

# IDENTIFICATION AND PREVENTION OF THE FORMATION OF MEAT WITH PSE AND DFD PROPERTIES AND QUALITY ASSURANCE FOR MEAT PRODUCTS FROM FEEDSTOCKS EXHIBITING AN ANOMALOUS AUTOLYSIS BEHAVIOR

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**Abstract:** A method for determining the stress resistance of slaughter animals by measuring the electric conductivity of the Tan-Fu biologically active point has been developed. The possibility of preventing the formation of signs of PSE and DFD properties in meat of stress-sensitive animals through the inclusion of succinic acid and a motherwort extract into their diet has been explored. A method for predicting the quality of meat of slaughter animals while they are alive has been developed. The possibility of using electrochemically activated water for proving consumer properties of meat products from feedstocks exhibiting an anomalous autolysis behavior has been explored.

**Key words:** meat with anomalies in autolysis, stress of slaughter animals

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## INTRODUCTION

At present, the problem of identification, prevention, and processing of meat feedstock exhibiting an anomalous autolysis behavior—the so-called meat with PSE (pale, soft, and exudative;  $\text{pH} < 5.2$ ), DFD (dark, firm, and dry;  $\text{pH} > 6.4$ ), and RSE properties (red, soft, and exudative;  $\text{pH} = 5.5$ )—is of high priority [1].

According to calculations of scientists, about 800 000 tons of DFD beef and 1 125 000 tons of PSE pork are used annually at domestic enterprises (the data are based on calculations of the NP Konsalting). It is obvious that the major portion of this meat makes the production of quality products problematic. For example, the use of PSE meat leads to an increase in the moisture loss during heat treatments and to the occurrence of a pale color, a sour taste, and an unusual texture of this type of product. Although DFD meat exhibits high moisture-retaining capacity (MRC) and water binding capacity (WBC), the use of this meat results in an increase in the duration of salting and the formation of a harsh texture of the product. Therefore, it is recommended that meat with signs of PSE properties in combination with DFD meat, plant protein preparations, and alkaline phosphates should be used in the uncooked smoked sausage technology. Meat with DFD properties is used in the production of cooked sausages, frozen

ready-to-cook foods, and meat products with high yields.

The formation of meat with anomalies in autolysis is caused by a variety of factors and can occur during both production and processing [2, 3].

A significant effect on the probability of occurrence of defects is exerted by the fat content in the feedstock, which is true for both pork and beef. The probability of occurrence of DFD properties is high in beef containing less than 4% of muscle fat. Selective breeding of meat-type pigs aimed at changing the ratio between the muscle and fat tissues (from 1 : 1 to 1 : 0.5) has led to an increase in the amount of exudative and dense dry pork [4].

Another case of the formation of meat with a non-conventional quality is the violation of hormonal homeostasis of animals owing to hormonal stimulants (reproductive hormones and their counterparts in the form of synthetic hormone-like compounds) that are used to accelerate the growth and development processes and improve the digestibility of the feeding stuff.

One of the factors of the formation of meat with an abnormal quality is the lack of protein and minerals in the diet and physical inactivity in the case of an intensive technology of breeding and feeding of farm animals.

Meat with defects is largely determined by the genotype of the animal. The quality of meat significantly

varies depending on the breed and species of slaughter animals.

One of the main causes of the formation of meat exhibiting an anomalous autolysis behavior is the effect of stress factors on the body of slaughter animals. There are the following stress factors:

- Physical (temperature, humidity, solar and ionizing radiation, noise, air motion).

- Chemical (an increase in the concentration of ammonia, hydrogen sulfide, carbon dioxide, and other gases in the air; chemicals used in livestock breeding and crop production).

- Psychic (ranking stresses in the struggle for dominance in a group of animals kept in loose housing systems to establish a hierarchical order and determine the leader of the group).

- Transport (loading and unloading, transportation of animals by various means of transport).

- Technological (weighing, weaning young stock from their mothers, crowded housing, small fronts of feeding and watering, mistreatment of animals, increased noise from the operation of machinery, long-term drives, sharp changes in housing conditions, etc.).

The above stress factors, or stressors, can be described as unfavorable housing conditions that can cause a stress under which the hormonal homeostasis of animals changes [5]. Farm animals of the same breed and species respond differently to the effects of stress factors. Animals are divided into sensitive and resistant to stress factors [5, 6]. Stress-sensitive animals are characterized by meat with PSE and DFD properties.

