POTENTIALS OF QUALITY CONTROL OF MUSCULAR TISSUE BY PENETRATION METHOD

Limonov G.E., Kossoy V.D., Tatulov V.Yu., Abramov A.N.
All-Russian Meat Research Institute, Talalikhina 26, 109316, Moscow, Russia

One of fhe most important characteristics of the meat raw materials (muscular tissue) and ready meat products is their consistency, evaluated by the strength properties and characterizing their toughness. It depends to a large extent not only on its chemical composition, but also on moisture content and forms of moisture binding in it, thermal state, pH value, etc. Since the structural and mechanical characteristics of meat and meat products are sensitive to changes of the above-mentioned factors, they can be used as objective characteristics for quality evaluation.

From all structural and mechanical characteristics the most sensitive one are the shear ones, such as the limiting shear stress, the values of which may be determined by penetrometer. A semi-automatic handy, small-size penetrometer-dynamometer PPM-4 (WEIGHT 0.7 kg) with self-contained power supply (Patent No. 2075751) was developed for convenient use in any conditions directly on the working place . This device comprises four easily changeable sleeves for measuring strength, and various types of indenters. Value of indenter penetration into the product is 40 mm, the error of its fixation - 0.1 mm.

This device was used for judging raw meat quality by the toughness determined according to the value of the limiting shear stress (Θ_0). Conical indenters were chosen with 10^0, 20^0, and 30^0 vertex angle; the force, by which penetration force value could be fixed, was 0,5 kg.

Rebinder formula ($\Theta_0 = KPh^{-2}$) was tested and grounded for estimating Θ_0 by the penetration value (h). To calculate the constant (K, H/kg) of the conical indenter depending on its vertex angle for various kinds of products, different dependences were chosen taking into account the structure of dispersed systems. Therefore, the known dependences for obtaining the constant of the cone were analyzed:

1. Rebinder formula: $K = 0.52\,(\mathrm{ctg}\alpha \cdot \cos^2\alpha)\pi^{-1}$ (1)
2. N.N.Agranat and Volarovich formula:

$$K^{-1} = \pi\,\mathrm{tg}^2\alpha\,\{[2\alpha - 2(\sin\alpha + 1)^2 \ln[\sin\alpha/(\sin\alpha + 1)] + [1 - \mathrm{ctg}(\pi/4 + \alpha/2)](2\sin\alpha + 1)^2 \ln[2\sin\alpha/(2\sin\alpha + 1)] + [\mathrm{ctg}(\pi/4 + \alpha/2) - \mathrm{ctg}(\pi/4 + \alpha)]\,\mathrm{ctg}^2(\pi/4 - \alpha)\ln[2/(\mathrm{ctg}\alpha + 1)] + \mathrm{ctg}(\pi/4 + \alpha/2)[\mathrm{ctg}(\pi/4 - \alpha) - (2\sin\alpha + 1)]\} \quad (2)$$

3. Kossoy and Karpychev formula:

$$K = 0.687\,\mathrm{ctg}^2\alpha \quad (3)$$

4. Arret correction to the formula (2):

$$K = 1{,}32\,tg\alpha\sqrt{9tg^2\alpha + 4}\,/(3\mathrm{tg}^2\alpha + 1) \quad (4)$$

Constants of the cone (K, H/kg) calculated by various dependences are shown in Table I.

The dependence (2) is widely used for calculating Θ_0 of the sausage meat. The rheometric studies for the determination of value Θ_0 on different rheological devices (rotary viscosimeter, penetrometer, testing machine "INSTPON") revealed the invariance of the data when using a conical indenter with vertex angle $2\alpha=60^0$ and the dependence (2) for the calculation of its constant. Correlation coefficients 0.52 and 1.32 were obtained for formulae (1) and (4), respectively.

In this connection, it was necessary to ground the selection of the dependence for estimating conical indenter constant using of which would result in sinular calculated values of muscular tissue Θ_0.

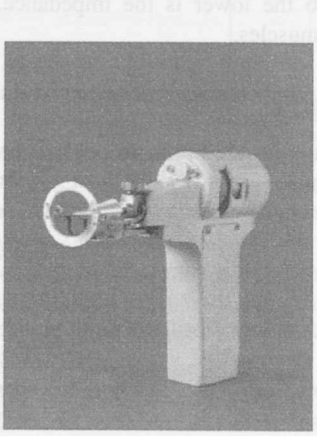
To realize such purposes, studies were carried out on L.dorsi muscle of Large White pigs. Penetration values were obtained by means of PPM-4 device; temperature and pH were measured 24 hrs. after the slaughter. Temperature fluctuated within of 5-8 ^{0}C. Penetration value for muscular tissue of the pork was estimated by cross and longitudinal sections of fibres by means of cones with vertex $2\alpha = 10^0$, 20^0, and 30^0. Measurements were repeated 5 times for each sample; the error was within 5 %. Results of the study are summarized in Table 2.

