausages. Additionally, it was found that green buckwheat flour enhances the structure of the minced meat, raises pH, and increases water-binding capacity. Furthermore, PFE was noted to improve the appearance and flavor characteristics of the sausages. These findings highlight the potential of these new ingredients to enhance the quality of cooked sausages in the food industry.

Keywords: beef, poultry, green buckwheat flour, water-binding capacity, shear stress.

ВЛИЯНИЕ БЕЛКОВО-ЖИРОВОЙ ЭМУЛЬСИИ ИЗ КОЖИ ИНДЕЙКИ И РАСТИТЕЛЬНОГО СЫРЬЯ НА КАЧЕСТВО ВАРЕНЫХ КОЛБАС

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В исследовании изучалось влияние белково-жировой эмульсии (БЖЭ), полученной из кожи индейки и муки зеленой гречихи, на качество вареных колбас. Цель состояла в том, чтобы выяснить, как добавление БЖЭ влияет на различные характеристики колбасы. Эксперименты показали, что добавление БЖЭ в количестве до 30% при перемешивании в течение 8 минут при температуре 10°C улучшает структуру колбасы. Об этом свидетельствует увеличение значений pH до 6,5, водосвязывающей способности до 71,2% и предельного напряжения сдвига до 321,86 Па. Было отмечено, что температура фарша и время перемешивания влияют на pH, водосвязывающую способность и предельное напряжение сдвига. В ходе исследования были определены оптимальные условия производства и максимальное количество БЖЭ, которое можно добавлять в колбасы. Кроме того, было установлено, что мука из зеленой гречихи улучшает структуру фарша, повышает pH и увеличивает водосвязывающую способность. Кроме того, было отмечено, что БЖЭ улучшает внешний вид и вкусовые характеристики колбас. Эти результаты подчеркивают потенциал новых ингредиентов для улучшения качества вареных колбас в пищевой промышленности.

Ключевые слова: говядина, мясо птицы, мука из зеленой гречки, водосвязывающая способность, напряжение сдвига.

КҮРКЕТАУЫҚ ТЕРІСІНЕН ЖӘНЕ ӨСІМДІК ШІКІЗАТЫНАН АҚУЫЗ-МАЙЛЫ ЭМУЛЬСИЯНЫҢ ПІСІРІЛГЕН ШҰЖЫҚ САПАСЫНА ӘСЕРІ

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Зерттеу барысында күркетауық терісінен және жасыл қарақұмық ұнынан алынған ақуыз-май эмульсиясының (АМЭ) пісірілген шұжықтардың сапасына әсері зерттелді. Мақсаты - ақуыз-май эмульсиясын қосу шұжықтың әртүрлі сипаттамаларына қалай әсер ететінін анықтау болды. 10°C температурада 8 минут бойы араластыра отырып, 30%-ға дейінгі мөлшерде ақуыз-май эмульсиясын қосу шұжықтың құрылымын жақсартатынын тәжірибе көрсетті. Бұл pH мәндерінің 6,5-ке дейін, суды байланыстыру қабілетінің 71,2% -ға дейін және шектік ығысу кернеуінің 321,86 Па дейін жоғарылауымен дәлелденеді. Тартылатын еттің температурасы мен араластыру уақыты pH, суды байланыстыру қабілеті және шектік ығысу кернеуіне әсер ететіні атап өтілді. Зерттеу барысында шұжық өнімдеріне қосуға болатын ақуыз-май эмульсиясының оңтайлы өндіріс жағдайлары мен максималды мөлшері анықталды. Сонымен қатар, жасыл қарақұмық ұны тартылған ет құрылымын жақсартатыны, pH жоғарылататыны және суды байланыстыру қабілетін арттыратыны анықталды. Сонымен қатар, ақуыз-май эмульсиясы шұжық өнімдерінің сыртқы түрі мен дәмдік қасиеттерін жақсартатыны атап өтілді. Бұл нәтижелер тамақ өнеркәсібінде пісірілген шұжықтардың сапасын жақсарту үшін жаңа ингредиенттердің әлеуетін көрсетеді.

Негізгі сөздер: сиыр еті, құс еті, жасыл қарақұмық ұны, суды байланыстыру қабілеті, ығысу кернеуі.