In view of the above, the current focus of research in the field of quality of meat products is the development of methods for determining the stress resistance of animals, the prevention and reduction of the negative effects of stresses on stress-sensitive animals, the development of reliable methods for identifying meat into groups with PSE and DFD properties, and, accordingly, quality assurance for meat products from feedstocks exhibiting an anomalous autolysis behavior.

The aim of this study is to prevent the formation of meat feedstock with defects in stress-sensitive animals, to identify meat with an anomalous autolysis behavior, and to improve the processing characteristics of meat systems.

To implement this objective, it is necessary to solve the following problems:

- To develop a method for determining the stress resistance of slaughter animals.

- To prevent the formation of meat with signs of PSE and DFD properties under the action of stress factors on stress-sensitive animals.

- To develop a method for identifying meat with an anomalous autolysis behavior.

- To explore the possibility of using electrochemically activated (ECA) water to provide a high quality of products from feedstocks exhibiting an anomalous autolysis behavior.

## MATERIALS AND METHODS

The following objects were studied:

- slaughter animals (bull-calves of a black-and-white breed);

- beef (the shoulder portion of the carcass and longissimus dorsi muscle after aging for 24 h);

- ECA water (anolyte);

- "Russkaya" cooked sausage samples.

Organoleptic, physicochemical, biochemical, microbiological, and instrumental methods of research were used.

The blood glucose level was determined by an orthotoluidine method based on the interaction between the aldehyde group of glucose and the amino group of orthotoluidine in an acid environment with the appearance of a blue-green color.

The sampling was conducted according to GOST (State Standard) R 51447-99 (ISO 3100-1-91) "Meat and meat products: Sampling methods."

The organoleptic analysis was conducted in accordance with GOST (State Standard) 7269-79 "Meat: Sampling methods and organoleptic methods for determining the freshness."

The pH value was determined by the potentiometric method according to GOST (State Standard) R 51478-99 (ISO 2917-74) "Meat and meat products: A test method for determining the hydrogen ion concentration (pH)."

The glycogen content was determined from the color reaction with anthrone, which is based on the hydrolysis of proteins with an alkali, the isolation of glycogen from the solution with ethyl alcohol, its washing and dissolving, reaction with anthrone, and the development of color with the subsequent measurement of its intensity.

The content of lactic acid was determined through the sedimentation of proteins and carbohydrates, heating with sulfuric acid, the development of a color reaction with veratrole, and measurement of the color intensity.

The WBC of meat was studied from the amount of bound water by the Grau-Hamm press-method in the modification of the All-Russia Research Institute of Meat Industry (VNIIMP).

The safety of the product was estimated in accordance with SanPin 2.3.2.1078-01 "Hygienic requirements for the safety and nutritional value of food products."

## RESULTS AND DISCUSSION

A few methods for determining the stress resistance of farm animals are currently used. Thus, the stress resistance of cows is estimated from the pattern of milk ejection during machine milking; this parameter for pigs is determined according to the response of the animals after subcutaneous injection of turpentine. In addition, the stress resistance of cattle is determined under loading with adrenocorticotrophic hormone (Thorn test). Preliminarily, the amount of eosinophils in the blood is counted; after that, adrenocorticotrophic hormone is intramuscularly injected in a dose of 25 units per 100 kg of live weight, and the amount of eosinophils in the blood is counted again after 2 and 4 h. A decrease in the number of cells by more than 50% and the failure to return to the initial state after 4 h suggest that the animal is highly sensitive to stresses.

A generally accepted method for determining the stress resistance of bull-calves is based on the level of cortisol in the blood. Animals with high stress resistance exhibit a rapid normalization of homeostasis: even in 30 min after the occurrence of stress reaction, the

amount of cortisol returns to the initial level; for animals with low stress resistance, a high content of plasma cortisol is observed for a long time.

We have developed a method for determining the stress resistance according to the electric conductivity of the Tan-Fu biologically active point (BAT) responsible for the activities of the cardiovascular system, because it is the most sensitive to the impact of stress factors.

Animals with a difference of potentials in the BAT of less than 5  $\mu$ A are regarded as stress-resistant. Animals exhibiting a difference of potentials in the Tan-Fu BAT of 2–4  $\mu$ A are stress-adaptable. Animals having this parameter at a level of more than 4  $\mu$ A are stress-sensitive.

