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STUDY OF PHYSICAL, CHEMICAL AND MICROBIOLOGICAL INDICATORS OF HAM FROM THE MEAT OF CULLED COWS, ENRICHED WITH SELENIUM AND ZINC

Abstract: *The effective utilisation of meat from culled cows presents a significant technical challenge for the meat industry due to the variability of its functional and processing properties. The aim of this study was to evaluate the combined effect of the probiotic culture Lactobacillus sakei and fortification with the trace elements selenium (Se) and zinc (Zn) on the quality, oxidative stability and microbiological safety of meat products made from culled cows. The effect of Lactobacillus sakei in combination with a 50% reduction in sodium nitrite levels on the microbiological parameters of raw meat during maturation was investigated. The use of L. sakei significantly reduced the total microbial count (from 6.4 to 5.6 log CFU/g) and inhibited the growth of spoilage-causing microorganisms, including Enterobacteriaceae, Pseudomonas spp. and Brochothrix thermosphacta. Pathogenic microorganisms (Escherichia coli, Staphylococcus aureus, Listeria monocytogenes and Salmonella spp.) were not detected. Samples of meat products containing L. Sakei and enriched with L-selenomethionine (0.525 mg/kg) and zinc citrate (150 mg/kg) were examined for their physicochemical and organoleptic properties. The peroxide value was assessed whilst the samples were stored in a refrigerator (4 °C, 30 days). Enrichment with micronutrients reduced lipid oxidation: after 30 days, the peroxide values were lower than in the control samples. The pH values (5.76-5.82) and water activity (0.958-0.962) remained stable, whilst water-holding capacity increased by 4% in the experimental samples. Sensory evaluation showed comparable quality between the control and experimental samples in terms of color, taste and appearance, whilst the texture and tenderness of the experimental samples were improved.*

The results demonstrate that the combined use of Lactobacillus sakei and micronutrient fortification (Se and Zn) can improve the oxidative stability and processing properties of meat products made from culled cows, whilst maintaining microbiological safety and sensory quality.
Key words: *Lactobacillus Sakei, selenium, zinc, peroxide value, water-holding capacity, microbiological safety.*

Introduction

The processing of meat from culled cows into ham-type products is one of the most promising areas for improving the efficiency of raw material use in the meat industry. This raw material is characterized by variability in its functional and technological properties, which requires the use of technological and biotechnological solutions to stabilize the structure, increase yield and ensure the microbiological safety of finished products.

The mineral composition of beef has been extensively described from a nutritional perspective; however, trace elements also play a crucial role in determining meat quality through their involvement in redox processes [1].

An imbalance of trace elements adversely affects the health status and productive performance of farm animals. Insufficient dietary intake of essential trace elements contributes to the development of various metabolic disorders and pathological conditions [2].

Fortification of meat products with essential trace elements (Se, Zn) is considered an approach to increasing nutritional value. In this case, the indicators of oxidative stability of the lipid phase and sanitary and microbiological safety criteria are technologically significant. Lactic acid bacteria, including Lactobacillus Sakei, are described as promising bioprotective cultures for meat products and are capable of suppressing undesirable microflora under refrigerated storage conditions [3].

Lactobacillus Sakei is capable of colonizing many different habitats. It is often isolated from plant-based products such as various types of flour, sourdough starters, or fermented cabbage, but it is systematically associated with meat products and often with seafood [4].

For ham-type products, lipid oxidation and microbiological stability are critical during storage; recent reviews on lipid oxidation in meat and meat products justify the need to monitor primary oxidation products (including peroxide value) [5]. The use of protective cultures is considered an effective approach to improving the microbiological stability of meat products without the use of additional preservatives [6].