Introduction

For the effective use of low-value raw meat obtained from the slaughter of farm animals and poultry, it is necessary to improve and optimize the processes in the technology for the production of sausages [1-5].

An urgent issue is the problem of rational processing of poultry meat products, in particular poultry skins [6-10].

The use of poultry skins as part of a protein-fat emulsion in the production of cooked sausages has a positive effect on the quality and profitability of the finished product. In addition, the use of a protein-fat emulsion in the technology of cooked sausages helps to reduce meat consumption, which reduces the cost of products and gives them social significance [11-14].

Among farm birds, the turkey is one of the largest birds. The mass of adult male turkeys weigh about 20-30 kg, and female turkeys - 7-10 kg. Indicators such as live weight, slaughter yield of edible parts of turkey carcasses (over 70%), the mass of muscle tissue (up to 60% or more), and pectoral muscle (up to 28%) in turkeys significantly exceed those of birds of other species (chickens, ducks) [8]. In agriculture and households, turkeys are bred to procure meat with elevated nutritional and biological value. The sensory characteristics of turkey meat are notably superior [8]. In terms of nutritional composition, turkey meat boasts a significant protein concentration, reaching an impressive 28%, a marked difference from the 14-18% typically observed in other avian varieties. Additionally, its fat content falls within a moderate range of 2-5%. Turkey meat stands out for its abundance of B vitamins and distinguishes itself by having the lowest cholesterol levels when juxtaposed with other types of poultry [8]. It has been demonstrated that turkey meat has good digestibility by enzymes of the gastrointestinal tract [8].

At present, the burgeoning expansion of local poultry farming in the Republic of Kazakhstan enables the production of a diverse array of turkey meat products. This trend not only facilitates the efficient utilization of raw materials but also promotes a systematic and comprehensive approach to the processing of turkey meat [7], [9].

When processing gutted poultry meat, the skin yield ranges from 5-9% of the carcass weight, and employing efficient cutting methods can increase this yield to a range of 10-17% [9]. In terms of chemical composition and biological value, turkey skin, particularly from the neck and legs, comprises 14-17% proteins, 20-25% fat, as well as vitamins (A, B1, B2, B3, PP, C, E), and calcium. The high-fat content in turkey skin makes it susceptible to rancidity [8].

The connective tissue in fat can separate into gelatin and fat during frying, thus contributing to the formation of a porous texture. To overcome this shortcoming and stabilize the fat present in the skin, it must first be emulsified with the help of additional ingredients and innovative technologies. Such an emulsion can be used as a replacement for the main raw material up to 20% in the production of meat products, such as cooked sausages, frankfurters, sausages, cooked-smoked and semi-smoked sausages, ham, pates, and chopped semi-finished products [10-14].

Many authors have studied the possibility of using chicken skin in combination with raw materials from cereals (soy protein, wheat gluten protein) in the technology of sausage products [15-20].

In the available literature, there is no information on the use of such plant raw materials as green buckwheat flour. Meanwhile, green buckwheat flour is characterized by high nutritional value. It contains more vitamins, minerals, and essential amino acids than other types of cereal flour [21].

Currently, the utilization of green buckwheat flour is constrained to its application in the processing of minced semifinished meat products.

Therefore, this study aims to investigate the influence of a protein-fat emulsion extracted from turkey skin and green buckwheat flour on various aspects, including physicochemical characterris-tics, functionaltechnological properties, structural-mechanical attributes, and organoleptic para-meters.

Material and research methods

Sausage production

In creating prototypes for cooked sausage, the following raw materials were used: 1st-grade beef (GOST 34120-2017. Cattle for slaughter. Beef and veal in carcasses, half carcasses and quarters. Specifications), turkey of the 1st category (GOST 31473-2012. Interstate standard Turkey meat (carcasses and parts thereof General specifications), turkey skin, green buckwheat flour [GOST 31645-2012. Flour for baby food products]. In the development of prototypes, supplementary ingredients, namely salt, sodium nitrite, and ground black pepper, were included. These components were acquired from the Almaty food market. Preserved meat was kept in the Liebherr GKPv 6573 Refrigerator (Germany). Minced meat from beef and turkey was mixed using an MP-300 meat grinder. Green buckwheat flour was added in a hydrated form. Water at room temperature was used for hydration. The degree of swelling of buckwheat flour was observed for 1 hour.

