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Study of Autolytic Changes in Red Deer Meat and Beef

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Abstract

Background/Objectives: The purpose of this research is to examine the indicators of the autolysis process (chemical composition, microbiological analysis, pH, water-binding ability, tissue enzymes activity, technological properties) to select the optimal timing of red deer meat maturation before using it in meat products. **Methods**: Experimental study was held in a comparative aspect with beef. Determination of microbiological indicators of the samples was performed by the method of bacteriological analysis. The glycogen content of the tissue samples was determined by qualitative reaction with anthrone chemical agent. Home-produced pH-meter millivoltmeter "pH-150" was used for potentiometric measurements of active acidity in meat. To identify activity of proteinases the Anson's method modified was applied. Shear force was measured with the help of the PM-3 device. Water-binding ability was determined by compaction method. Weight loss in the end products was determined by weight method. **Findings**: The research showed that the behavior of protein substances in the process of autolysis is determined by meat pH and glycolysis intensity. The studies of water-binding ability and structural-mechanical properties of red deer meat in the process of autolysis are consistent with findings on myofibrillar proteins solubility. The study showed that the resolution of rigor mortis process takes place on the sixth day in red deer meat, and on the third-fourth day in beef. Comparative analysis of the nutritional value showed that red deer meat differs from beef by almost all indicators. Thus, moisture content in red deer meat is greater by 5,58% than in beef, protein content slightly prevails in red deer meat as compared to beef – by 0,96%. Fat content in red deer meat is much different from beef – 1,21% against 9,59%, since fat in red deer carcasses largely concentrates in the croup area. **Applications/Improvements:** Determination of chemical composition and biological value of trimmed red deer meat showed that it matches quality indicators of other kinds of meat and can be used in producing health products.

Keywords: Beef, Cathepsins, Functional and Technological Properties of Meat, Meat Maturation, Meat Enzymes, Red Deer Meat

1. Introduction

The strategy for development of the country until the year 2030 specifies that improvement of diet patterns of the population of the Republic of Kazakhstan is determined by the rational use of primary resources for food production. Meat and products of meat processing are main sources of nutrient materials necessary for maintaining human body vital activities.

In this respect development of new kinds of meat products provides for the maximum possible involve-

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ment of non-traditional slaughter beasts – Altai red deer – into the technological process.

The East Kazakhstan Region, especially its mountain and submontane parts, is a unique natural and climatic area favourable for breeding antler Altai red deer. Slaughter meat and products are considered by-products in red deer breeding in the East Kazakhstan Region of the Republic of Kazakhstan, for this reason meat yield of Altai red deer is poorly studied.

Owing to an increase in red deer meat production and consumption, the issue of its use as industrial commodities at meat-processing factories is of interest. The lack of in-depth researches regarding meat production characteristics, red deer meat and slaughter products chemical and biochemical contents, biological value, technological characteristics are a deterrent to complex processing of the raw material what determined relevance of the research.

In-depth study of red deer meat functional and technological properties will give it value, which, in turn, will increase demand for this kind of meat products and at the same time have the positive influence on the red deer breeding economy as a whole[1,2].

Enzyme autolytic reactions that bring about improvement of structural and mechanical properties of meat take place in the muscle tissue of live-stock animals in the process of postmortem changes. Tissue softening and improvement of structural and mechanical properties of meat in the maturation period are attributed to the proteolytic degradation of protein structures under the effect of tissular protein-degrading enzymes. Meat autolysis occurs involving active enzymes of lysosomes – cathepsins and calpains.

The level and developmental character of autolytic processes are some of conditions of quality and product yield formation. Studying properties of tissular proteinases will make it possible to purposefully change red deer meat functional and technological properties.

In this regard the paper studies indicators, which characterize the process of autolysis (chemical composition, microbiological analysis, pH, water-binding ability, tissular enzyme activity, technological indicators) in order to choose optimal periods of red deer meat conditioning before its use in the manufacture of meat products.

2. Materials and Methods

Experimental studies were held in a comparative aspect with beef.

A zero point in graphs, representing a change of studied indicator, was taken for a period of 2-3 hours after slaughter and butchering, when meat is 35-36°C and considered fresh.

Samples of muscle tissue were made from the longissimus of studied animals' meat just after butchering, packed and kept at a temperature of 2-4°C. At the beginning of studies microbiological indicators of samples were determined upon cooling during two weeks. The determination of microbiological indicators of samples was carried out by the procedure of bacteriological analysis according to GOST9958-81. Sampling was carried out according to GOST9792-73.