The novelty of this study lies in the fact that, for the first time, ham produced from culled cows was evaluated as part of a comparative study involving two enrichment variants (Se and Zn) under identical biotechnological conditions – the use of Lactobacillus sakei during the curing and maturation stages. A comprehensive evaluation was carried out, including oxidative stability (peroxide value), physicochemical parameters (water-holding capacity, water activity and pH), and organoleptic parameters in the finished products, and the effect of Lactobacillus sakei on microbiological parameters in the raw material was investigated. Despite the relevance of the research, there is little information and few experiments in the literature describing the use of the bio-protective culture Lactobacillus sakei in beef from culled cows, used to produce meat products enriched with minerals. The results obtained provide a scientific basis for the use of Lactobacillus sakei in combination with micronutrient fortification to improve the stability, quality and safety of ham produced from raw materials with reduced processing suitability.

Materials and methods

The study involved two groups of samples. The first group comprised control samples (100% $NaNO_2$) and test samples (L. sakei – 0.01% + $NaNO_2$ – 50%) intended for analyzing the effect of Lactobacillus sakei on the microbiological parameters of the raw material. The effect of the bio-protective culture Lactobacillus sakei on the microbiological indicators of meat samples from culled cows (NMAFAM, coliforms/E. coli, Listeria monocytogenes, Staphylococcus aureus, sulphite-reducing clostridia) was analysed after the maturation stage.

The second group of samples comprised control samples (Control + L. sakei) and test samples (L. sakei + Se, L. sakei + Zn), intended for the investigation of the physicochemical and organoleptic properties of the finished product. The samples were prepared in accordance with the method described in [7]. Fortification was carried out during the mince preparation stage by adding trace elements to the mince. Selenium was added in the form of L-selenomethionine (an organic form of selenium) at a dose of 0.525 mg per 1 kg of raw material, and zinc in the form of zinc citrate (an organic zinc salt) at a dose of 150 mg per 1 kg of raw material.

Some of the samples were vacuum-packed and stored in a refrigerator at 4 °C for 30 days at a relative humidity of 85%, to determine the peroxide value on days 0, 20 and 30. At each time point, samples were collected aseptically from the packaged products and analyzed according to the respective standard methods. The second set of samples was examined for physicochemical and organoleptic parameters immediately after preparation. Test conditions were: temperature 21°C, relative humidity 64%.

The following methods were used in the study:

– Microbiological indicators in control and test samples of meat raw materials were determined in accordance with GOST 10444.15-94 (NMAFAM), GOST 31747-2012 (Escherichia coli group bacteria), GOST 32031-2012 (Listeria monocytogenes), GOST 31746-2012 (Staphylococcus aureus), GOST 8558.1-2015 (Residual sodium nitrite), GOST ISO 15214-2013 (Lactic acid bacteria (LAB), GOST ISO 21528-2-2013 (Enterobacteriaceae), GOST ISO 13720-2013 (Pseudomonas spp.), ISO 13722:2017 (Brochothrix thermosphacta), ISO 6579-1:2017 (Salmonella spp.) [8].

– The peroxide value of fat was determined in accordance with GOST 34118-2017 [9]. Determined using a spectrophotometric method based on the oxidation of hydroperoxides with Fe^{2+} ions to Fe^{3+}. Fe^{3+} interacted with thiocyanate (SCN^-), forming a colored complex, the intensity of which was measured at a wavelength of 507 nm. Experimental samples were analyzed at predefined storage times: day 0, day 20, and day 30 for peroxide value;

– The pH of the control and test samples of the finished products was determined using the potentiometric method in accordance with GOST R 51478-99 [10]. The method is based on measuring the difference in electrical potential between a glass electrode and a reference electrode placed in the product sample. The ham sample was first minced by passing it through a mincer twice, after which it was thoroughly mixed. A sample quantity sufficient for immersing the electrodes was taken for analysis. The pH meter was pre-calibrated using a buffer solution with a known pH value at a temperature of (20 ± 2)°C. The electrodes were inserted into the prepared sample and measurements were taken until stable readings were obtained. The pH value was recorded with an accuracy of ±0.05 units. Three parallel measurements were carried out on each sample, after which the arithmetic mean was calculated and taken as the final result.