Minced meat for prototypes of cooked sausage was prepared in a cutter. According to the recipe (Table 1), green buckwheat flour was introduced into the cutting machine, and then drinking water was added and mixed. Next, meat components and spices were added and mixed for 3-4 minutes.

The object of the experiment was a cooked sausage encased in a 45 mm diameter casing.

In the subsequent phase of the study, five variations of cooked sausages were formulated and detailed in Table 1. The benchmark for comparison was established using cooked sausages manufactured by TU 9213-330-23476484-01 standards. The thermal treatment of the boiled sausage samples took place in a SPAKO universal heat chamber, specifically designed for a wide range of sausage products. The temperature of the prepared samples was meticulously monitored using an infrared thermometer equipped with a laser pointer and a Testo 826-T 4 penetrating food probe.

Subsequently, the sausages underwent a cooling process on ice until they reached a temperature of 21°C. The finalized products were hermetically sealed in polyethylene bags through vacuum-sealing procedures and then stored at a controlled temperature of 4±1°C. This experimental protocol was replicated across four distinct production series to ensure the robustness and reliability of the findings.

Table 1. Formulations for cooked sausage incorporating protein and fat emulsion

Component name	Control sample	Ratio of the components of the formulation				
		option I	option II	option III	option IV	option V
Unsalted raw materials kg (per 100 kg)						
Turkey meat, category 1	50	50	50	50	50	50
Ground beef, grade 1	25	25	25	25	25	25
Pork side steak	25					
Turkey skin		24	22	20	18	16
Green buckwheat flour		1	3	5	7	9
Spices and additives g per 100 kg						
Nitrite-salt mixture	2000	2000	2000	2000	2000	2000
Sugar	200	200	200	200	200	200
Ground black pepper	100	100	100	100	100	100
Ground nutmeg	50	50	50	50	50	50

The moisture content

The moisture content of cooked sausages was assessed using the drying method by GOST 9793-2016, "Meat and meat products. Methods for determining moisture".

Ph value

The pH level, representing the concentration of hydrogen ions in the cooked sausages, was determined using a potentiometric method. This technique involves measuring the change in electrical potential between a glass electrode and a reference electrode immersed in a sample of the meat or meat product.

Water-binding capacity (WBC)

The water-binding capacity of cooked sausages was evaluated using the Grau and Hamm method. This method involves determining the quantity of water released from the meat during gentle pressing, which is then absorbed by filter paper, resulting in the formation of a wet spot.

Water-holding capacity

The water-holding capacity of cooked sausages was calculated as the disparity between the moisture content in the minced meat and the quantity of moisture separated during the heat treatment.

Shear stress

The ultimate shear stress in cooked sausage was assessed using the immersion cone method.

Sensory analyses

The evaluation of the sensory characteristics of the cooked sausages involved eight trained panelists following the guidelines outlined in Standard ISO 11036-2017. Each panelist independently assessed the taste, color, aroma, and texture of the cooked turkey sausages using a 5-point hedonic scale (1: extremely poor, 2: poor, 3: acceptable, 4: good, and 5: excellent). To ensure unbiased evaluation, 2-centimeter pieces of sausages were presented on white polystyrene plates, each assigned a unique four-digit code. These codes were randomly arranged for assessment by the panelists. The experiments were conducted in a purposefully designed and well-illuminated room, and the average score was computed for each product.

Experiments on the trial production of cooked sausage, involving the analysis of physicochemical, functional-technological, structural-mechanical, and organoleptic parameters of the product, were conducted at the Scientific research institute "Food Safety" of Almaty Technological University.

Results and discussion

In our studies carried out with prototypes of protein-fat emulsion, a certain dependence of water-binding ability on pH was noted. Thus, with an increase in pH, the water-binding capacity in the test sample also increased [22].