Tests of 95 bull-calves of a black-and-white breed at the age of 18 months have revealed that 46 animals (48%) are stress-sensitive, 28 animals (30%) are stress-adaptable, and 21 animals (22%) are stress-resistant. The novelty of the engineering solution is protected by RF patent no. 2 292 197 "A method for determining the stress resistance of bull-calves" [6].

The next stage of our studies was the prevention of the formation of meat with an anomalous autolysis behavior caused by a transport stress of stress-sensitive animals.

For the experiment, two groups of ten stress-sensitive slaughter animals in each were formed (bull-calves of a black-and-white breed at the age of 16 months).

The animals were transported to a distance of 110 km. Before the transportation, the bull-calves of the first group received their basic diet; the basic diet of the animals of the second group was enriched in succinic acid a dose of 100 mg/kg, and a motherwort herb extract in an amount of 50 mg/kg in the form of a 10% aqueous solution was injected into these animals during 10 days prior to transportation. The motherwort extract was manufactured at the OOO NPP Erakond-Ural according to the technology for producing extracts from plant raw materials (RF patent no. 2 456 825).

During transportation, the animals were in a state of stress: the body temperature, respiratory rate, and cardiac rate were increased. Table 1 shows the clinical data for the animals subjected to tests.

The results of examination of the clinical data under stress are consistent with the results of foreign authors [7–9].

It is evident from Table 2 that the introduction of a motherwort extract and succinic acid into the diet of slaughter animals reduces the live weight losses under transport stresses (Table 2).

The results of studying the quality of meat of the stress-sensitive bull-calves of the control group and the group treated with succinic acid and a motherwort extract are shown in Table 3.

The deep brown color of the meat of the stress-sensitive animals of the first group is caused by the mechanism of stress development. Thus, at the stage of anxiety, or the stage of mobilization (this is the first short-term phase of the stress), the secretion of adrenaline in

creases, which enhances the heart activity. Red blood cells are released into the bloodstream to help the respiratory system to absorb oxygen. Therefore, if animals are in a state of stress during slaughter, then a higher amount of hemoglobin remains in their meat, which subsequently leads to the formation of a dark color.

**Table 1.** Clinical and physiological data of stress-sensitive bull-calves of the control group and the group treated with succinic acid and a motherwort extract ( $X \pm mx$ ;  $n = 10$ )

Group	Temperature, °C	Pulse, beats per minute	Respiratory rate per minute
Before transportation			
1	37.70 $\pm$ 0.02	68.5 $\pm$ 2.2	29.4 $\pm$ 1.5
2	37.70 $\pm$ 0.05	67.3 $\pm$ 2.5	28.7 $\pm$ 1.3
In 1 h after transportation			
1	38.30 $\pm$ 0.04	76.3 $\pm$ 2.1*	35.3 $\pm$ 1.0**
2	37.90 $\pm$ 0.03	75.0 $\pm$ 2.4*	32.2 $\pm$ 1.8
In 24 h after transportation			
1	38.2 $\pm$ 0.02	75.1 $\pm$ 1.9**	30.5 $\pm$ 1.6
2	37.70 $\pm$ 0.04	68.4 $\pm$ 2.5	28.0 $\pm$ 1.5

Hereinafter, the value is significant: \* at  $P < 0.05$ ; \*\* at  $P < 0.01$ ; and \*\*\* at  $P < 0.001$ .

**Table 2.** Losses of live weight of bull-calves of the control group and the group treated with succinic acid and a motherwort extract ( $X \pm Sx$ ;  $n = 10$ )

Parameter	Group of animals	
	1	2
Body weight of animals before transportation, kg	341.0 $\pm$ 2.5	340.3 $\pm$ 2.1
Body weight of animals after transportation, kg	318.2 $\pm$ 3.1***	329.4 $\pm$ 3.2**
Live weight losses during transportation, kg	22.8	10.9
Live weight losses, %	6.7	3.2

A motherwort extract regulates the functional state of the central nervous system, decreases the secretion of adrenaline and thereby has a calming effect and reduces the nervous irritability during stress. Therefore, the animals of the second group were less susceptible to the effects of stress factors; their hormonal status was normal; this subsequently had a positive impact on the organoleptic parameters.