– The water activity (aw) in the control and test samples of the finished products was determined in accordance with the requirements of GOST R ISO 21807-2012 [11]. The method is based on measuring the equilibrium water vapor pressure above the product sample in a closed measuring chamber using a water activity analyzer. Prior to measurement, the instrument was calibrated using standard salt solutions with known water activity values. Sample preparation was carried out without homogenization to avoid heating and moisture loss. The sample was placed in the instrument's measuring chamber, maintaining a constant temperature of 25 °C. The water activity value was determined after equilibrium had been established between the water vapor of the sample and the chamber atmosphere. Measurements were taken both on the surface and within the bulk of the product to account for a possible water activity gradient.

– Water-holding capacity was determined using the Vartanyan method [12]. The method is based on pressing a weighed sample between filter papers under a standardized load and measuring the amount of water released. A representative sample (approximately 0.3 g of minced meat) was accurately weighed. The sample was placed in the center of a pre-weighed filter paper and covered with a second filter paper. The assembly was positioned between two glass plates. A standardized load (typically 1 kg) was applied for 10 minutes at room temperature. After pressing, the sample was removed. The filter paper with the absorbed moisture was weighed to determine mass loss. Water-holding capacity (WHC) was determined by the Vartanyan pressing method and calculated as:

$$\mathrm{WHC}\ (\%) = \frac{\mathrm{m1}}{\mathrm{m0}} * 100$$

m_0 – sample mass before pressing (g);

m_1– sample mass after pressing (g).

The mass loss during pressing (m_0−m_1) corresponds to the released moisture.

– The organoleptic evaluation of the control and experimental samples of the finished products was carried out in accordance with the requirements of GOST 9959:2015 [13]. The evaluation was performed by a tasting panel comprising at least five specialists with experience in assessing meat products. The tasting was conducted in a specially equipped room free from extraneous odors at an air temperature of (20 ± 2)°C and relative humidity of (70 ± 5)%, under uniform lighting of at least 500 lux. Prior to analysis, product samples were coded with three-digit numbers and served at a temperature corresponding to their intended consumption conditions. The assessment was carried out individually by each taster, with the results recorded on tasting sheets. Organoleptic characteristics were first determined on the whole product, then on a cross-section. The following characteristics were assessed in sequence: appearance, color, smell (aroma), taste, texture and tenderness of the product.

Appearance and color were assessed visually; odor was assessed on the surface of the product and, where necessary, deeper inside using a metal needle. Texture was assessed by pressing and chewing the sample, whilst taste and aroma were assessed by tasting slices of the product. Quality was assessed on a 5-point scale, where 5 points corresponded to excellent quality, 4 to good, 3 to satisfactory, 2 to unsatisfactory and 1 to very poor quality. The final score was calculated as the average of the scores across all indicators. The study complied with the ethical principles for research involving human participants outlined in the Declaration of Helsinki [14].

All measurements were performed in triplicate. Results are presented as mean ± SD, where SD denotes the standard deviation. Means within groups were compared using one-way analysis of variance, followed by Duncan's multiple range test ($p < 0.05$). Statistical analyses were performed using SPSS software (version 24.0; SPSS Inc., Chicago, IL, USA).

Results and Discussion

In the first stage of the experiment, the effect of the Lactobacillus sakei probiotic culture on the microbiological parameters of meat samples from culled cows was investigated.

The Lactobacillus sakei probiotic culture was added to the experimental beef samples (meat from older animals) for maturation at a temperature of +4°C for 18 hours. Sodium nitrite was added to the control samples in accordance with GOST 8558-2015 «Sodium Nitrite. Specifications» [15]. For the experimental samples, a reduced dosage (50% $NaNO_2$) was used, with the active L. sakei culture added simultaneously at a concentration of 0.01%.