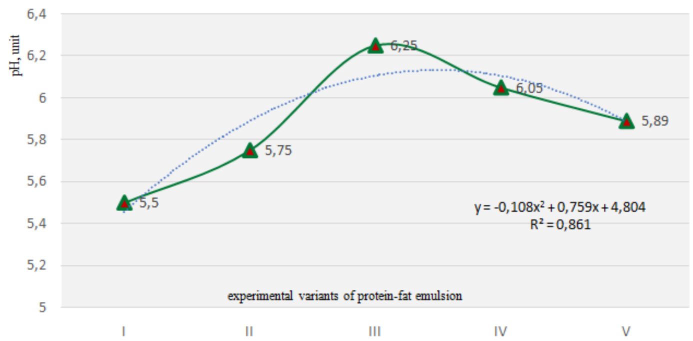

Figure 1. Dependence of pH of experimental samples on the level of injection protein and fat emulsion

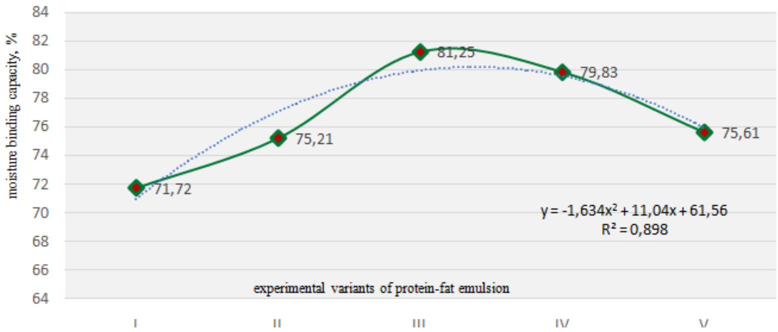

Figure 2. Dependence of water-binding capacity of experimental samples on the level of protein-fat emulsion introduction

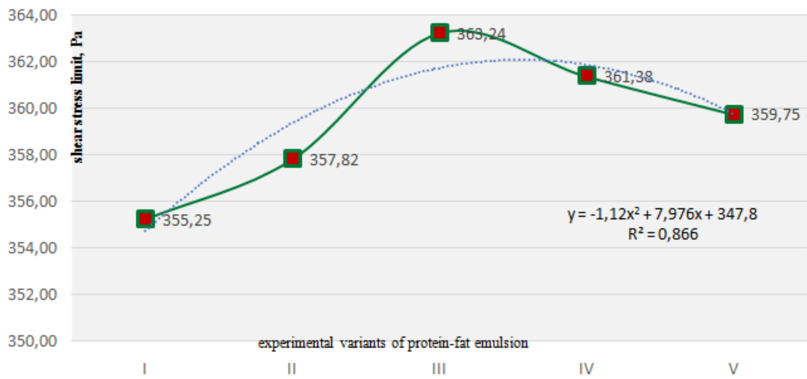

Figure 3. Dependence of ultimate shear stress of experimental samples on the level of protein-fat emulsion introduction

It has been shown that when green buckwheat flour is added to minced turkey skin, the pH increases to certain indicators - from 5.5 units to 6.25 units, then noticeably decreases to 5.89 units.

A similar picture is observed in the study of WBC in different versions of prototypes of the protein-fat emulsion.

In the prototype of option I, the water-binding capacity of PFE was 71.72%. The maximum rate of PFE water-binding capacity - 81.25% - turned out to be in option III.

In options IV and V, the studied indicators deteriorated. Therefore, research has indicated that the best option for the protein-fat emulsion was option III (turkey skin - 20%; green buckwheat flour - 5%).

In the process of increasing the dosage of green buckwheat flour in the composition of the protein-fat emulsion, a gradual increase in WBC occurred, the level of which stabilized over time [22].

An increase in the level of WBC is facilitated by the mixing process, namely the action of table salt with green buckwheat flour and chopped turkey skin [22].

The dual-complex system inherent in the formulated protein-fat emulsion, extracted from a combination of turkey skin and buckwheat flour, operates based on interactions between two compounds characterized by opposite charges. Essential to this system is the presence of at least one polyelectrolyte, contributing to the electrostatic interactions that shape the overall structure and stability of the emulsion [22]. The creation of a novel protein-fat emulsion can take place within systems featuring various combinations of interacting components. This includes scenarios where there is a pairing of a polyelectrolyte with a low molecular weight ion, such as a polyacid with a cation or a polybase with an anion. Alternatively, the formation of the emulsion can also occur through the interaction between a polyacid and a polybase. These diverse combinations contribute to the versatility and adaptability of the protein-fat emulsion formulation process [22]. The coexistence of two oppositely charged polyelectrolytes within a mixture imparts the capability to engage in interactions leading to the formation of associates. These associates exhibit superior structure-forming abilities compared to the original individual components. The synergy between oppositely charged polyelectrolytes contributes to the enhancement of the overall structural properties, showcasing the potential for intricate and robust formations in the resulting mixture.