To determine the constant of the cone and to continue estimating values of the limit shear, stress the dependence (1) securing obtaining of practically identical values concerning cross and longitudinal sections of fibres separated from pig L.dorsi muscle (see Table 2) was recommended. Changes of penetration values measured by various cones were shown in Fig. 2. The limit shear stress in dependence on pH values were shown in Fig. 3. It was evident that the limit value of the shear in cross section of fibres was two times higher than in their longitudinal section. Thus, the carried out studies allowed to recommend the penetration method and the device PPM-4 as: - objective instrumental express-method for estimating meat and meat product quality on the basis of their consistency;

-method for the control of raw meat quality by limit shear stressr (methodology of estimation was proposed), and for the rational use in the course of production of half-finished and sausage products as well;

-method of the control of filling the sausage meat into casings level;

-method for the control of drying smoked dry sausages by indestructive means in order to avoid the tempering and to obtain products of the proper density.



Pic. 1. Penetrometer PPM-4

Table 1. Calculated constants of the cone

2α, degree	K(1)	K(2)	K(3)	K(2) with correction (4)
10	18.50	29.00	-	10.00
20	8.92	17.93	22.16	7.89
30	5.66	9.40	9.68	5.90
45	3.35	4.08	4.01	3.47
60	2.11	2.13	2.06	2.13
75	1.34	1.10	1.17	1.32
90	0.81	0.715	0.69	0.85

Table 2. Indices obtained during the experiment

Nos	pH	$h_{p,av}$	h_{av} 10, M	$2\alpha^0$	Θ_0, Pa	$\Theta_{0,av}$, Pa
1.		218.0/3.14	2.180/3.14	10	19465/9381	
	5.28	152.0/219	1.520/2.19	20	19300/9299	19455
		120.6/174	1.206/1.74	30	19600/9305	
2.		244.2/327	2.442/3.27	10	15435/8650	
	5.29	168.0/227	1.680/2.27	20	15800/8655	15497
		136.2/182	1.362/1.82	30	15255/8544	
3.		260.4/364	2.604/3.64	10	13640/6981	
	5.31	183.8/256	1.838/2,56	20	13550/6826	13587
		144.4/208	1.444/2.08	30	13570/6541	
4.		270.0/375	2.700/3.75	10	12685/6578	
	5.32	188.0/260	1.880/2.60	20	12620/6597	12650
		149.6/207	1.496/2.07	30	12645/6605	
5.		276.0/390	2.760/3.90	10	12140/6081	
	5.34	192.0/272	1.920/2.72	20	12100/6028	12120
		152.8/216	1.528/2.16	30	12120/6066	
6.		290.0/400	2.900/4.00	10	11000/5781	
	5.38	203.6/283	2.036/2.83	20	10760/5568	10848
		162.0/226	1.620/2.26	30	10785/5540	

*- Numerator is cross-section of fibres; denominator is longitudinal section of fibres.

*- h_{av} is penetration value equal to 0,1 mm

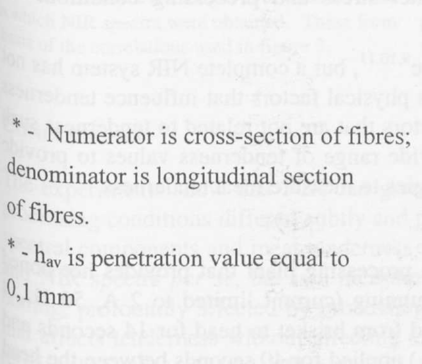


Fig. 2. Depth of indenter penetration (h_{av}) against pH values measured by different cones (1,1' 10^0; 2,2'-20^0; 3,3'-30^0);
(1', 2', 3' - cross section; 1, 2, 3 - longitudinal section)

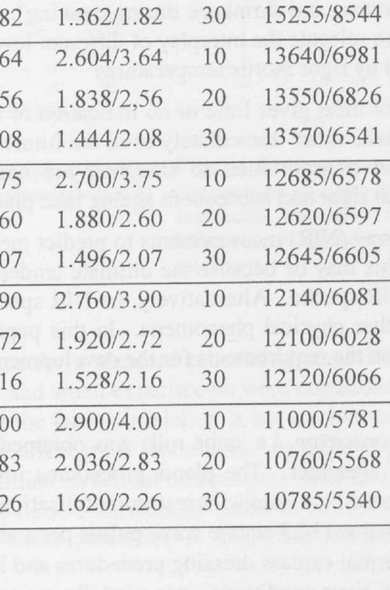


Fig. 3. Limit shear stress Θ_0 in pork muscle tissue: longitudinal section of fibres (1) and cross section of fibres (2) against pH values.