Table 1 – Microbiological parameters of raw materials following ripening using L. sakei

№	Parameter	Unit	Control (100% $NaNO_2$)	Experiment (L. sakei – 0.01% + $NaNO_2$ – 50%)
1	NMAFAM	log CFU/g	6,4 ± 0,2	5,6 ± 0,1 ↓
2	Lactic acid bacteria (LAB)	log CFU/g	4,0 ± 0,3	6,3 ± 0,2 ↑
3	Enterobacteriaceae	log CFU/g	3,2 ± 0,3	1,8 ± 0,2 ↓
4	Pseudomonas spp.	log CFU/g	2,9 ± 0,4	1,6 ± 0,2 ↓
5	Brochothrix thermosphacta	log CFU/g	2,4 ± 0,3	1,4 ± 0,2 ↓
6	Escherichia coli (БГКП)	CFU/g	< 10^2	< 10
7	Staphylococcus aureus	CFU/g	< 10^2	< 10
8	Listeria monocytogenes	in 25 g	Not found	Not found
9	Salmonella spp.	in 25 г	Not found	Not found
10	Residual sodium nitrite	mg/kg	52,2 ± 4	25,5 ± 3 ↓

The results of the study of the microbiological parameters of the raw material after ripening, following a 50% reduction in the sodium nitrite dose and the use of Lactobacillus sakei, showed a statistically significant reduction ($p < 0.05$) in the total microbial count (CFU/g) in the experimental batch from 6.4 ± 0.2 to 5.6 ± 0.1 log CFU/g. This indicates a pronounced antagonistic effect of L. sakei on the level of microbiological spoilage. The growth of lactic acid bacteria reached 6.3 ± 0.2 log CFU/g, indicating the active development of the introduced L. sakei and its ability to dominate the meat microbiocenosis under conditions of moderate pH, ranging from 6.0 to 6.3 [16].

The number of bacteria of the Enterobacteriaceae family decreased by more than 1.5 log (from 3.2 to 1.8 log CFU/g), confirming the inhibitory effect of LAB due to competition for nutrient substrates and the formation of organic acids. A similar trend was observed for Pseudomonas spp. and Brochothrix thermosphacta, with a reduction in their numbers of 1.3 and 1.0 log, respectively. These microorganisms are known to be the primary causes of spoilage in chilled meat; therefore, their suppression is an important indicator of microbiological stability [17]. No Escherichia coli, Staphylococcus aureus, Listeria monocytogenes or Salmonella spp. were detected in either sample.

In the experimental samples, the residual sodium nitrite content fell to 21 ± 3 mg/kg, whereas in the control sample it was 42 ± 4 mg/kg, and the amount of $NaNO_2$ was reduced by a factor of two. This is explained by the nitrite-reducing activity of L. sakei and the enzymatic reduction of nitrite to nitrosamines, which contribute to colour stabilisation. This is confirmed by the results of the organoleptic evaluation of the finished meat products, where the colour score of the experimental samples was rated on a par with the control. The data obtained are consistent with the results of Wang X.H. et al. which describe a rapid decrease in residual nitrite during the fermentation of meat systems in the presence of lactic acid bacteria [18].

Thus, the use of Lactobacillus sakei culture, combined with a 50% reduction in the sodium nitrite dose, ensures the microbiological safety and stability of the raw materials during the maturation stage without increasing the risk of contamination.

In the next stage of the experiment, following the production of the finished products in accordance with the method described in [7], the control sample (Control + L. sakei) and the test samples (L. sakei + Se, L. sakei + Zn) were analysed for their physicochemical and organoleptic properties.

The control samples did not contain any trace element additives. The meat products were heat-treated to a core temperature of ≥ 70 °C and subsequently smoked.

To characterize the oxidative stability of ham during storage, the peroxide value of fat in control and experimental samples (with Se and Zn) was determined on days 0, 20, and 30. The values obtained were used to compare the dynamics of the accumulation of primary oxidation products (Table 2).

Таблица 2 – Dynamics of the peroxide value of fat during storage

Storage period	Indicator, unit of measurement	Control + L. sakei	L. sakei + Se	L. sakei + Zn
0	Peroxide value (mmol O_2/kg fat)	0,64a ± 0,05	0,55b ± 0,05	0,52b ± 0,05
20	Peroxide value (mmol O_2/kg fat)	0,89a ± 0,07	0,72b ± 0,06	0,68c ± 0,05
30	Peroxide value (mmol O_2/kg fat)	1,25a ± 0,09	0,98b ± 0,08	0,93b ± 0,07

values are shown as mean ± SD; letters (a–c) represent significant differences at $p < 0.05$.

