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# Dependence between the Rheological Properties of the Initial Raw Material and Whole Muscle Ham Products from Beef

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**Abstract:** The changes in the rheological characteristics of beef ham products were studied using a dynamic penetrometer with a cone angle of 10° and 30°. The ratios of the immersion depths of the cone of a dynamic penetrometer for different muscles (m.Semimembranosus and m. Longissimus dorsi) were calculated. When using different cones, the ratios varied depending on the content of the connective tissue in the meat, as well as in the process. Moreover, the more connective tissue in meat, the less the ratio of strength characteristics of meat along and across its fibers. The stage at which there was significant deterioration in the sensory indices was determined.

**Keywords:** *Beef, Dynamic penetrometer, Rheological characteristics, Ham products*.

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## INTRODUCTION

Each group of meat products is characterized by a complex of sensory indicators, in which consumers note priority. The main sensory traits of ham meat products made of beef are juiciness, tenderness, elasticity. They largely depend on the properties of the initial raw materials, the processing regimes, the prescription composition of the brine and many other factors. Each of these factors can be decisive. However, other things being equal, it is the original rheological properties of the meat that ensure the juiciness, density and solidity of the product. Rheological characteristics of raw materials are due to the anatomical location of muscle tissue, the age of the animals, the conditions of fattening, the breed and the stage of autolytic ripening. Some of these factors can be determined through sensory analysis, for others instrumental express methods are applied. Different methods are used for research and production purposes, such as gravitational impulse method, texture measurement method (Warner-Bratzler method), penetrative method, etc. (Kosoy and Dorohov, 2006; Migdał et al., 2007; Poldvere et al., 2014; Kakimov et al., 2015).

When exploring the resilient-elastic environments concerning whole muscle beef tissue, it is rational to use devices whose principle of action consists of the introduction of working body in the research object. The dynamic penetrometer with a conic indentor as a portable device of the size of the penetration in the whole muscle raw materials has proved to be perfect (Kosoy et al., 2005; Kosoy and Dorohov, 2006, Kakimov et al., 2015). However, depending on the characteristics of the studied object, different cone apex angles may be used. For plastic bodies, in particular minced meat, it is rational to use cones with angles of more than 30° (Kosov et al., 2005; Kakimov et al., 2015), for the elastic-elastic (whole muscle beef tissue) - cones with apex angles less than 30° (Savinok, 2015).

Previous studies have made it possible to determine the optimal cone angle of the indenter of a dynamic penetrometer and to choose the calculation equations with correction factors (Savinok, 2015, 2016) to estimate the rheological characteristics of whole muscle beef. The smallest error is provided by a penetrometer with a cone angle at the apex of 10 º, and with a force of 0.5 kg.

However, for the practical application of the obtained data, it is necessary to establish a relationship between the rheological indexes of the initial raw materials and finished products after the end of heat treatment and during storage.

### Material and Methods

The objects of the research were isolated semi-finished products from carcasses of young Simmental cattle at the age of 14-15 months. The slaughter and refrigeration conditions were identical. The beef halves (30 pieces) were received for processing after 3 days of maturation from the moment of slaughter. The temperature in the depth of the muscles when admitted to the meat processing plant did not exceed +4 ºC. For the production of whole muscle products, pieces of muscle tissue weighing

1.8-2 kg, derived from m. Longissimus dorsi and m.Semimembranosus muscles were selected. The pH values in the analyzed muscles were in the range of 5.42-5.46. The salting process included brine injecting, massaging, maturing in a massage machine in a vacuum.

The percentage of brine during the injecting was 75 %. Massaging was carried out for 8 hours, the duration of the active phase was 20 minutes, the duration of the resting phase was 10 minutes, the depth of vacuum – 85%, the drum rotation speed – 8 rp/m. The duration of ripening was 16 hours, the temperature at the salting was +2 ºC, the diameter of the drum of the massager was 1 m. For the injecting, the supplement of the German-Polish company "Fleisch Mannschaft", Shinka FCB was used. The technology of the brine preparation corresponds to the company's instructions. Heat treatment and storage were carried out according to the following regimes: short time smoking– τ = 1.5 h, t = 70 ° C; smoking – τ = 20 min, t = 70 ° C; cooking – τ = 1,5 h, t = 78 ° C, to t at the center = 72 ° C; cooling - t = 4 ° C to t at the center ≤ 22 ° C; final cooling – t = 4 ° C to t at the center = ≤ 6 ° C; storage – τ = 9 days, t air = 0-4 °C. The pH of the meat after the injecting was 5.95-6.01.

