EVALUATION OF MEAT FRESHNESS ON THE BASIS OF DETERMINATION OF THE MUSCLE TISSUE VISCO-ELASTIC PROPERTIES

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INTRODUCTION

In the USSR meat industry there exist chemical, microscopical and organoleptical methods of meat freshness control. Chemical and microscopical methods are not widely used in production practice for they are highly labour-consuming, and the analysis needed for their realisation are complicated and time-durable, besides, special equipment and chemical agents are needed. Under conditions of in-line production organoleptical method of meat freshness determination is used.

With that much importance is attached to consistency as one of the main characteristics of meat freshness. Organoleptical determination of meat consistency is based on the visual assessment of muscle tissue reaction on meat pressing by the finger in the place of a fresh cut. According to time duration needed recovery an expert judges about the meat quality - fresh, doubtfully fresh or not fresh. Consequently, organoleptical method of meat consistency determination for freshness control is based on the organoleptical perception of viscoelastic properties of meat muscle tissue. In the VNIKIMP research is conducted aiming at the development of instrumental methods for meat and meat products quality control on the basis of measuring their mechanical characteristics (static, dynamic, viscoelatic) (Ivashov et al., 1982; Ivashov et al., 1983; Ivashov et al., 1985).

One direction of this research is connected with the study into possibility of using an instrumental method for meat consistency determination in order to control its freshness. The development of such a method is conducted on the basis of the analytical and experimental study into viscoelastic properties of meat.

In the present paper part of this development is described dealing with the viscoelastic characteristics of beef muscle tissue.

MATERIALS AND METHODS

We have investigated viscoelastic properties of beef muscle tissue at the following temperatures: 14°, 4°, -4°, -12°C, corresponding to the technological parameters of raw material processing and storage. In this connection press relaxation was studied under conditions of uniaxial compression on the universal testing machine MR-500T2(USSR). The machine is provided with a loading reverse, thermocryocamera, electronic devices for force and deformation recording. Before tests the samples were thermostated in a cryocamera at a predetermined temperature in order to level their temperature field. During the samples loading, at the moment when the predetermined deformation value was achieved, the loading device of the machine disconnected and the sample was rigidly fixed between the reverse plates. Loading chaniges were automatically recorded on the diagram tape of a dynamometer. Testing time was 60sec., samples deformation level (E) changed in the range of 0-0.30. Investigation was conducted on the rump muscles of 2-3

years old cattle, those muscles being conditioned during 72 hours at 2-4°C after slaughter. The samples having a cylindrical form (diameter 28mm, height 15-17mm) were taken by means of the special device with a rotating knife having a circular section, the samples being excised transversely to the muscle fibers. Press relaxation was tested on 112 samples; in each temperature series 24 samples were tested - taking by 6 at the deformation of 0.1; 0.15; 0.2; 0.3.
For each temperature value families of curves illustrating loading changes (P) in time (τ) at the corresponding deformation levels were obtained.

RESULTS
P - τ dependencies were transformed into press relaxation curves $\sigma - \tau$ (Fig.1).