Table 2 shows a reduction in the peroxide value (PV) in the test samples, reflecting the antioxidant effect of L-selenomethionine and zinc citrate, which inhibit both primary and secondary lipid peroxidation.

The indicators of lipid peroxidation demonstrate a pronounced antioxidant effect of micronutrient fortification. In the control samples, the peroxide value (PV) was 0.64 ± 0.05 mmol O_2/kg fat, corresponding to a moderate level of primary oxidation products. Upon the addition of L-selenomethionine and zinc citrate, the PV decreased to 0.52–0.55 mmol O_2/kg. This indicates the inhibition of lipid hydroperoxide formation due to the activation of enzymatic antioxidant systems, in particular glutathione peroxidase (Se-dependent) and superoxide dismutase (Zn-dependent) [19].

An increase in PO_2 values was observed during storage, which may be linked to the development of lipid oxidation processes. However, in all fortified samples, this increase occurred at a significantly slower rate than in the control samples. After 30 days of storage, the PO_2 value in the control reached 1.25 mmol O_2/kg, whereas in the samples containing L-selenomethionine and zinc citrate, it was 21% and 26% lower, respectively.

Similar results were also reported in studies by Abilmazhinova N. et al., where a decrease in the peroxide value was observed in the experimental samples during the storage of semi-finished meat products [20].

To evaluate the technological properties, microbiological stability and shelf life of the meat product, the water-holding capacity (WHC), pH and water activity were determined in the control and experimental samples (containing Se and Zn). The results are presented in Table 3.

The fortification of meat products with Se (L-selenomethionine) and Zn (zinc citrate) had no significant effect on the pH value, which ranged from 5.76 to 5.82 in all variants, indicating that optimal conditions for moisture binding and the stability of the protein-water system were maintained.

Water activity values (aW = 0.958-0.962) remained virtually unchanged, ensuring the microbiological stability of the product.

Table 3 – Determination of the physicochemical quality parameters of meat products fortified with trace elements

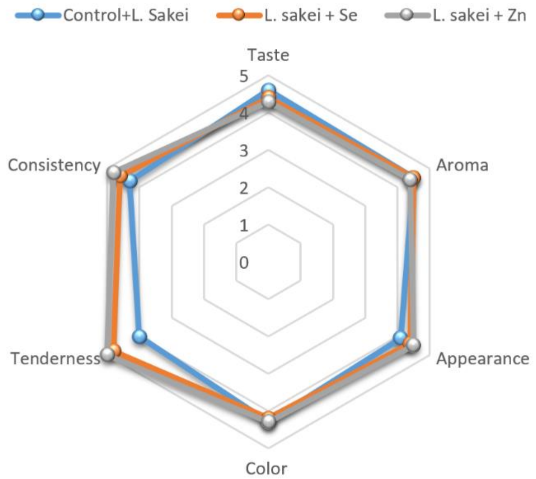
Indicator	Control + L. sakei	Test samples	
		L. sakei + Se	L. sakei + Zn
pH	5,78b ± 0,05	5,82a ± 0,04	5,76b ± 0,04
aw (water activity)	0,962a ± 0,005	0,958b ± 0,004	0,959b± 0,004
WHC, %	69,0c± 1,2	71,8a ± 1,1	70,9b ± 1,0

values are shown as mean ± SD; letters (a–c) represent significant differences at $p < 0.05$.

The results obtained are consistent with the findings of Arihara K., who noted that the addition of functional ingredients and trace elements to meat products generally does not lead to significant changes in pH and water activity when traditional production technology is maintained [21]. Similar conclusions are presented in the works of Pogorzelska-Nowicka E. et al., where no significant changes in pH and aW values were observed when meat products were enriched with biologically active components [22].