The findings from the examination of the physicochemical, functional-technological, and structural-mechanical characteristics of the final cooked sausages are illustrated in Figures 4, 5, and 6.

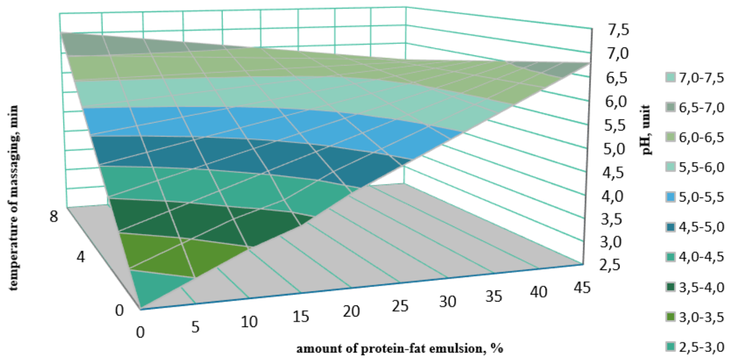

Figure 4. Changes in pH at different levels of PFE and agitation

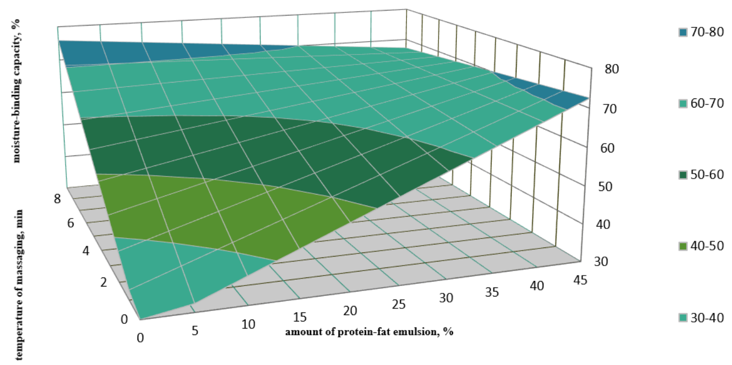

Figure 5. Variation in WBC at different levels of PFE and agitation

This composition with structure-forming properties not only maintains high detoxification efficacy but also enhances the structure-forming ability of the protein filler. Consequently, minced meat systems incorporating this formulation exhibit a juicy and tender texture. The synergy of these attributes contributes to the overall quality of the product, ensuring both effective detoxification and a pleasurable textural experience in minced meat preparations [22].

The impact of meat pH on water-binding capacity (WBC) holds a significant role. Given that the isoelectric points of meat proteins reside in the "acidic" pH range, particularly around 5.3, an elevation in the concentration of hydrogen ions results in a reduction in the water-binding capacity (WBC) [23]. The acidic conditions bring about changes in the protein structure, influencing its ability to bind water effectively. This insight underscores the importance of pH regulation in understanding and manipulating the water-binding characteristics of meat proteins [23]. The observed dependence, particularly evident during stirring, can be elucidated by the formation of protein molecules with proteinase activity at the initial stages of hydrolysis. These molecules possess a considerable number of readily accessible charged groups, contributing to their capacity to retain water effectively. The enzymatic hydrolysis process appears to generate protein fragments with enhanced water-binding capabilities, explaining the observed relationship during stirring. This phenomenon underscores the intricate interplay between protein structure, hydrolysis, and water retention [23]. Beyond 8 minutes of stirring, there is an accumulation of oligopeptides and free amino acids. Notably, these components lack the effective water-binding capacity observed in larger protein structures [23]. Moreover, the resultant amino acids, through a decrease in the pH of the medium, further exacerbate the decline in water-binding capacity (WBC) [23]. This dual effect, involving the presence of less water-binding molecular structures and the acidification of the medium, underscores the intricacies of the hydrolysis process and its impact on the water-holding properties of the system.

