On the evaluation of meat and meat product consistency by means of instrumental methods

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The problem of improving meats quality and food value is a most important one in the meat industry. To solve it on the basis of quality control systems, means of the objective evaluation of raw meat, raw and finished meat products at the processing stages are necessary. Consistency is one of the primary characteristics of the quality of meat and meat products. It can be objectively measured with instrumental methods, the one based on determining shear force being most common.

The basic element of the devices used in this method is a cutting edge ground at a certain angle. As a rule, such devices allow to measure the maximum shear force of a sample; it is compared with the reference value and the consistency is estimated. In operation the edge is becoming dull and the reference values, which correspond to a sharp edge, vary greatly. To make the estimation of meat and meat product consistency with the above method significant, the sharpness of the cutting edge should always be controlled, this being very difficult. To eliminate this shortcoming it is suggested that the estimation of meats consistency by their shear force be made using a non-chamfered blade, i.e. a plate knife without tapering.

For this, we experimentally studied the process of cutting, with a non-chamfered blade, of beef muscle tissue. As the object of the study, the longissimus dorsi muscle was used. It was dissected from the carcasses of 18-24-month-old animals, and held for 72 hr at 2-4°C. Test samples were 10 x 10 x 50 mm parallelepipeds.

Tests were performed with a special cutting device in a universal tearing machine MR-500-T-2 at -4°C.

As a non-chamfered blade, a steel band having the thickness δ of 0.02, 0.06, 0.1, 0.15 or 0.2 mm was used, which was fixed tightened in the cutting device. Samples were cut across the fibers at the constant rate of the blade. During testing, P-values (shear force) were recorded, as related to , i.e blade penetration depth, on a chart of the dynamometer of the testing machine.

As a result of the statistical processing of the experimental data, a relation has been derived:

$$P_{max} = f(\delta) \quad \text{(Table)},$$

where P_{max} is the maximum shear force, δ is the blade thickness (see Table).

Table

The maximum shear force as related to blade thickness

Blade thickness $\delta \cdot 10^{-3}$, m	0.02	0.05	0.1	0.15	0.2
Maximum shear force P_{max}, N	4.68	21.68	35.65	40.39	42.76

The experimental relation $P_{max} = f(\delta)$ was approximated with the function

$$P_{max} = A\delta^a e^{b\delta}$$

The experimental plots P-h correspond completely to the physical model of a non-chamfered cutting process. The Figure illustrates a typical muscle cutting.

At the initial stage of blade penetration into the tested sample muscle fibers are compressed (A-B). This compression continues up to a certain critical value $P_{compt.}$ equal to the material shear strength (point B). If at this moment the compression force is decreased, no cutting occurs and the sample recovers partially its initial dimensions, the extent of this recovery being due to the viscoelastic properties of the material. When loading continues and $P_{compr.}$ exceeds the material shear strength, the blade starts to penetrate the sample, i.e. the cutting process is initiated (B-C). In this case, the lower fibers are further being compressed and the upper ones are stretched and finally break. The $P = f(h)$ curve area determines the compression work at A-B and the cutting work $A_{compr.}$ at B-C.

The efficiency of a non-chamfered blade is characterized as follows:

$$\eta = A_{cut} / A_{compr} + A_{cut}$$

The following approximating relation which describes changes in η as depending on δ has been derived:

$$\eta = B + Ce^{k\delta} \qquad (2)$$

Coefficients of relations (1) and (2) were calculated by a microcomputer (D3-28) with the least square method:

$A = 89.024$ kN/m^2; $a = 1.151$; $b = -5.886$ m^{-1}; $B = 0.35$; $C = 0.65$; $k = -30.748$ m^{-1}.

The study carried out indicated that muscle consistency determination using a non-chamfered blade of a definite thickness, the maximum shear force depend only on the structuro- mechanical properties of a biomaterial, the accuracy and stability of the measurements being improved.

Further improvements should be effected through tne mathematical modelling of the process of non-chamfered blade cutting and with account for the structuro-mechanical properties of meat and meat products.

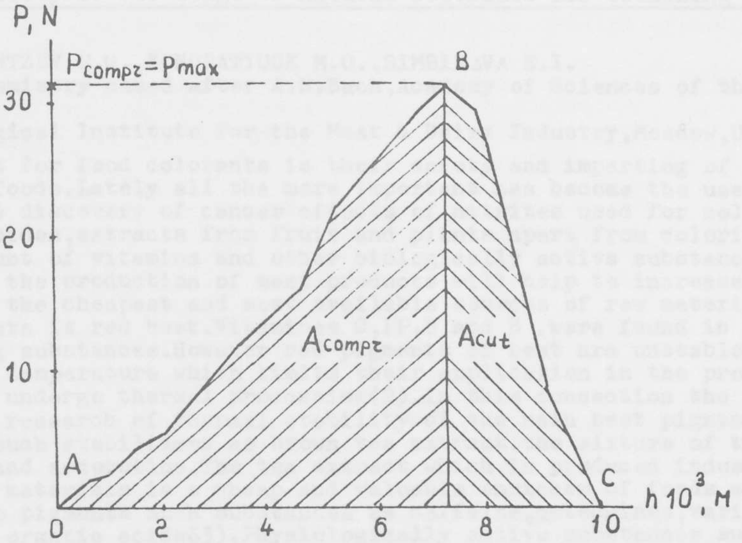

Fig. A chart P-h of muscle cutting