The most pronounced differences were observed in water-holding capacity (WHC): upon the addition of L-selenomethionine and zinc citrate, WHC increased by 2.7-4.0% relative to the control. This indicates an improvement in structural and mechanical properties and the formation of a denser protein-fat matrix due to the interaction of Se^{2-} and Zn^{2+} ions with the functional groups of proteins. A similar trend is described in the studies by Xu Y. and Xu X., who showed that the addition of mineral components and antioxidant compounds can enhance the interaction of metal ions with the functional groups of muscle tissue proteins, contributing to the formation of a more stable protein-fat matrix and an increase in the water-holding capacity of meat systems [23].

To complement the instrumental analysis, sensory evaluation was performed. The results are presented in Figure 1.



Figur 2 – Sensory evaluation of ham samples (5-point scale)

The organoleptic evaluation of the control and experimental samples was carried out in accordance with GOST 9959-2015, «Meat and meat products. General conditions for organoleptic evaluation» [13]. The maximum score for the assessment was 5. Three samples from each group were selected for the organoleptic assessment. The tasting panel consisted of representatives from the academic staff of the Department of Food Technology. The sensory assessment was carried out with the voluntary participation of trained academic staff. All participants were informed of the aims of the study and gave their verbal informed consent before the assessment began. The study did not involve any medical procedures, and no personal data was collected. The study complied with the ethical standards applicable to research involving human subjects [14].

Based on the tasting panel's responses, as shown in Figure 2, it can be concluded that there is a negligible difference between the control and experimental samples. The experimental samples L. sakei + Zn and L. sakei + Se outperformed the control sample in two parameters – consistency and tenderness – whilst criteria such as taste, aroma and colour were close to those of the control sample. Figure 2 presents the results of the average scores for all parameters. Similar results are described in the work of Absalimova et al., where the addition of a protein-carbohydrate composition as an enhancer and filler in minced meat semi-finished products had a positive effect on the consistency of the products [24].

Conclusion

The results of this study demonstrate the technological potential of combining the bioprotective culture Lactobacillus sakei with micronutrient fortification for the production of ham from meat of culled cows. The application of L. sakei during the maturation stage, together with a 50% reduction in sodium nitrite, contributed to the suppression of spoilage microflora and ensured microbiological safety of the raw material without the detection of pathogenic microorganisms. Fortification of the ham with selenium (L-selenomethionine) and zinc (zinc citrate) improved oxidative stability during refrigerated storage, as indicated by significantly lower peroxide values compared with the control samples. At the same time, the introduction of micronutrients did not adversely affect the key physicochemical parameters of the product, as pH and water activity remained within the optimal range for meat products. An increase in water-holding capacity in fortified samples indicates improved structural and technological properties of the meat system. Sensory evaluation confirmed that micronutrient fortification did not reduce product acceptability and even contributed to improved texture and tenderness. Overall, the combined use of Lactobacillus sakei and micronutrient enrichment represents a promising approach for improving the quality, stability, and safety of ham produced from culled cow meat, thereby enhancing the efficient utilization of this raw material in the meat industry.

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ЖАСЫ ҰЛҒАЙҒАН СИЫР ЕТІНЕН ДАЙЫНДАЛҒАН, СЕЛЕН ЖӘНЕ МЫРЫШПЕН БАЙЫТЫЛҒАН ВЕТЧИНАНЫҢ ФИЗИКА-ХИМИЯЛЫҚ ЖӘНЕ МИКРОБИОЛОГИЯЛЫҚ КӨРСЕТКІШТЕРІН ЗЕРТТЕУ

