THE STADY OF THE CHANGE IN MOLECULAR-DYNAMIC CHARACTERISTICS OF MUSCULAR TISSUE IN STORAGE DEPENDING ON MEAT CHILLING CONDITIONS.

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SUMMARY

The problem of molecular-dynamic characteristics of muscular tissue and their application for studying changes in meat during cold treatment and storage has been considered. It is found that rapid cooling of meat up to temperature below 10°C results in two-phase change of muscular tissue which is connected with contracting of muscular fibres under the action of cold and with the development of stiffening. With variable temperature conditions of cooling being used and meat being maintained at temperature 12 - 15°C one phase change in muscular tissue is seen. It indicates the abcence of CMFAC. The data obtained were used in developing of the meat processing method confirmed by the autor's certificate.

INTRODUCTION

The improvement of meat preservation ways demands the use of up-to-date methods of investigating changes that vecur in muscular tissue. Among such methods these are rheological method and method of statistical physics. The application of these methods allows to estimate the state of meat accordiny to its molecular-dynamie characteristics/1, 2/.

The aim of this study is investigating changes of molecular-dynamic characteristics in muscular tissue during the storage depending on meat chilling conditions.

MATERIALS AND METHODS

As the object of investigation was chosen halftendon extracted from a beef carcass. It was delivarad to the laboratory an hour and a half after the slaughter.

Changes in meat during its processing and storage were estimated according to molecular-dynamic characteristics of muscular tissue. Here some considerations were followed /1,2/.

Considerating muscular tissue as a net thire-dimensional system with chemical and fluctuating attachment nots it is possible to estimate mechanical-chemical prosesses in meat accordiny to its molecular-dynamic characteristics, in particular, to molecular mass of dynamic segments or to mass of one mole in the section between the nots of the structural net and also according to the number of segments in a volume unit and the number of segment moles in a volume unit. The nature of biopolymeric molecule packing is closely associated with their configuration. The latter can be estimated by means of covering the object studied by outer mechanical field. Depending on interrelation of the field energy and the energy of activating rotation barrier high-molecular chains will be deformed to some extent. Moreover, deformation propertias may serve as a measure of molecular configuration thus providing the particular packing and therefare as a measure of molecular mass. The specific feature of muscular tissue is its thermoelasticity. /3/ Thermoelasticity of muscular tissue manifests itself in the following: in rapid expansion its temperature rises; the temperature rise of the tissue results in its shortening; in expansion the tissue acquires cristalline properties; the curve of the relation between lengthening and tension has a S-shaped form. In this connection the consideration of muscular tissue elasticity from the point of view of thermodynamics is of interest. Procceding from the first principle of thermodynamics it is possible to put down the pollowing expression

$$dQ = dU + p\,dV = T \cdot dS \qquad (1)$$

where dQ - is quantity of heat supplied to the system; dU - increment in internal energy of the system; pdV - the work performed by the system; T - absolute temperature; dS - the change in entropy. Differentiation of the equation (1) in the volume of the system at constant temperature T llads to the expression

$$-p = (\partial U/\partial V)_T - T(\partial S/\partial V)_T \qquad (2)$$

Procceding from the second principle of thermodynamics

$$dS = dQ/T = (1/T) \cdot (dU + p\,dV) \qquad (3)$$

After a series of transformations it can be shown that

$$(\partial P/\partial T)_V = (1/T) \cdot [(\partial U/\partial V)_T + P] = (\partial S/\partial V)_T \qquad (4)$$

Taking into account equations (2) and (4) elasticity in quasistatic covering of biopolimer by the external mechanical field can be represented as

$$K = -pF = F(\partial U/\partial V)_T - FT(\partial S/\partial V)_T = (\partial U/\partial L)_T - FT(\partial P/\partial T)_V \qquad (5)$$

$$K = (\partial U/\partial L)_T + T(\partial K/\partial T)_L \qquad (6)$$

where P is force; F - cross section area of the fragment studied; u - internal energy of the system; S - entropy of the system; V - volume of the system; L - length of the fragment; T - temperature. The first component of the equation (6) represents the potential elasticity component defined by adhesion forces and the second one represents a thermokinetic component. For museular tissue at relatively small deformations the potential elasticity component is near zero which can be indirectly sudged by S-like dependence of tissue deformation on unit load. On the basis of considerations developed for an elastometer and proceeding from the first and the second principles of thermodynamics the thermokinetic component can be expressed as

$$(\partial K/\partial T)_L = -(\partial S/\partial L)_T \qquad (7)$$

Equation (7) expresses the entropic nature of museular tissue elasticity.