Glucogene content from the tissue samples under analysis was determined in the following way: Qualitative reaction with an athrone chemical agent was carried out, absorption of light of color solutions was determined with subsequent determination of glycogen concentration according to the calibration graph[3].

Home-produced pH – meter millivoltmeter "pH-150" was used for potentiometric measurements of active acidity in meat.

To identify activity of proteinases the Anson's method modified was applied when catalytical properties are defined by the degree of common protein breakdown with formation of low-molecular products: peptides and amino acids, particularly, by tyrosine accretion. Caseine was used as a substance for determining activity.

Shear force was measured on the PM-3 device.

Water-binding ability was determined by compaction method.

Loss in end products weight was determined by weight method.

3. Results and Discussion

The carried out analysis of literature found no works regarding autolytic changes in red deer meat. Meanwhile, the process of autolysis in beef is studied in depth[4,5].

Table 1. Microbiological indicators of samples of muscle tissue of different animal species upon cooling

Cooling period, days	QMA&OAMO, cfu/g	
	Red deer meat	Beef
2	$1,2 \times 10^2$	$2,0 \times 10^2$
4	$3,1 \times 10^2$	$4,2 \times 10^2$
6	$6,1 \times 10^2$	$7,1 \times 10^2$
7	$2,3 \times 10^2$	$2,2 \times 10^2$
8	$5,4 \times 10^3$	$5,1 \times 10^3$
9	$8,2 \times 10^3$	$1,6 \times 10^4$
10	$2,1 \times 10^4$	$3,5 \times 10^4$

Table 2. Chemical composition of red deer meat and beef

Weight content, %	Meat	
	Red deer meat	Beef
Moisture	75,8	70,22
Protein	19,99	19,03
Including connective-tissue protein	2,26	2,17
Carbohydrates (glycogen)	3,13	1,86
Lipids	3,2	4,23
Ashes	1,2	1,11

To determine the optimal time for studying the process of autolysis at the beginning of researches microbiological indicators of red deer meat and beef samples were studied upon cooling during two weeks.

The findings show that the number of mesophilic aerobiotic and optionally anaerobic microorganisms is within normal range ($1x10^4$) upon storage of cooled packed meat for nine days. In this regard the further studies of the process of muscle tissue maturation were carried out within nine days Table 1.

Chemical composition of red deer meat and beef in a fresh state is represented in Table 2.

Studying red deer meat composition Table 2 showed 2 times increased glycogen content as compared to beef.

Increased glycogen content has an impact on the speed of autolysis.

Upon slaughtering anaerobic decomposition of glycogen occurs in animal's meat through phosphorolysis with accumulation of lactic acid, which amount depends on the glycogen reserve in muscle tissue.

Glycogen content in red deer meat and beef in a fresh state is represented in Figure 1.

Figure 1 shows that the value of glycogen in red deer meat is 2 times more than in beef. The greater content of glycogen in red deer meat is apparently attributed to the need for replenishment of energy store upon long physical work of these animals, since the main animal carbohydrate – glycogen meets the organism's need in energy and metabolites.

Lactic acid accumulates as a consequence of phosphorolytic glycogenolysis. It changes acidity of environment, that's why studying of red deer meat pH is informative

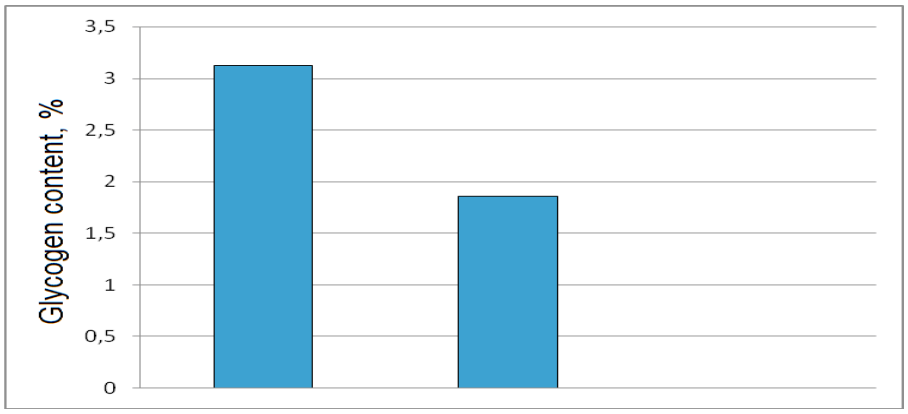

Figure 1. Glycogen content in fresh red deer meat and beef.