During stress, the functional activity of the anterior pituitary and adrenal cortex increases and the secretion of adrenocorticotrophic hormone (ACTH) increases manifold; under the action of thereof, the secretory activity of the adrenal cortex enhances, which contributes to a rapid arrival of corticosteroid hormones in the bloodstream. Glucocorticoids and mineralocorticoids (they are also referred to as adaptive hormones) complement each other and are involved in the organization of a protective response. During stress, glucocorticoids increase the blood glucose level. However, the stores of carbohydrates in the body are limited and rapidly consumed. Therefore, before transportation, the animals received succinic acid as a source of energy.

**Table 3.** Quality of meat of the stress-sensitive bull-calves of the control group and the group treated with succinic acid and a motherwort extract ( $X \pm Sx$ ;  $n = 10$ )

Parameter	Group of animals	
	1	2
Color	Deep brown	Red-pink
Texture	Elastic, dense. A pit formed under pressing with a finger levels out slowly.	Elastic, dense. A pit formed under pressing with a finger levels out rapidly.
Flavor of meat	Specific, characteristic of fresh meat	Specific, characteristic of fresh meat
Cooking test - flavor of broth - transparency - flocculation	Aromatic Turbid Significant	Aromatic Transparent Insignificant
Degree of bleeding	Satisfactory	Good
pH	$6.5 \pm 0.1$	$5.8 \pm 0.1^*$
Glycogen, mg%	$12.1 \pm 2.7$	$860.1 \pm 15.7^{***}$
Lactic acid, mg%	$118.4 \pm 12.0$	$948.1 \pm 10.1^*$
WBC, %	$67.9 \pm 3.5$	$61.1 \pm 2.0$

It has been found that the amount of the energetic material—glycogen—in the meat of the bull-calves of the second group was significantly higher. The decomposition of glycogen during anaerobic glycolysis yields lactic acid, which leads to a shift of pH to the acidic side. The content of lactic acid in the meat samples of the first and second groups was at a level of 118.4 and 948.1 mg%, respectively.

The pH value characterizes the level of ionization of the amino groups of the protein molecule and predetermines the ratio between charged and uncharged groups, which affects the amount of hydrophilic centers and, accordingly, the WBC value. The last-mentioned quantity changes the rheological properties, organoleptic parameters, structure, and degree of stability of meat products during storage.

The results of the studies have shown that, in 24 h after slaughter, the pH value of the meat was 6.5 for the bull-calves of the first group and 5.8 for the animals of the second group against the background of the use of succinic acid and a motherwort extract. The beef samples obtained from the first group of bull-calves had a high WBC (67.9%), which is characteristic of meat feedstocks with DFD properties.

Thus, the treatment of stress-sensitive slaughter animals with succinic acid and a motherwort extract hinders the formation of meat with anomalies in autolysis.

The most important criteria for estimating the meat exhibiting an anomalous autolysis behavior are organoleptic biochemical parameters and processing properties.

A significant contribution to the identification of meat feedstocks into quality groups was made by foreign scientists Eikelenboom, Smuldes, Ruderus, Hawrysh, Shand, Wolfe [10, 11], etc.

One of the methods for controlling the nutritional value of meat involves the butchering of animals, the sampling of the test specimen, and the subsequent con-

trol of the nutritional value of meat by sorting carcasses into groups of meat with a normal nutritional value (NOR) and PSE and DFD properties. The gist of this method is that, after the bleeding of carcasses (during butchering), the free activity of tissue proteinase—cathepsin D—is determined in the muscle tissue; meat with the cathepsin D activity of less than  $0.05 \mu\text{M/h} \cdot \text{g}$  of protein is regarded as meat with a normal nutritional value; the cathepsin D activity of  $0.05\text{--}0.075 \mu\text{M/h} \cdot \text{g}$  of protein is characteristic of meat with DFD properties; and the cathepsin D activity of more than  $0.075 \mu\text{M/h} \cdot \text{g}$  of protein is typical for meat with PSE properties [12].