Henee, the quantative connection between configuration elasticity and molecular mass can be estimated by considering the interrelation between microseopic thermodynamic values and the behaviour of molecules. This interrelation is known to be expressed by the law of Boltzman

$$S = k \cdot \ln W \qquad (8)$$

where k is constant of Boltzman; W - thermodynamic probability. Under the influence of external mechanical field on animal tissue there occurs deformation of biopolymeric chains.

The number of patterns of link arrangement reduccs with this, that is, entropy reduces. According to the theory of estimation the number of conformations which the chain or the thermodynamic probability of the chain may have is expressed by Gauss formula /4/.

$$W_h = [3/(2\pi \cdot N \cdot A^2)] \cdot h^2 \cdot 4\pi \cdot e^{3h^2/2NA^2} \qquad (9)$$

Where N is the number of segments in a chain; A - statistic element; h - distance between the ends of a chain.

Assuming that thermodynamic probability of a chain in muscular tissue is subject to the distribution of Gauss after some transformations the expression follows for the molecular mass of one mole in a chain section between the points of a structural net

$$M_c = 3 \cdot R \cdot T \cdot \rho / G \qquad (10)$$

where R is gas constant; ρ - density; G - module of configurative elasticity. The frequency of the structural net can be represented by the equation

$$n_c = N_c / V = \rho / M_c \qquad (11)$$

where n_c - net frequency; N_c - the number of moles in a net section; V - volume of a sample. Thees, for calculating molecular-dynamic characteristics used in the present study it is necessary to determine T, S and G. The temperature of the sample was measured by the instrument "Thermistor", the density was estimated by hydrostatic method and the modulus of configuration elasticity was estimated by means of the installation /5/, the diagram of which is represented in Fig.1

In the process of investigation changes in meat processed in two ways of chilling were studied: 1 - refrigeration at t=0.C and air velocity V=1,5 . 2,0 m/s up to temperature of the surface layer of the object t = = 12 - 15°C; maintaining the object at air temperature t = 12 . 15C during 18-20 hours; additional refrigeration at t = 0 . C up to t = 4°C across the whole width of the object with further storage at t = 0°C; 2 - refrigeration at t = 0°C; air velocity V = 1,5 - - 2 m/s up to 4°C across the whole width op the object with further storage at t = 0°C. The meat was stored in the cold chamber "Grunland".

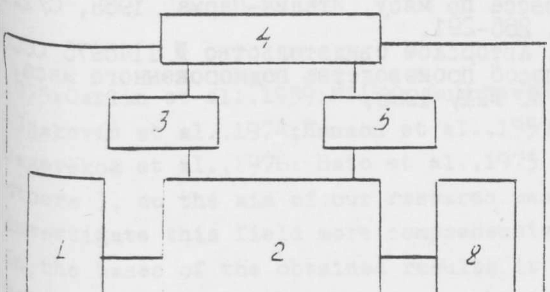

Fig. 1 The diagram of the installation for estimating index G, characterizing the configuration alasticity of muscular tissue; 1 - thermostat; 2 - measurement stand; 3 - power actuating mechanismus; 4 - programming device; 5 - power unit; 6 - plotting device; 7 - temperature measuring instrument; 8 - amplifier; 9 - bridge.