The optimal angle of the conical indenter for a dynamic penetrometer, which provides a minimum error in calculating the limiting shear stress (10º and 30º) was chosen based on previous studies (Savinok et al., 2014). In order to study the influence of the initial rheological properties of beef on rheological and respectively the sensory indices, the studies were carried out at the main technological stages: after separation of semi-finished products, after salting, after heat treatment and at storage stages.

**Results and Discussion**

Since the strength properties along and across the fibers differ in absolute value, to determine the absolute values and their ratios, the measurements were made on the cross section of the muscle tissue of the meat into which the indenter was introduced along the fibers and in the longitudinal section where the introduction of the working body occurred across the fibers. In the latter case, the strength of the meat is much larger than in meat, where measurements were made along the fibers. The strength of the meat was estimated by the rheological value which is the limiting shear stress (LSS) measured in Pa. The ratio of the depth of the cone immersion for the two muscles were different. When using different cones, the ratios varied depending on the content of connective tissue in the meat, as well as in the process. Moreover, the more connective tissue in meat, the less the ratio of strength characteristics of meat along and across its fibers (Table 1). When studying the properties of salted meat, it was noted that the destruction of loose connective tissue fiber between the bundles of muscle fibers and the muscle fibers themselves during the injecting and massaging, helped to reduce the LSS, which was clearly demonstrated by the ratio of the values of LSS, this value increased from 0.53 to 0.82 (cone angle 10º) for m. Semimembranosus, while for m. Longissimus dorsi, which refers to a semi-static, the calculated ratio has changed within the error of measurement. This was due to the fact that the analyzed muscle contains a minimal amount of loose connective tissue fiber between the bundles of muscle fibers, which, in addition, is filled with fat cells. Consequently, the established relationship can be used for dynamostatic muscles, statodynamic, containing a significant amount of connective tissue between muscle fibers and having thick muscle fibers, which causes their stiffness (Cherniavskiy, 2002). The results obtained will make it possible to use the penetration method to assess the quality of meat (by the content of connective tissue) by the ratio of the lateral LSS (across the fibers) to the axial (along the fibers).

**Table 1.** Change of the rheological characteristics of beef during processing

| Properties and type of object | Name of muscles | Cone angle | Direction of introduction of the cone into the muscle tissue | Depth of the introduction (h), cm | Relative penetration voltage ($\Theta_п$), Pa | Limiting shear stress $\Theta_о$, Pa | $h_{along}$ / $h_{across}$ | $\Theta_{п\ along}$ / $\Theta_{п\ across}$ |
|---|---|---|---|---|---|---|---|---|
| Meat before processing | m.semimembranosus | 10 | along | 2.57 | 7432.67 | 5748.95 | 1.37 | 0.53 |
| | | | across | 1.87 | 14087.31 | 10896.10 | | |
| | | 30 | along | 1.63 | 18483.41 | 8430.70 | 1.20 | 0.70 |
| | | | across | 1.36 | 26530.13 | 12100.99 | | |
| | m. longissimus dorsi | 10 | along | 2.40 | 8486.35 | 6563.93 | 1.01 | 0.97 |
| | | | across | 2.37 | 8758.34 | 6774.31 | | |
| | | 30 | along | 1.81 | 15117.55 | 6895.46 | 1.25 | 0.65 |
| | | | across | 1.45 | 23349.92 | 10650.42 | | |
| Meat after massaging | m.semimembranosus | 10 | along | 2.69 | 6796.85 | 5257.15 | 1.11 | 0.82 |
| | | | across | 2.43 | 8270.94 | 6397.32 | | |
| | | 30 | along | 1.68 | 17269.62 | 7877.06 | 1.04 | 0.91 |
| | | | across | 1.61 | 18903.59 | 8622.35 | | |
| | m. longissimus dorsi | 10 | along | 3.06 | 5217.86 | 4035.86 | 1.06 | 0.89 |
| | | | across | 2.90 | 5836.46 | 4514.32 | | |
| | | 30 | along | 1.91 | 13471.92 | 6144.85 | 1.06 | 0.89 |
| | | | across | 1.80 | 15123.46 | 6898.15 | | |