Another method consists in the exposure to an electric current and the measurement of the pH value. Yet another method is based on the sampling of the test specimen, the exposure to electromagnetic radiation of a given wavelength range, and the measurement of the parameter that correlates with the quality of meat, i.e., the ratio between reflection intensities of the test specimen and the reference, which are measured using a color comparator (KTsSh). In this case, the quality of meat is controlled with allowance for the derived values of this ratio. The ratio of 1.05–1.0 characterizes NOR meat; the ratio of 1.2–1.25 is typical for DFD meat; and the ratio of 0.9–0.95 is characteristic of PSE meat [12].

The generally accepted method for classifying meat feedstocks into groups of PSE, DFD, and NOR quality is based on the measurement of pH values in 1 and 24 h after the slaughter of the animal [13].

The method developed in the United Kingdom makes it possible to classify meat into quality groups according to the scattering of light passing through the probe placed in the meat.

Canadian researchers use a portable spectrophotometer to derive reflection spectra in a wavelength range of 400–700 nm. The measurement data correlate with the quality factors for meat with DFD and PSE properties.

Polish specialists have developed a method for determining the quality of beef in slaughter lines, which is based on the rapid glycolysis of meat. In this case, 3 g of the muscle tissue is mixed with 20 mL of calcium chloride and 20 mL of magnesium chloride; after that, the pH value is measured to classify meat into quality groups [3].

Another method for identifying meat with a nonconventional quality is based on the measurement of the electric conductivity of biologically active points of animals while they are alive [14].

Each of the above methods has certain disadvantages, and their practical use is fairly limited. Therefore, the development of reliable and affordable methods is an urgent problem.

We have developed a method for predicting the quality of meat of slaughter animals while they are alive. The method consists in the following. The blood glucose content of animals is determined at the beginning of the preslaughter holding; after that, they are given to drink a 10% glucose solution in a dose of 2 L per 100 kg of live weight, and the analysis is repeated after 24 h. If the measured value is higher than the initial one, then it is concluded that the animal is prone to

the formation of meat with anomalies in autolysis.

To verify the method, an experiment was conducted. Two groups of 20 slaughter animals in each were formed (bull-calves of a black-and-white breed at the age of 16 months). The first group was a control group. At the beginning of the preslaughter holding, the animals of the second group were given to drink a 10% glucose solution in the above dose. Within 24 h of the preslaughter holding, the glucose content in the control group significantly decreased to 2.7 mmol/L compared to a value of 3.1 mmol/L at the beginning of the preslaughter holding; this is attributed to the fact that the animals were not fed. In the test group, the glucose content returned to the initial level of 2.3–3.9 mmol/L for ten animals, became higher—3.9–4.13 mmol/L—for six animals, and became lower than the initial level for four animals.

The results of the post-slaughter measurement of pH in the longissimus dorsi muscle are shown in Table 4.

**Table 4.** Classification of meat into quality groups

Number of animals	Blood glucose content, mmol/L	pH of meat in 45 min after slaughter	Quality group of meat
4	2.14–2.2	5.3–5.7	PSE
10	2.3–3.9	5.3–6.2	NOR
6	3.9–4.13	6.4–6.6	DFD

After 45 min, the pH of the meat of the slaughter animals with a low glucose content (2.14–2.2 mmol/L) was 5.3–5.7, which is indicative of meat with PSE properties; six animals had a pH value of more than 6.4 (meat with DFD properties), and only ten animals had a normal pH value.

Thus, the use of the proposed engineering solution makes it possible to classify the quality of meat of slaughter animals while they are alive into three groups—PSE, DFD, and NOR—by treating the slaughter animals with a 10% solution of glucose and measuring its content in their blood.

It is recommended that meat with DFD properties should be used in the production of cooked sausages. It should be noted that meat products from this meat feedstock are unstable to microbiological spoilage because of high WBC and pH values.

To provide a high quality of meat products, phosphates of different brands are used, in particular, "Albright," "Puromix," and "Puron," which give the possibility to compensate for the defects of meat feedstock (PSE and DFD).

Therefore, the providing of a high quality of meat products during storage is of current concern.

The shelf life of cooked sausages in natural casings is up to 5 days at a storage temperature of 0–6°C and a relative air humidity of no higher than 75%.

Studies on the use of ECA water for the production of cooked sausages from meat feedstock with signs of DFD properties were conducted.