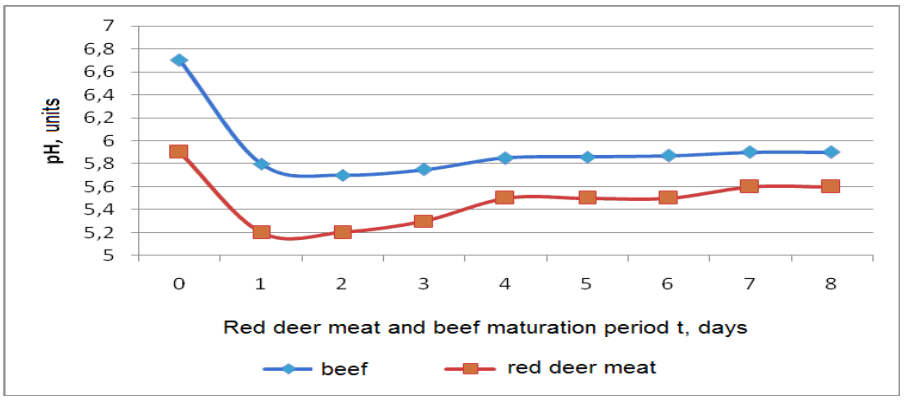

Figure 2. Red deer meat and beef pH change dynamics in the process of maturation.

Figure 2. The findings showed that pH change tendency in red deer meat is similar with that of beef. However, glycolysis is slightly long-drawn in red deer meat in comparison with beef, since the pH minimum value, equal to 5.45 units, is achieved no sooner than on the second day. It should be noted that the pH minimum value in red deer meat is almost 0.2 units lower than in beef ($p<0,05$).

The relation between the environment acidity change dynamics and activity of protein-degrading enzymes in red deer meat and beef was studied.

Proteolytic changes in proteins are caused by the action of lysosomal cathepsins and calcium-dependent neutral proteinases – calpains localized in the sarcoplasm of cells. The activity of calcium-dependent proteinases is maximum in fresh muscle tissue, therefore, the activity of calpains were studied first Figure 3.

which support neutral calpain in an active state, promote slow decrease in calpains' activity within four days of the research in spite of a dramatic drop in environment pH.

It is found that calpains' activity dependence on Ca^{2+} can provide functioning of regulatory mechanism due to a change of the cation level in cells and involvement of Ca^{2+} - activated neutral protease in limited proteolysis, which in turn leads to reproportion of activity of a number of enzymes[6–14].

A gradual decline in environment acidity in the process of post mortem changes creates conditions for yielding cathepsins D from lysosomes and their activation.

Finding on the activity in the process of autolysis in the muscle tissue of different types of meat, represented in Figure 4, showed the similar nature of its change, but

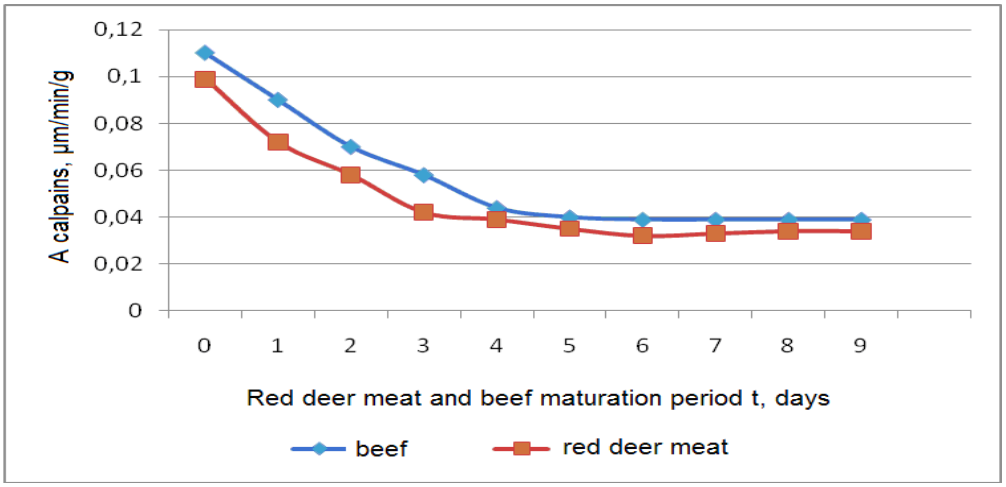

Figure 3. Dependence of red deer meat and beef muscle tissue calpains' activity on autolysis duration.