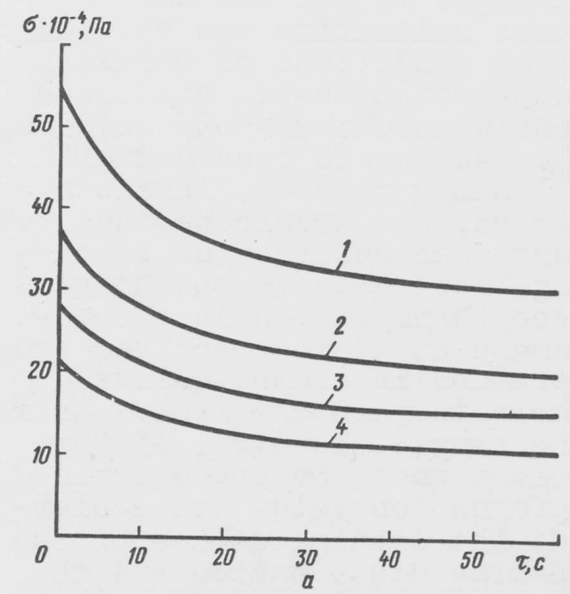
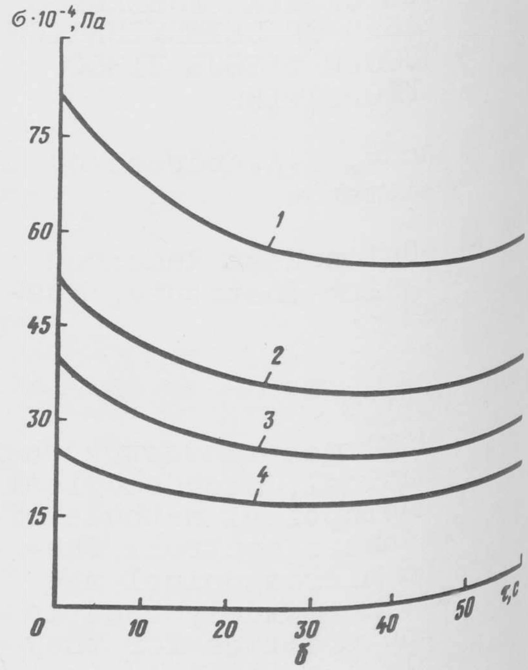
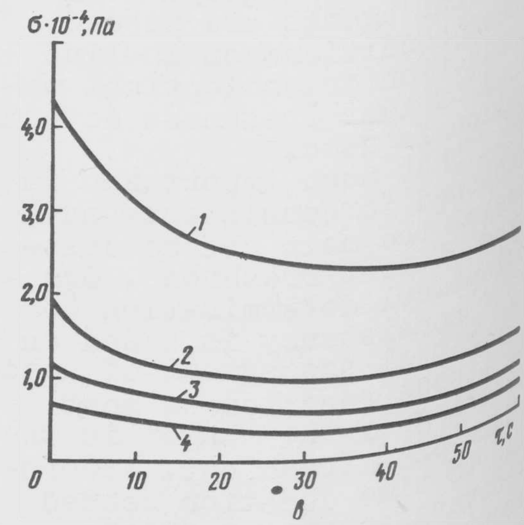


Fig.1. Press relaxation curves $\sigma - \tau$:

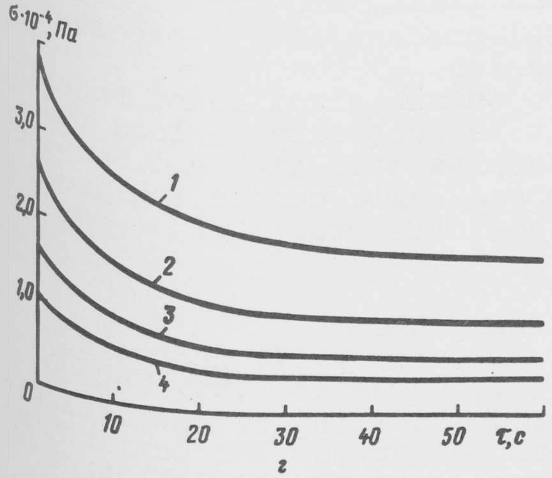
a. t° = -4°C
1 - E = 0.3



b. t° = -12°C
2 - E = 0.2



c. t° = 4°C
3 - E = 0.15



d. t° = 14°C 4 - E = 0.1

For each family of curves a mean nondimensional press relaxation curve was found.

$$\sigma/\sigma_0 - \tau$$

Where σ_0 - initial testing press, Pa;
σ - press at a given moment of testing, Pa.

In Fig. 2 the obtained dependencies $\sigma/\sigma_0 - \tau$ for each testing temperature value are presented.