Жасы ұлғайған сиыр етін тиімді пайдалану оның функционалдық және технологиялық қасиеттерінің өзгермелілігіне байланысты ет өнеркәсібі үшін маңызды технологиялық міндет болып табылады. Осы зерттеудің мақсаты жасы ұлғайған сиыр етінен дайындалған ет өнімдерінің сапасына, тотығу тұрақтылығына және микробиологиялық қауіпсіздігіне биоқорғаушы культура Lactobacillus sakei мен микроэлементтер – селен (Se) және мырышпен (Zn) байытудың кешенді әсерін бағалау болды. Пісіп-жетілу процесі кезінде шикі еттің микробиологиялық көрсеткіштеріне Lactobacillus sakei қолдану және натрий нитриті мөлшерін 50 % төмендету арқылы олардың бірлескен әсері зерттелді. L. sakei қолдану жалпы микроорганизмдер санын айтарлықтай төмендетті (6,4-тен 5,6 log КОЕ/г дейін) және өнімнің бұзылуын тудыратын микроорганизмдердің, соның ішінде Enterobacteriaceae, Pseudomonas spp. және Brochothrix thermosphacta өсімін тежеді. Патогенді микроорганизмдер (Escherichia coli, Staphylococcus aureus, Listeria monocytogenes және Salmonella spp.) анықталған жоқ. L. sakei қосылған және L-селенометионинмен (0,525 мг/кг) және мырыш цитратымен (150 мг/кг) байытылған ет өнімдерінің үлгілері физика-химиялық және органолептикалық қасиеттері бойынша зерттелді. Үлгілерді тоңазытқышта сақтау кезінде (4°C, 30 күн) пероксид саны зерттелді. Микронутриенттермен байыту липидтердің тотығуын төмендетті: 30 күннен кейін пероксидтік сан көрсеткіштері бақылау үлгілеріне қарағанда төмен болды. pH мәндері (5,76-5,82) және су белсенділігі (0,958-0,962) тұрақты болып қалды, ал тәжірибелік үлгілерде су ұстау қабілеті 4 %-ға артты. Сенсорлық бағалау бақылау және тәжірибелік үлгілердің түсі, дәмі және сыртқы түрі көрсеткіштері бойынша сапасы ұқсас екенін көрсетті, ал тәжірибелік үлгілердің текстурасы мен жұмсақтығы жақсарғаны байқалды.

Зерттеу нәтижелері көрсеткендей, Lactobacillus sakei қолдану мен микронутриенттермен (Se және Zn) байытудың бірлескен әсері жасы ұлғайған сиыр етінен дайындалған ет өнімдерінің тотығу тұрақтылығын және технологиялық қасиеттерін жақсартып, сонымен қатар олардың микробиологиялық қауіпсіздігі мен сенсорлық сапасын сақтай алады.
Түйін сөздер: *Lactobacillus sakei, селен, мырыш, пероксидтік сан, су ұстау қабілеті, микробиологиялық қауіпсіздік.*

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ИССЛЕДОВАНИЕ ФИЗИКО-ХИМИЧЕСКИХ И МИКРОБИОЛОГИЧЕСКИХ ПОКАЗАТЕЛЕЙ ВЕТЧИНЫ ИЗ МЯСА ВЫБРАКОВАННЫХ КОРОВ, ОБОГАЩЁННЫХ СЕЛЕНОМ И ЦИНКОМ

Эффективное использование мяса выбракованных коров представляет собой важную технологическую задачу для мясной промышленности ввиду изменчивости его функциональных и технологических свойств. Целью настоящего исследования была оценка комбинированного воздействия биозащитной культуры Lactobacillus Sakei и обогащения микроэлементами – селеном (Se) и цинком (Zn) – на качество, окислительную стабильность и микробиологическую безопасность мясных изделий, изготовленной из мяса выбракованных коров. Изучалось влияние Lactobacillus Sakei в сочетании с 50-процентным снижением уровня нитрита натрия на микробиологические показатели сырого мяса в процессе созревания. Использование L. Sakei значительно снизило общее количество микроорганизмов (с 6,4 до 5,6 log КОЕ/г) и подавило рост микроорганизмов, вызывающих порчу продуктов, включая Enterobacteriaceae, Pseudomonas spp. и Brochothrix thermosphacta. Патогенные микроорганизмы (Escherichia coli, Staphylococcus aureus, Listeria monocytogenes и Salmonella spp.) не были обнаружены. Образцы мясных изделий, содержащие L. Sakei и обогащенные L-селенометионином (0,525 мг/кг), цитратом цинка (150 мг/кг), исследовали на физико-химические и органолептические свойства. Перекисное число было исследовано при хранении образцов в холодильнике (4 °C, 30 дней). Обогащение микронутриентами снизило окисление липидов: через 30 дней показатели перекисного числа оказались ниже, чем в контрольных образцах. Значения pH (5,76-5,82) и водной активности (0,958-0,962) оставались стабильными, в то время как водоудерживающая способность увеличилась на 4 % в опытных образцах. Сенсорная оценка показала сопоставимое качество контрольных и опытных образцов в показателях цвета, вкуса и внешнего вида, в то время как показатели текстуры и нежности опытных образцов были улучшены.