RESULTS AND DISCUSSION

The intensity of stiffening and weakening of muscular tissue is identified by the spesific feature of configurative changes in contractive proteins and the nature of their intermolecular ineraction. The process of steffening and weakening of muscular tissue is to a certain extent asynchronic and depends on the mean statystic number of steffened and weakened fibres. During the development of steffening of muscular tissue and with the application of both ways of refrigeration a reduction in M and an increase in N_c and n_c is observed. (Fig. 2) For meat processed according to the second method the extreme values of indexes are noticed on the second day while those for meat processed in the first way they are noticed on the first day. During further storage in the process of tissue weakening an increase in M_c and a reduction in N_c is seen.

The stabilization of meat characteristic values refrigerated by the second method occurs approximately on the sixth day and that of meat processed by the first method - on the second day. The data obtained can be explained in the fallowing way. An increase in the number of active protein centres in steffening is accompanied by the increase in the number of molecular bonds between myofibrillar proteins.

The creation of new bonds results in a bend of flexible high - molecular chains and in the formation of new segments. As a result in a three-dimensional net carcass of muscular tissue occurs an increase, if it may be put so, of tuisting degree (the number of segment moles in a volume unit) of molecular structure, an increase in the number of segments and decrease of segment mass. With muscular tissue weakening, there oicurs the reduction in a number of active protein centris, in a number of bonds between molecules of contractive proteins and so redustion in a number of segments, twisting degree and increase in arcrage mass of dynamic segments.

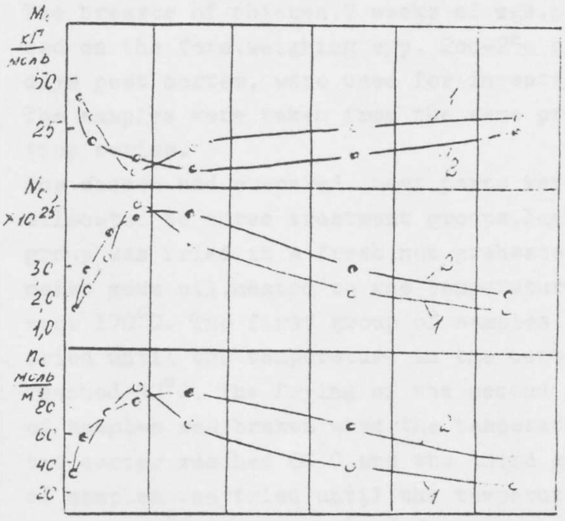

Fig. 2 The relation of molecular dynamic characteristics of muscular tissue M_c, N_c and n_c and storage life of meat at different refrigerating conditions; 1 - condition 1; 2 - condition 2.

Meat processed by method 1 is characterized by one - phase change in stiffening. The application of method 2 leads to two - phase change of meat indexes considered in the period. The first phrase of parameter change can be seen immediately after the temperature of muscular tissue becomes lower 10°C. The velocity of changing M_c, N_c and n_c for meat processed by method 2 in the first phase exceeds the velocity of changing these parameters for meat processed by method 1 2-3 times. The first phase for meat processed by the second method is followed by the second phase which is characterized by further changes of indexes but with a lower velocity which is 8-10 times less that the velocity in the first phase.
This indicates that in the meat processed by method 2 there are two mechanisms causing its structural transformations. The first mechanism is probably connected with rapid falling of temperature below 10°C, which causes contracting of fibres under the action of cold. The second one is connecte with the development of stiffening in muscular tissue. The results of the complex study of changes in meat depending on refrigerating conditions (G) confirm the interpretation of data obtained. The application of method 1 prevents from contracting of fibres under the action of cold. The data obtained here were used in developing the method of meat processing confirmed by the autor's certificate /7/.
The possibility of using molecular - dynamic characteristics (MDC) for studying changes in meat during cold treatment and storage is shown. It is foocend that rapid cooling of meat up to temperature below 10°C results in two-phase change of MDC which is connected with contracting of muscular fibres under the action of cold and ducto development of stiffening (CMFAC). In using variable temperature conditions of cooling with maintaining meat at 12-15°C one-phase change is observed which indicates the abcence of CMFAC. The data obtained were applied in developing the method of meat processing confirmed by the autor's certificate.

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