The findings showed that the level of calpains' activity depends on the type of original material and the level of hydrogen ion concentration. In fresh meat the level of calpains' activity in red deer meat is lower by 13% than in beef. Inactivation of calpains occurs because of autolytic changes, besides, rate of activity decay is maximum within three days, which most probably resulting from, particularly, environment acidity change and the presence of an inhibidor – calpastatin. The yield of calcium ions,

different speed. The starting value of cathepsin activity in all types of meat is low, it makes up only 0.05 μm/min per 1 g of protein.

The low activity of D cathepsin activity after slaughtering is due to the presence of native membrane in meat, which holds cathepsins in a latent state.

With further maturation lysosome membrane permeability dramatically increases and active release of

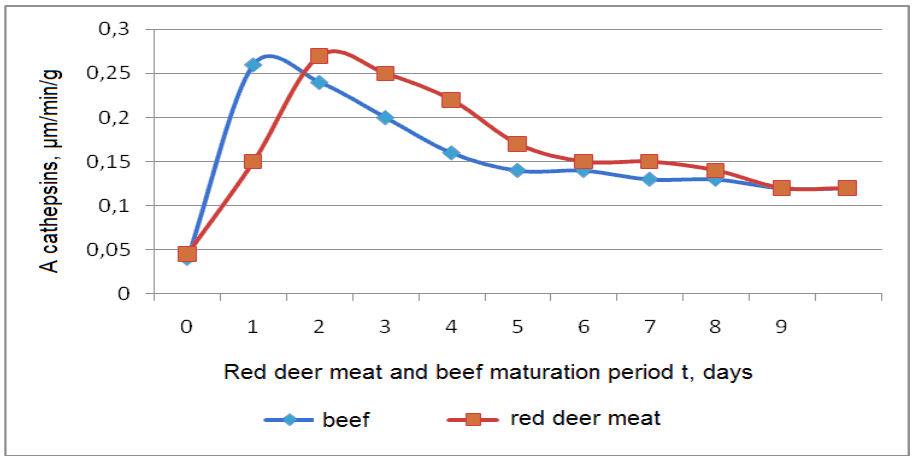

Figure 4. Change of D cathepsin activity in red deer meat and beef muscle tissue.

cathepsin D and increase in hydrogen ion concentration in the sarcoplasm of muscle fiber occur.

The growth of cathepsin D activity is determined by the speed and depth of glycolytic changes.

The maximum activity of cathepsin D of beef muscle tissue reaches the value 0,25 μm/min per 1 g of protein in 24 hours and then its modulated reduction takes place.

This process was observed in red deer meat in 24 hours, since the maximum value of activity, equal to 0,26 μm /min per 1 g of protein, was reached on the 2nd day, in horse meat – only on the 3rd day as compared to beef.

Owing to the action of a complex of enzymes on the proteins of the meat system in the period of autolysis their hydrolysis occurs and collagen swells under the action of lactic acid, which contributes to improvement of structural and mechanical indicators of meat. Shear force of boiled meat of red deer and beef represented in Table 3 was measured to track meat softening dynamics in the process of maturation.

The findings showed that consistence of red deer meat changes is subject to the processes of rigidity taking place after slaughtering and beginning of maturation.

The period of red deer meat rigidity and stiffening takes place on the second day as distinct from beef (1st day). Values of red deer meat slice shear force exceed that of beef, the difference between red deer meat and beef stiffness is significant ($p<0,05$). Most probably, strength properties of muscle tissue are determined not only by

Table 3. Red deer and beef shear force in the process of autolysis (102 N/m).

Indicator	Autolysis length, day							
	0	1	2	3	4	5	6	7
Red deer meat	4,2±0,02	4,5±0,06	4,8±0,02	5,1±0,06	4,9±0,02	4,7±0,05	4,5±0,03	4,2±0,03
Beef	3,4±0,03	4,3±0,05	4,2±0,04	4,1±0,04	3,8±0,03	3,6±0,04	3,3±0,05	3,0±0,03

meat type and structure but the depth of autolytic processes development.