Результаты демонстрируют, что совместное применение Lactobacillus Sakei и обогащения микронутриентами (Se и Zn) может улучшить окислительную стабильность и технологические свойства мясных изделий, произведенных из мяса выбракованных коров, при этом сохраняя микробиологическую безопасность и сенсорное качество.
Ключевые слова: *Lactobacillus sakei, селен, цинк, перекисное число, влагоудерживающая способность, микробиологическая безопасность.*

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БИОЛОГИЯЛЫҚ ҚОСПАЛАРДЫ ҚОЛДАНУ АРҚЫЛЫ ДАЙЫНДАЛҒАН ШҰЖЫҚ ӨНІМДЕРІНІҢ ҚҰРЫЛЫМДЫ-МЕХАНИКАЛЫҚ ҚАСИЕТТЕРІН ЗЕРТТЕУ

Аңдатпа: *Бұл мақалада биологиялық белсенді қоспаларды қосу арқылы дайындалған шұжық өнімдерінің құрылымдық-механикалық қасиеттеріне, ылғал байланыстырғыш қасиеттеріне, pH мәніне тәуелділігі қарастырылған. Қазіргі таңда тамақтану мен адамдардың денсаулық мәселелерін жақсарту үшін, ондаған ғасырлар бойы адамзаттың табиғи өсімдік және жануарлардан алынатын өнімдерді, минералдық табиғи көздерді рационалды қолдануды қамтамасыз ету мәселесі әрқашанда өзекті болып табылады. Сауатты тамақтану талаптарына сай келетін өнімдерге ең бірінші кезекте әртүрлі функционалдық бағыттағы өнімдерді, оның ішінде тағам өнімдеріне биологиялық белсенді қоспаларды жатқызуға болады. Бұл аталған бағыт адам баласының құнды тамақтануын қамтамасыз етуге, сонымен қатар аурулардың алдын алуға, адам денсаулығы мен оның еңбекке деген қабілеттілігін артыруға бағытталған.*

Зерттеу жүргізу барысында пісірілген шұжық өнімінің құрамына өсімдік және жануарлардың шикізаттары негізінде жасалған биологиялық қоспаны енгізудің мөлшері 10 % екендігі негізделді және биологиялық қоспа қосылған пісірілген шұжық өнімінің жаңа рецептурасы құрастырылды және технологиясы ұсынылды. Пісірілген шұжық өнімінің құрамына кешенді зерттеулер жүргізілді. Құрамына өсімдік және жануар тектес шикізаттар негізінде жасалған биологиялық қоспаның пісірілген шұжық өнімінің тағамдық және биологиялық қасиеттеріне оң әсер ететіндігі, сонымен қатар функционалды ингредиенттер дайын өнімнің сапалық көрсеткіштерін жақсартып, сақтау кезінде оң әсер ететіндігі дәлелденді. Дайын өнімнің физика-химиялық, құрылымды – механикалық, органолептикалық көрсеткіштерін анықтауға бағытталған зерттеу жұмыстары жүргізілді.

Түйін сөздер: *пісірілген шұжық, биологиялық белсенді қоспа, субөнімдер, дәнді дақылдар, күріш дақылы, ылғал байланыстырғыш қабілеттілік, органолептикалық көрсеткіштері.*