Changes in Pork Freshness Indicators When Stored at Positive Temperatures

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Abstract. The article examines the processes occurring during the ripening of pork meat during storage at a temperature of 0–4 ºC. Particular attention is paid to a group of chemical indicators of freshness of raw meat: acidity (pH), mass fraction of sodium chloride, and the presence of protein breakdown products. The author concludes that instrumental methods, along with methods of organoleptic control of raw meat, make it possible to assess the properties of meat more accurately. Based on the study of samples, it was established that measuring the pH (acidity) of meat 24 hours after slaughter and in the subsequent period allows characterizing in detail the autolysis process and detect signs of NOR, PSE or DED. Considering changes in pH values, it is possible to determine the direction of use of raw meat. It was revealed that the mass fraction of sodium chloride does not change during maturation and storage under the conditions under study. In all samples, the presence of protein degradation products was not detected.

1. Introduction
The chemical composition and properties of the tissues of the slaughtered animal undergo changes during storage. The main direction of biochemical processes is tissue breakdown and metabolic disorganization. The nature of the changes depends on many parameters: genetic factors, conditions of keeping animals, veterinary conditions, and storage parameters of raw meat [1].

The main process taking place in raw meat is autolysis – self-destruction of tissues under the influence of their own enzymes. In the process of autolysis, changes in the chemical composition of tissues, muscle structure, and the appearance of meat occur. Products accumulate, giving a pronounced aroma. The ripening process of meat involves multiple changes in carbohydrate, protein and lipid structure. The water-salt composition of tissues changes [2]. Modified proteins that have undergone phosphorylation, acetylation, nitrosylation and other transformations make a great contribution to the formation of consumer qualities of meat [3]. Multiple and uneven changes do not allow establishing unambiguous indicators of meat maturity. As a rule, organoleptic studies are the main methods of analysis of raw meat at processing plants [4]. Along with them, instrumental methods are actively used to ensure the objectivity and reliability of the results. In recent years, non-invasive methods have been increasingly used to determine quality indicators. These include: infrared spectroscopy, multispectral and hyperspectral imaging, thermal imaging, tomographic imaging, and electronic nose. Combined with dedicated data processing programs, these methods enable real-time analysis of meat quality [5, 6].

A promising direction in the issue of meat quality control is the method of biological markers. The development and use of biomarkers will make it possible to diagnose and predict the direction of changes in meat quality indicators depending on environmental factors, feeding conditions and keeping animals
Biosensors make it possible to assess microbiological indicators, the degree of glycolysis, freshness, tenderness of consistency, and quality defects. Methods of analysis using biological indicators are highly dependent on the types of receptors and the sensitivity of the sensors [8].

When using industrial methods of raising pigs, the proportion of raw meat with an abnormal course of the autolysis process increases. The reasons for the development of abnormal autolysis are being actively studied. The influence of the conditions of raising animals, the state of stress in the pre-slaughter period was found [9, 10]. The complexity of biological systems and a multitude of operating parameters lead to a different course of processes even in animals with phenotypic similarities and similar housing conditions [11].

Special terms have been introduced for meat, the parameters of which deviate from the norm. Meat with DED signs has a pH value above 6.2 24 hours after slaughter. It is characterized by a rough structure, stiffness, stickiness and dark color. Meat with DED marks has a high water holding capacity. These qualities reduce resistance to microbiological contamination. Another variant of abnormal autolysis belongs to the meat with signs of PSE, which is characterized by a pH value of 5.2–5.5 60 minutes after slaughter. The following qualities are inherent in it: softness, pallor, loose consistency, and sour taste. Low water retention capacity should be taken into account when processing such meat into products [12]. Meat with DED and PSE deviations requires special techniques and changes in the technological process so that the finished products meet the established quality parameters.

The acidity index (pH, pH) is an important characteristic for the control of DED, PSE or NOR signs. The structure of proteins, water-holding capacity, resistance to the reproduction of microorganisms depend on its values. PH values largely determine the terms and conditions of meat storage, as well as influence the choice of processing method.

Mineral substances, present in meat in small quantities, affect the structure of tissues and autolysis processes [13]. NaCl is of particular importance of the mineral salts. On the one hand, sodium chloride is required for the processing of raw meat. On the other hand, it causes an increased risk of cardiovascular diseases [14]. Therefore, careful control of the NaCl content in the feedstock is required. In the course of processing, it is possible to replace sodium chloride with potassium chloride or calcium chloride [15].

The instrumental methods of analyzing the freshness of meat include the method for determining the products of protein decay. This method confirms the processes of meat spoilage caused by the breakdown of proteins. The method is very important in case of suspicion of falsification of meat raw materials.

2. Materials and methods

Raw meat is analyzed considering the direction of its further use. At the same time, as a rule, indicators of biological value storage fitness parameters; technological indicators that determine the direction of processing, and other special indicators are studied. In this work, we analyzed the indicators characterizing the changes in meat raw materials during storage at positive temperatures.

The research was carried out in the production and testing laboratory of “Velikonovgorodsky Myasnoy Dvor”. The object of research was pork samples of Volotovskaya II category. Samples weighing 200 g were taken from the studied pork carcass in the thigh area from the thick parts of the muscles. Samples were taken from each batch of pork and examined within a week. Eight samples were examined. The samples under study were stored in a refrigerator at a temperature of 0 – 4 ºC.