Analysis of the rheological characteristics of the finished product (Table 2) showed that the limiting shear stress in the analyzed ham products after heat treatment decreased by 17.83% with longitudinal measurement of the penetration depth (cone angle 10º) and 43.69% at the transverse for m. Semimembranosus; by 61.2% at longitudinal and 39.0% at transverse – for m. Longissimus dorsi. A slight decrease in LSS with longitudinal measurement of the introduction depth in m. Semimembranosus, indicated partial swelling of collagen during heat treatment and simultaneous longitudinal compression of the muscle fibers. On the other hand, significant decrease in LSS in the transverse measurement in this muscle was justified by the destruction of the intermuscular connective tissue due to mechanical action with saline. The decrease in LSS in m. Longissimus dorsi was justified by a more delicate cellular structure of muscles, a loose connective tissue between the fibers.

**Table 2.** Change of the rheological characteristics of ham products from beef during storage

| Duration of storage, days | Name of muscles | Cone angle, degrees | Direction of introduction of the cone into the muscle tissue | Depth of the introduction, h, cm | Relative penetration voltage $\Theta_п$, Pa | Limiting shear stress $\Theta_o$, Pa | $h_{along}/h_{across}$ | $\Theta_{п\ along}/\Theta_{п\ across}$ |
|---|---|---|---|---|---|---|---|---|
| 1 day | m.semimembranosus | 10 | along | 2.83 | 6107.40 | 4723.89 | 1.14 | 0.77 |
| | | | across | 2.48 | 7942.92 | 6135.50 | | |
| | | 30 | along | 1.56 | 20134.78 | 9183.93 | 0.96 | 1.09 |
| | | | across | 1.63 | 18527.70 | 8450.90 | | |
| | m. longissimus dorsi | 10 | along | 3.86 | 3292.94 | 2546.99 | 1.27 | 0.62 |
| | | | across | 3.04 | 5317.09 | 4112.61 | | |
| | | 30 | along | 2.36 | 8772.96 | 4001.54 | 1.25 | 0.64 |
| | | | across | 1.89 | 13782.16 | 6286.35 | | |
| 4 days | m.semimembranosus | 10 | along | 2.70 | 6746.50 | 5218.21 | 1.10 | 0.83 |
| | | | across | 2.46 | 8097.03 | 6262.81 | | |
| | | 30 | along | 1.38 | 25581.38 | 11668.24 | 0.99 | 1.01 |
| | | | across | 1.39 | 25224.72 | 11505.56 | | |
| | m. longissimus dorsi | 10 | along | 3.69 | 3600.85 | 2785.15 | 1.24 | 0.65 |
| | | | across | 2.98 | 5526.01 | 4262.92 | | |
| | | 30 | along | 2.08 | 11276.47 | 5143.45 | 1.32 | 0.58 |
| | | | across | 1.58 | 19518.30 | 8902.74 | | |
| 6 days | m.semimembranosus | 10 | along | 2.36 | 8788.45 | 6797.59 | 1.00 | 1.00 |
| | | | across | 2.36 | 8816.43 | 6819.24 | | |
| | | 30 | along | 1.55 | 20362.57 | 9287.82 | 1.01 | 0.97 |
| | | | across | 1.53 | 20904.78 | 9535.14 | | |
| | m. longissimus dorsi | 10 | along | 3.24 | 4664.13 | 3607.56 | 1.08 | 0.86 |
| | | | across | 3.01 | 5426.34 | 4197.11 | | |
| | | 30 | along | 2.51 | 7808.73 | 3561.74 | 1.14 | 0.77 |
| | | | across | 2.20 | 10101.00 | 4607.29 | | |
| 9 days | m.semimembranosus | 10 | along | 2.41 | 8436.49 | 6525.37 | 1.06 | 0.89 |
| | | | across | 2.27 | 9530.19 | 7371.31 | | |
| | | 30 | along | 1.58 | 19711.35 | 8990.79 | 1.10 | 0.82 |
| | | | across | 1.43 | 23895.17 | 10899.12 | | |
| | m. longissimus dorsi | 10 | along | 3.84 | 3315.62 | 2564.53 | 1.11 | 0.80 |
| | | | across | 3.45 | 4119.17 | 3186.05 | | |
| | | 30 | along | 2.50 | 7867.95 | 3588.75 | 1.21 | 0.69 |
| | | | across | 2.07 | 11484.77 | 5238.46 | | |