For the experiment, an experimental batch of the "Russkaya" cooked sausage was produced according to GOST (State Standard) R 52196-03. The shelf life of the sausage is 5 days. The first group (control) was pro-

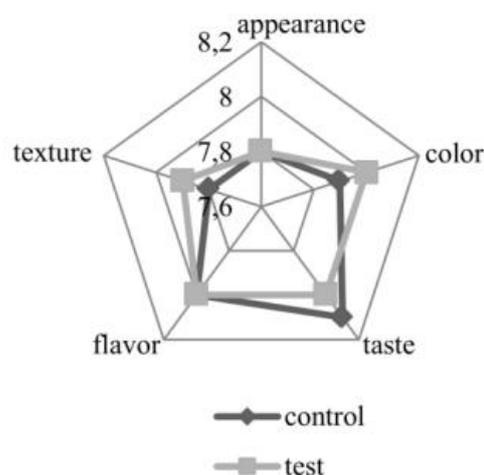
duced according to the conventional technology and formulation, while the second group of the sausage samples was prepared using ECA water.

The sausage samples were placed in a storage room ( $t^{\circ}$  of 0–4°C; relative air humidity of 75%).

The storage ability of the sausage was determined from organoleptic and microbiological parameters, peroxide value, pH value, and the results of microscopic studies.

ECA water (anolyte with a pH value of 2.5 from drinking water) was used for the preparation of the cooked sausages. The use of the anolyte in the production of cooked sausages is attributed to a high pH value of the meat feedstock.

Figure 1 shows the results of the organoleptic estimate of the control and test samples of the cooked sausages after storage for 5 days (in points).



**Fig. 1.** Organoleptic estimate of the cooked sausages after storage for 5 days (in points).

It is evident from Fig. 1 that the test samples of the cooked sausages were superior to the control samples in color and texture.

After storage for 5 days, the sausage samples of the control and test groups met the requirements of SanPiN 2.3.2 1078-01.

Table 5 shows the organoleptic parameters of the cooked sausages after storage for 10 days.

The organoleptic studies have revealed that, after 10 days, the sausage samples of the control group had an unpleasant taste and odor and a gray-green color. The sausage filling of the product was softened and loose. All the examined organoleptic parameters of the sausage of the test group were within normal limits.

One of the important criteria of the freshness of meat products is the pH value.

It has been found that the sausages of the first group, after storage for 3 and 5 days, have a pH value of 5.2 and 5.8, while the normal value for a fresh product is 5.0–6.8; after 10 days, their pH is 7.0, which corresponds to sausages of dubious freshness. This is probably attributed to the accumulation of metabolic products of microorganisms that cause the breakdown of proteins (amines, nitrogen bases, ammonia). After storage for 10 days, the medium's reaction of the test cooked sausage samples is at a level of 6.4.

**Table 5.** Organoleptic parameters of the cooked sausages after storage for 10 days

Parameter	Requirements of GOST R 52196-2003	Group	
		1 (control)	2 (test)
Actual			
Outward appearance	Loaves with a clean dry surface free from stains, slips, casing damage, sausage filling overflows, broth and fat pockets	Loaves with a moist surface and sticky casing	Loaves with a clean dry surface free from stains, slips, casing damage, sausage filling overflows, broth and fat pockets
Texture	elastic	The sausage filling of the product is softened and loose.	elastic
Cross sectional view of the sausage filling	The sausage filling is light pink to dark pink in color with no gray stains; it is homogeneous, uniformly mixed and has inclusions of lard no larger than 6 mm.	The sausage filling taken from the surface of the loaf is light pink to greenish in color with gray stains; it is homogeneous, uniformly mixed and has inclusions of lard no larger than 6 mm.	The sausage filling is light pink to dark pink in color with no gray stains; it is homogeneous, uniformly mixed and has inclusions of lard no larger than 6 mm.
Taste and flavor	Pleasant, characteristic of this type of product, free from foreign flavor and odor, with a pronounced flavor of spices.	Unpleasant odor, slightly sour taste	Pleasant, characteristic of this type of product, free from foreign flavor and odor, with a pronounced flavor of spices.

An increase in the peroxide and acid values of the sausages during storage was not observed.

One of the main causes of spoilage of meat products is the development of residual microflora in sausage

products during storage.