The pH was determined in accordance with the requirements of GOST R 51478-99. An I-160.1MP laboratory ionometer was used to measure the potential difference.

The determination of the mass fraction of sodium chloride was carried out in accordance with the requirements of GOST 9957-2015 by the Mohr method: titration in a neutral medium of chlorine ions with silver ions in the presence of chromic acid potassium.

The products of the primary breakdown of proteins in the broth were determined by reaction with copper sulfate of 5% concentration. For analysis, 20 g of minced meat was placed in a flask, 60 ml of distilled water was added, and thoroughly mixed. The flask was covered with glass and kept in a boiling
water bath for 10 minutes. The hot broth was filtered until transparent. Three drops of a 5% solution of copper sulfate were added to 2 ml of broth. Visual inspection was performed 5 minutes later. Broth of stale meat forms blue-blue or green flakes or clot.

3. Results
The experiment was carried out in the conditions of the production and testing laboratory of “Velikonovgorodsky Myasnoy Dvor”. All batches of pork supplied to the enterprise are tested for microbiological contamination and organoleptic characteristics. No abnormalities were found.

An important characteristic of the quality of meat is the acidity index in the first 24 hours after slaughter. The measurement results are shown in table 1.

| Sample | pH in 2 hours | pH in 24 hours | Signs of meat |
|--------|---------------|----------------|---------------|
| 1      | -             | 6.5            | DED           |
| 2      | 6.4           | 5.9            | NOR           |
| 3      | 6.6           | 5.7            | NOR           |
| 4      | 6.6           | 5.7            | NOR           |
| 5      | 6.3           | 5.8            | NOR           |
| 6      | 6.3           | 5.8            | NOR           |
| 7      | 6.1           | -              | NOR           |
| 8      | 6.1           | 6.1            | NOR           |

As a result of the experiment, it was revealed that only one sample showed signs of DED. Samples with signs of PSE were not found. Measurement of the pH of the samples immediately after slaughter and during the next 96 hours made it possible to reveal the different nature of the change in the analyzed parameter. The results are shown in Table 2. In one case, the final pH value exceeds the initial value (sample 1). Autolysis proceeds abnormally, without the accumulation of lactic acid. The formation of the desired consistency of meat and its juiciness does not occur. Samples 2–7 show the normal autolysis pathway. The meat is firm and juicy. It can be attributed to the NOR group. Sample 8 shows an abrupt change in pH. It can be attributed to the NOR group only taking into account measurements in the first 24 hours. An increase in the final pH value to 6.5 indicates a low lactic acid content in this sample. This fact requires careful attention to the storage conditions of raw meat due to the risk of microbial contamination.

| Sample | Time after slaughter, hour |
|--------|----------------------------|
|        | 0  | 2  | 24 | 48 | 72 | 96 |
| 1      | 6.6| -  | 6.5| 6.9| -  | 6.8|
| 2      | 6.5| 6.4| 5.9| 5.7| 5.8| 5.8|
| 3      | 6.3| 6.6| 5.7| 6.4| -  | -  |
| 4      | 6.4| 6.6| 5.7| 5.8| 5.8| 5.7|
| 5      | 6.3| 6.3| 5.8| 5.8| -  | -  |
| 6      | 6.5| 6.3| 5.8| -  | 6.2| -  |
| 7      | 6.2| 6.1| -  | -  | 5.8| 5.7|
| 8      | 6.4| 6.1| 6.1| 6.0| 6.5| -  |
Experimental results show that measuring the pH value is an important method for sorting meat into groups, taking into account the further direction of processing into products. But it makes sense to take pH measurements not only 24 hours after slaughter, but also over longer periods.

Determination of the mass fraction of sodium chloride in the samples showed an almost unchanged value – 0.1%. The data obtained indicate that the NaCl content does not change during storage of meat at a temperature of 0–4 °C. Such a low concentration of sodium chloride has no significant effect on its content in the finished product. Reducing the content of sodium chloride in meat products is possible only through the development of special formulations or by replacing NaCl with potassium or calcium chlorides.

Protein degradation products were not detected in any of the samples even on the tenth day of the experiment. Although organoleptic studies revealed signs of dubious freshness already on the seventh day. This fact confirms the objectivity of instrumental methods as opposed to subjective – organoleptic.

4. Conclusion
The conducted studies of pork samples indicate that all the selected instrumental methods are effective for determining various parameters of meat raw materials. Based on the measurement of pH during the first and next days after slaughter, a more accurate distribution of raw materials into groups and directions of further processing is possible. It is recommended to carry out such sorting to obtain a quality finished product.

Determination of the mass fraction of sodium chloride is important for obtaining products with a low NaCl content. It was revealed that sodium chloride contained in meat cannot affect the sodium chloride content in finished products. It is possible to reduce the sodium chloride content only by selecting the components of the recipes.

During storage of pork at a temperature of 0–4 °C for 10 days, no hydrolysis of proteins occurs. Protein degradation products by a qualitative reaction with copper sulfate were not detected. The data obtained indicate the possibility of storing pork in the studied conditions for ten days without loss of quality.

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