Identical samples of red deer meat (in 6 days after slaughtering) and beef (in 4 days) were selected from longissimi and technological indicators were studied to compare properties of matured meat. pH values in the samples were roughly the same (within arithmetic average error) and made up 5,76 and 5,78 correspondingly.

Studying forms of moisture bindings in the meat system – strongly bound (adsorptive and osmotic) and weakly bound (mechanically bound moisture) is crucially important for practical technology, which is focused on high and stable finished products yield.

The studies represented in Figure 5 showed that the level of strongly bound moisture in red deer meat is lower by 3% as compared to beef ($p<0,05$). Degree and strength of water binding in complex food systems, including meat, depend on a number of factors.

It is known that proteins and state of raw material morphological structure play an important role in water retention in meat systems.

The low content of strongly bound moisture in red deer meat is logically consistent with high concentration of connective tissue and loss in weight upon heat treatment Figure 6.

Studying hydrophilic indicators of red deer meat and beef muscle tissue showed that greater losses in weight upon heat treatment were determined in beef. Red deer meat loses by 3% less weight than beef upon heat treatment.

The carried out studies showed that resolution of the process of rigor mortis takes place on the sixth day in red deer meat, and on the third-fourth day in beef. In this regard it's necessary to provide methods and procedures for enhancement of red deer meat and slaughter products processing efficiency.

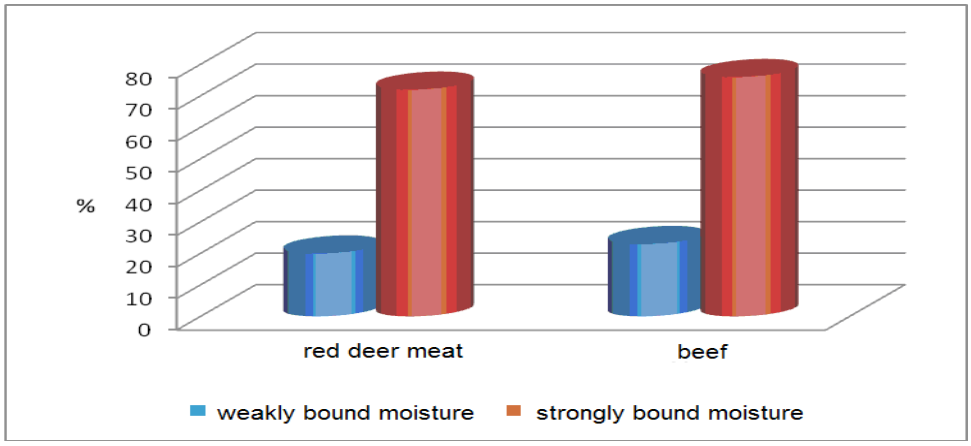

Figure 5. Weakly- and strongly bound moisture ratio in red deer meat and beef.

Figure 6. Hydrophilic indicators of red deer meat and beef muscle tissue.

4. Conclusion

Red deer meat is a by-product in red deer breeding in the Republic of Kazakhstan. Today domesticated red deer well adapted to different natural and climatic areas are raised on the red deer farms of the East Kazakhstan Region. The major part of the meat of culled animals are sold to the population in the form of meat or used for producing chopped half-finished goods in mini shops. However, almost no use is made of red deer meat and slaughter products in sausage and canning production.

Findings showed that strength properties of red deer muscle tissue are determined by the nature and depth of autolytic processes development and essentially depend on tissues structure. As rigor mortis takes place strength properties enhance.

Findings show that changes of red deer meat strength properties at the end of maturation have a tendency to decrease. According to findings, this is due to conformational changes of actomyosin complex proteins and polyunsaturated fatty acids in the postmortem period.

The carried out research found that the behaviour of protein substances in the process of autolysis is determined by meat pH and glycolysis intensity. The studies of water-binding ability and structural-mechanical properties of red deer meat in the process of autolysis are consistent with findings on myofibrillar proteins solubility.

The comparative analysis of red deer meat and beef nutrition value was carried out. It's found that red deer meat differs from beef almost by all indicators. Thus, moisture content in red deer meat is greater by 5,58% than in beef, protein content is slightly prevails in red deer meat as compared to beef – by 0,96%. Fat content in red deer meat is much different from beef – 1,21% against 9,59%, since fat in red deer carcasses largely concentrates in the area of croup.

Determination of chemical composition and biological value of trimmed red deer meat showed that it matches quality indicators of other kinds of meat and can be used to produce general health products.

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