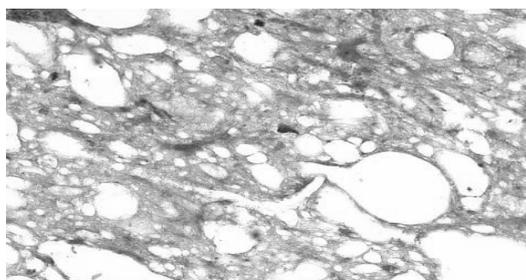
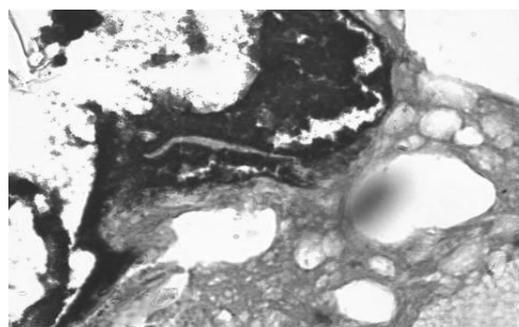
Table 6 shows the microbiological parameters of the cooked sausages after storage for 10 days.

**Table 6.** Microbiological parameters of the cooked sausages after storage for 10 days

Parameter	Norm according to SanPuN 2.3.2 1078-01	Group	
		1 (control)	2 (test)
QMAFAnM, CFU/g, no more	$1 \times 10^3$	$15 \times 10^6$	$15 \times 10^1$
CGB (coliforms) in 1.0 g	not allowed	not detected	not detected
sulfite-reducing clostridia in 0.01 g	not allowed	not detected	not detected
S.aureus in 1.0 g	not allowed	not detected	not detected
Pathogenic, particularly salmonellas, in 25 g	not allowed	not detected	not detected

After storage for 10 days, the control cooked sausage samples do not meet the regulatory requirements. Thus, the amount of QMAFAnM is  $15 \times 10^6$  CFU/g, while the norm is no more than  $1 \times 10^3$  CFU/g; hence, the studied product is unfit for sale and consumption. At the same time, the test cooked sausage samples do not exhibit deviations in the microbiological parameters.

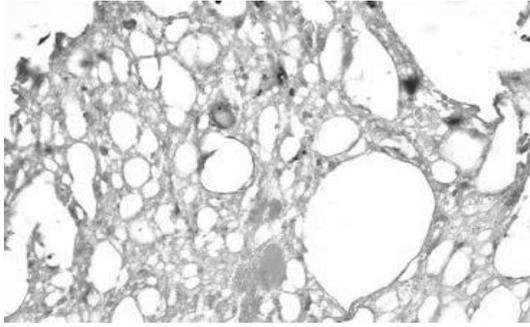
Analysis of the microbiological studies suggests that the use of ECA water in the production of cooked sausages constrains the development of pathogenic microflora in the product.

**Fig. 2.** Microstructure of the cooked sausage samples after storage for 5 days (control).**Fig. 3.** Microstructure of the cooked sausage samples after storage for 10 days (control).

The microstructure of the cooked sausage during storage was studied. Microscopically, the sausage is a homogeneous amorphous finely grained mass with large particles of fat, dispersed inclusions of fibers of the transversely striated muscle tissue, and fragments of loose and dense connective tissue.

Figure 2 shows the cooked sausage of the control group after storage for 5 days.

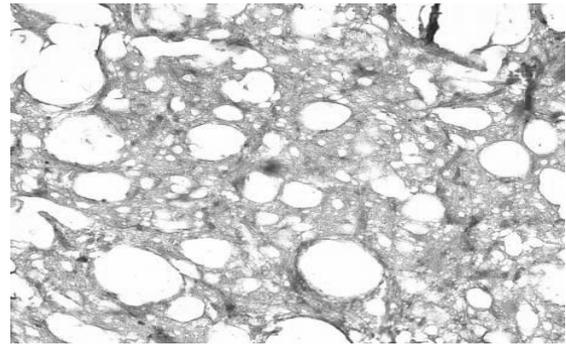
A cluster of cocci and colonies of yeast fungi are evident in Fig. 3.



**Fig. 4.** Microstructure of the cooked sausage samples after storage for 5 days (test).

Thus, on the basis of the studies, a method for determining the stress resistance of slaughter animals has been developed. It has been shown that the meat of stress-sensitive bull-calves under transport stress is characterized by DFD defects. The use of succinic acid and a motherwort extract in the diet of slaughter animals before transportation makes it possible to hinder the formation of meat with a nonconventional quality. A method for predicting meat with PSE, DFD, and NOR properties has been described. It has been shown that ECA water can be used in the production of meat prod-

ucts from feedstocks exhibiting an anomalous autolysis behavior.