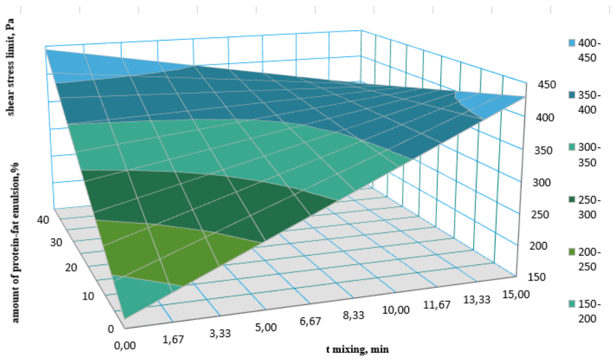

Figure 6. Change in ultimate shear stress at different levels of PFE and agitation

Structural and mechanical parameters of prototypes of cooked sausages were determined after heat treatment.

Moreover, it was discovered that the optimal value of the ultimate shear stress was the most optimal in option III and amounted to 321.86 Pa.

In summary, the conducted experiments have demonstrated that incorporating a protein-fat emulsion at levels of up to 30% brings about a significant enhancement in the functional-technological and structural-mechanical properties of the minced meat used in experimental sausages. The findings provide conclusive evidence that the composition of experimental sausage No. 3 stands out as optimal, showcasing the positive impact of the protein-fat emulsion on various characteristics of the final product.

An examination of the relationship between the duration of mixing and the quantity of protein-fat emulsion in cooked sausages revealed correlations with physicochemical, functionaltechnological, and structural-mechanical parameters. The analysis indicates that within the minced meat, a considerable portion of moisture becomes securely bound. This binding occurs due to the grouping and robust retention of water molecules around the solvate shells of fat globules and proteins [23]. The observed phenomena suggest that the presence of the protein-fat emulsion plays a crucial role in influencing the water-binding characteristics of the minced meat, thereby impacting various aspects of the sausage's overall composition and quality.

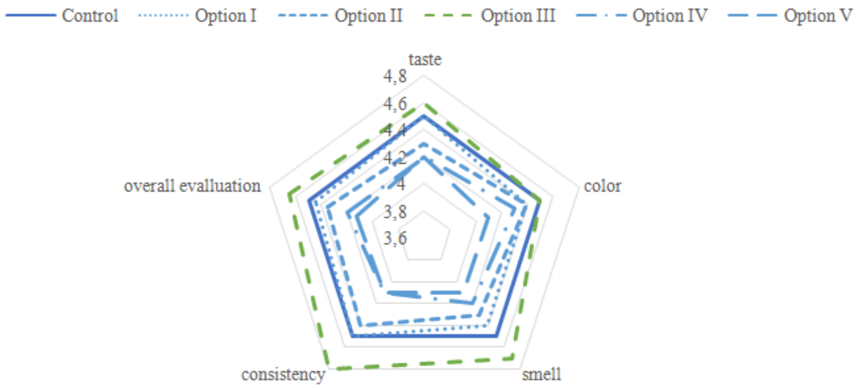

Figure 7. Sensory properties of cooked sausages

The sensory evaluation data of the cooked sausages (Figure 7) in this study revealed significant differences among various formulations, particularly when compared to the control sample. Notably, sausages containing PFE and green buckwheat flour exhibited distinct variations in taste and smell. Specifically, option III, which incorporated turkey skin - 20% and green buckwheat flour - 5%, received the highest ratings in taste (4.6) and smell (4.7) among all the options. This suggests that the addition of PFE positively influenced these sensory attributes. Conversely, option IV, with increased PFE content, demonstrated the lowest values for color, smell, and consistency, indicating a negative impact on overall organoleptic characteristics.

Conclusion

This research showcases the significant impact of using a protein-fat emulsion derived from turkey skin and green buckwheat flour in making cooked sausages. Incorporating this emulsion within specific limits, along with controlled mixing, notably improved sausage structure. This improvement was seen in optimal pH, increased water-binding capacity, and better shear stress, crucial for texture. Mathematical models derived from temperature assessments help predict and control sausage properties. Green buckwheat flour reinforced meat structure and enhanced pH and water-binding capacity. This highlights the potential of natural, plant-based materials in processed meat. The emulsion positively affected sensory aspects—color, taste, aroma, and texture—enhancing the overall sausage experience. These findings suggest these ingredients can improve sausage production technically and enhance consumer appeal. Ultimately, the research offers insights into the food industry, guiding better formulations and processes for superior sausages, and meeting changing consumer needs for nutrition and experience.

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