When storing ham products obtained from beef m. Semimembranosus, an increase in the limiting shear stress, characterizing the rigidity and density of the product, was observed. During the storage period from 6 to 9 days, in the products made of this muscle, intensive separation of moisture was observed, the structure becoming friable. This justified the decrease in LSS after 9 days of storage with longitudinal insertion of the cone (cone angle 10º) and the increase in the transverse. Similar trend was observed for the m. Longissimus dorsi products. The separation of moisture could be explained by the composition of the brine. It contains hydrocolloids, from which the separation of the liquid phase occurs due to syneresis. Consequently, starting from 6 days, the products begin to soften the structure due to the syneresis of the colloid structure formed after heat treatment and subsequent cooling, consisting of meat myofibrillar proteins and brine hydrocolloids.

The use of indentors with angles of 10º and 30º showed similar dependencies, however, when using a cone with an angle of 30º, the error percentage in the measurement was larger. Sensory analysis of ham products during the whole storage period also allowed to note a significant deterioration in quality indicators, starting from 6 days. The products had an intensive separation of moisture upon pressing, the cutting was deteriorated, the consistency became friable, and the monolithicity of the product at the cut disappeared.

**Conclusion**

The ratios of the depths of the cone immersion for m. Longissimus dorsi and m. Semimembranosus allowed to establish that the more connective tissue in meat, the less the ratio of meat strength along and across its fibers. These data will allow us to rationally sort the meat raw materials for the production of whole-muscle beef products. The study of rheological characteristics of beef ham products using a dynamic penetrometer with a cone angle of the working body of 10º allowed us to recommend this method for determining the stage at which a significant deterioration in sensory indices occurs.

## REFERENCES

Cherniavskiy, M.V. (2002). Anatomico-topographic foundations of technology, veterinary and sanitary expertise and commodity evaluation of slaughter products. M.: Kolos S, 376.

Kakimov, A., Z. Yessimbekov, A. Bepeyeva, B. Kabulov and Z. Kakimova (2015). Consistency cone penetrometry for food products. Pak. J. Nutr., 14 (11), 837-840.

Kosoy, V. D. and V. P. Dorohov (2006). Improving the production of sausages (theoretical foundations, processes, equipment, technology, formulations and quality control) M.: DeLi print, 72–99.

Kosoy, V. D., A. D. Malyshev and S. B. Yudina (2005). Engineering rheology in the production of sausages M.: KolosS, 262.

Migdał, W., B. Živković, A. Nowocień, I. Przeor, K. Palka, M. Natonek-Wiśniewska, D. Wojtysiak, M. Walczycka and I. Duda (2007). Chemical composition and texture parameters of loin from polish landrace fatteners slaughtered in different age. Biotechnol. Anim. Husbandry, 23 (5-6), 277– 282.

Poldvere, A., L. Lepasalu, A. Tanavots, J. Olt, U. Sannik, A. Sats, R. Saar, R. Martinson and V. Poikalainen (2014). An alternative method for meat shear energy estimation during ageing. J. Agron. Res., 12(3), 793–800.

Savinok, O. N. (2015). Rheometrik investigations of beef muscle tissue in different periods of autolysis. Maced. J. Anim. Sci., 5 (2), 101–105.

Savinok, O. N. (2016). Improvement of the methods of calculation of rheological characteristics of resilient-elastic environments by the penetration method Maced. J. Anim. Sci., 6 (1), 59–64.

Savinok, O.N., V.D. Kosoy, V.G. Garbuz (2014). Choice of rational parameters for measuring the rheological characteristics of whole muscle tissue of beef by the penetration method Scientific Works ONAFT, Odessa, 46 (2), 160-164.