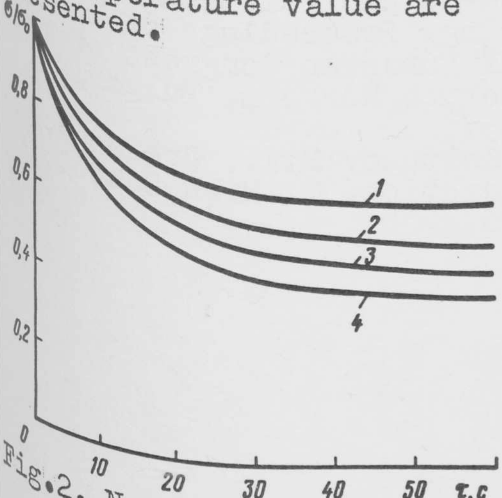


Fig.2. Nondimensional press relaxation curves $\sigma/\sigma_0 - \tau$:
1. t° = -12°C; 2. t° = -4°C;
3. t° = 4°C ; 4. t° = 14°C

Considering nondimensional press relaxation curves σ/σ_0 it becomes clear that along with temperature fall viscoelastic properties change significantly. The quantitative evaluation of these properties changes may be done using the theory of heritable viscoelasticity by Boltzman-Walter. In case of press relaxation

$E(t) = E_k$ = const. the linear integral Walter equation of the second order assumes the following appearance:

$$\sigma(t) = \sigma_0 \left[1 - \int_0^t T(\tau)\, d\tau\right] \qquad (1)$$

where $T(\tau)$ is the influence function.

In the theory of integral equations any function of arbitrary appearance as a dependence function $T(\tau)$, also called a relaxation nucleus, may be taken. To describe experimental relaxation curves of the muscle tissue a weakly singular nucleus may be used.

$$T(t) = A \cdot e^{-\beta t} \cdot t^{\alpha - 1} \qquad (2)$$

where $0 < \alpha < 1$; α, β, A - are parameters of the relaxation nucleus.

To determine α, β, A-parameters a combination method may be used.

The essence of this method lies in the comparison of experimental curve with its analogue from the family of theoretical curves constructed for different parameters of influence functions in the logarithmic coordinate grid and for the use of integral tables on the basis of singular functions dependence. As the result of such comparison theoretical curve parameters are related to the experimental curve (Koltunov, 1976).

According to the described method mathematical evaluation of experimental data was conducted on the basis of nondimensional press relaxation curves (see fig.2). From equation (1) it follows:

$$\frac{\sigma(t)}{\sigma_0} = 1-\int_0^t T(\tau)d\tau \quad (3)$$

The left part of equation (3) substitutes for the graphic image of the experimental nondimensional relaxation curve, and the right one - for its analytical expression.
Relaxation nuclei parameters T (t), determined by the combination method, are equal: at all temperatures β =0.75, α = 0.05; A at 14°C = 0.0539, at 4°C = 0.0485, at -4°C = 0.0431 and at -12°C = 0.0324.
With the help of equations (1), (2) and the driven relaxation parameters of the nuclei, the analytical relaxation curves of the muscle tissue were obtained at the σ_0 values. All calculations were performed on the microcomputer "Electronics D.Z-28"(USSR). Approximation deviations of the experimental data did not exceed $\pm$ 3 - 5%.

CONCLUSIONS
The analysis of the obtained results permits to drive some conclusions that are significant for instrumental method development aiming at determination of the meat consistency according to the data of its viscoelastic properties measurement.
It was established that depending on temperature, muscle tissue develops under loading the properties of a rigid or a soft biopolymer, deformation of which is described with the help of the theory of heritable viscoelasticity.
At the determination of the viscoelastic characteristics of the muscle tissue a testing scheme on the press relaxation during compression is desirable for use. With that the process of samples preparation and fixing and the experimental process itself become easier.
To obtain significant results it is necessary to load the samples with high and constant speed while conducting press relaxation tests.

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