**Fig. 5.** Microstructure of the cooked sausage samples after storage for 10 days (test).

All the studied pieces (Figs. 4, 5) contain individual colonies of cocci. The fragments of the connective tissue exhibit the monotony of perception of histological stains; however, the nuclei are clearly visible.

Thus, the use of ECA water in the production of cooked sausages has a positive effect on the shelf life of products from feedstocks with DFD properties.

#### REFERENCES

1. Rogov, I.A., Zharinov, A.I., Tekut'eva, L.A., and Shepel', T.A., *Biotechnologiya myasa i myasoproduktov* (Biotechnology of Meat and Meat Products), Moscow: DeLi print, 2009.
2. Krishtafovich, V.I., Kolobov, S.V., and Yablokob, D.I., Potrebitel'skie svoistva myasa s otkloneniyami v protsesse avtoliza (Consumer properties of meat with anomalies in autolysis), *Myasnaya Industriya (Meat Industry)*, 2005, no. 1, pp. 30–33.
3. Zharinov, A.I. and Kudryashov, L.S., Chto nuzhno znat' o parnom myase (What we should know about slaughter-warm meat), *Myasnaya Industriya (Meat Industry)*, 2005, no. 7, pp. 16–19.
4. Tatulov, Yu.V., Kosacheva, T.V., and Kuznetsova, S.A., Vliyaniye stressa na kachestvo myasnogo syr'ya (Effect of stress on the quality of meat feedstock), *Myasnaya Industriya (Meat Industry)*, 2009, no. 7, p. 55.
5. Tikhonov, S.L., *Stress i kachestvo myasa* (Stress and Quality of Meat), Troitsk: UGAVM, 2007.
6. Tikhonov, S.L., Tikhonova, N.V., Sunagatullin, F.A., and Stepanov, A.V., RF Patent 2 292 197, 2005.
7. Everly, G.S., The organ specificity score as a measure of psycho-physiological stress reactivity, *Doctoral Dissertation*, University of Maryland, 1978 (unpublished).
8. Levi, L., Stress, distress, and psychosocial stimuli, in *Occupational Stress*, McLean, A., Ed., Springfield, Ill.: Thomas, 1974.
9. Vigas, M., in *Catecholamines and Stress: Recent Advances, Ser. Developments in Neuroscience*, Usdin, E., Kvetnansky, R., and Kopin, I.J., Eds., New York, Amsterdam, Oxford: Elsevier, 1980, vol. 8, pp. 573–578.
10. Eikelenboom, G., Smuldes, F.J.M., and Ruderus, H., The effect of high and low voltage electrical stimulation on beef quality, *Meat Science*, 1985, vol. 15, no. 4, pp. 247–254.
11. Hawrysh, Z.J., Shand, P.J., and Wolfe, F.N., Effects of low voltage electrical stimulation on the quality of the round from young and mature cows, *Canadian Institute of Food Science and Technology Journal*, 1986, vol. 19, no. 3, pp. 121–129.
12. Kudryashov, L.S., Gurinovich, G.V., and Potipaeva, N.N., RF Patent 2 092 836, 1997.
13. Tatulov, Yu.V., Nemchinova, I.P., and Loseva, N.A., Kachestvennyye kharakteristiki syr'ya myasnoi promyshlennosti v SSSR i za rubezhom (Quality characteristics of feedstock for meat industry in the USSR and abroad), in *Myasnaya i kholodil'naya promyshlennost': Peredovoi nauchno-proizvodstvennyi opyt, rekomenduemyi dlya vnedreniya* (Meat and Refrigeration Industry: Advanced Research and Production Experience Recommended for Implementation), Moscow: AgroNIITELmyasomolprom, 1990, issue 2, pp. 22–26.
14. Lapshina, A.A., Tikhonov, S.L., Pershina, E.I., and Kudryashov, S.L., Sposob sortirovki myasa na gruppy kachestva PSE, DFD i NORM (A method for sorting meat into PSE, DFD, and NORM quality groups), *Myasnaya Industriya (Meat Industry)*, 2012, no. 9, pp. 24–27.

