MEAT PRODUCTS DEFORMATION DURING HEATING

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SUMMARY : Deformation character of meat and meat products, their expansion or shrinkage depends on moisture content, on water-binding capacity and on the degree of meat comminution. Deformation value is influenced bu temperature, pressure, dimensions of samples, by molds elasticity.

INTRODUCTION: Heating causes qualitative and quantitative changes in physico-chemical properties of meat and meat products. It is reflected through external and internal traits, one of them being deformation. Tensions, emerging during meat deformation and related with structural changes of muscle proteins and collagen, effect parameters of finished products. For instance, during cooking of uncured meat products, part of water with solubilized therein substances is outpressed into external environment (Sokolov, 1970). Ignoring of deformation phenomena during manufacture of sausage items and canned products may cause can or casing breakage. At present, due to the lack of scientifically based data on the mechanisms of deformation during heating of ground meat, development of progressive technology for skinless sausage items manufacture is therefore restricted.

Complexness of the studied problem lies in diametrically opposite deformation character of meat and ground meat during heating. Intact meat in the process of heating decreases in volume (shrinks), and ground meat expands, on the contrary. During heating most characteristic behaviour of meat products, having different structure, includes: heat-induced denaturation of muscle proteins, softening and hydrothermic breakdown of collagen (Sokolov, 1970).

During heat-treatment of meat with intact structure, muscle fibers retain their integrity, however, they become smaller in diameter by 25-30%, thus showing increased density. After cooking and collagen desaggregation length of fibers decreseases to 60%, however, due to expanded thickness, their volume gradually widens. Strength and character of muscle tissue deformation is influenced by position of collagen fibers in it. For example, during heating of M. Semimembranosus it shortened by 38%, which was accompanied by significant change of its form. Meat contains 70-75% of water and changes in meat/water ratio are also reflected in deformation value. At the process of heating due to pH-shift to the isoelectric point, water-holding capacity of muscle protein diminishes, particularly, tightly-bound moisture decreases by 15-20%. Cooking loss of meat products achieves 10-40%, this depending on several factors: salt content, temperature, time, etc.

Thus, while heating, the volume of intact muscle decreases due to lenthwise shrinkage of collagen fibers. Narrowing of muscle fibers diameter and release of tightly bound moisture contribute to this process.

During mechanical comminution of meat , cell structure is destroyed, and thus meat emulsion is formed.

MATERIALS AND METHODS: Study into parameters of comminuted meat revealed another character of volumetric deformation change during heating. To compare and to understand completely experimental data, one has to analyse methods of these data obtaining.

Deformation means change of linear dimensions of an object, when particles or molecules shift relative to each other without products breakage. Relative deformation $\mathcal{E}$ represents the ratio of absolute deformation Δl and initial dimension of an object, i.e:

$$\mathcal{E} = \Delta l / l, \qquad (1)$$

Deformation can be linear, volumetric and shift-like. Volumetric deformation represents the ratio of objects volume change ΔV and its initial volume V_i:

$$\mathcal{E}_v = (V_i - V_u) / V_i \, , \qquad (2)$$

where V_i - is initial volume of an object;

V_u - is ultimate volume of an object after deformation.

In modern meat processing equipment raw material is subjected to volumetric shrinkage. To investigate deformation value of volumetric shrinkage and expansion, special instruments are used, of the type "piston-cylinder". In order to determine products deformation in the non-elastic form, linear distance, covered by the above-said piston, is measured. The described method is not accurate enough, because volumetric deformation with accuracy to endlessly small values represents sum of volumetric deformation along three perpendicular axes and is proportional to pressure level. Hydrostatic value in the point, situated in really viscous liquids, or liquid-like systems does not depend on site orientation, and as far as ground meat is concerned, on the contrary, certain dependence is observed. If an object, concluded in a definite volume, is influenced by hydrostatic pressure P, then in normal direction lower pressure P_h will be established. Therefore, linear displacement of a piston fully reflects deformation along one axis and partly along the other two perpendicular axes. The latter are caused by tensions, resulting because of pressure, part of it appearing in the form of outward pressure along cross-section of a non-elastic mold.

In order to improve measuring accuracy of volumetric deformation, the following method was suggested: ground meat is placed into elastic mold, for instance, artificial sausage casing and then immersed into a vessel, filled with water. Vessel is hermetically sealed by a cap with a measuring tube, incorporated therein, through which liquid is introduced, having a definite ratio of volumetric heat-induced expansion up to zero-mark of a measuring tube. At a definite volume of a vessel and known amount of introduced liquid, one can determine the initial volume of the studied meat emulsion. Value of volumetric change can be determined by move of meniscus, belonging to a measuring tube.

RESULTS AND DISCUSSION: Graphic dependence of volumetric deformation of ground meat in molds, made from materials with various elasticity and air-tightness degree on temperature is shown in fig. 1.

According to the data, obtained by A.M.Brazhnikov, V.V.Vagin, V.V.Karpov, S.N.Tumenov, expansion of ground meat volume during heating shows a continuous character.

In accordance with Brazhnikov's results, ground meat deformation depends exclusively on temperature. V.V.Vagin considers that the main reasons for ground meat expansion (according to degree of significance) are as follows: expansion of the air, contained in ground meat, change of volume due to physical process of body expansion, expansion of ground meat caused by moisture and formation of a new structure, rearrangement (in the presence of water) of fibrillar and globular polypeptide protein chains from curved and folded form to a plain, unfolded one; expansion of water and water-protein solutions. V.D.Kosoi considers that heat-induced expansion of liquid (water), solid and gaseous (air bubbles) fractions, being main constituents of ground meat, is not the decisive factor. Air is expanded by 2% and its total expansion, related to total volume, equals to less than 0,01%.

Expansion of water and water-protein-saline solutions practically is not able to influence significantly volume increase, as temperature coefficient of water volumetric expansion is not significant. The main reason for ground meat expansion, induced by meat weight, state of initial raw material, moisture and degree of comminution, lies in formation of a new structure.

The study of artificial sausage casings (fibrous, saran, armoured viscose) has shown, that temperature increase causes their thermal shrinkage. Consequently, the observed deformations can be fully explained by expansion of ground meat, filled in a casing.

The main difference between whole meat and ground meat deformation lies in volumetric expansion of ground meat during heating. The reason for this is lack of compressive tensions, caused by lengthwise change of collagen fibers during comminution. On the other hand, because of the fact, that protein structural elements are in a finely dispersed condition and possess high water-binding ability, liquid is not separated. Water-binding ability of muscle tissue during optimum comminution condition reaches 86-87%.

Peculiarity of ground meat volumetric deformation during compression in a non-elastic mold lies in dependence from dimensions of the latter. Directly proportionsl dependence of the relative volumetric deformation from samples diameter can be explained by the fact that with linear increase of diameter, volume is increased quadratically. Along with the rise of samples height relative volumetric deformation increases initially and then, having reached its extremity, decreases. Dependence of volumetric deformation of ground meat, placed in a non-elastic mold, on samples height can be explained by the following: with the rise of samples height volume of ground meat is not influenced by friction forces, existing between meat emulsion and side surface of the mold, usually causing increase of the relative volumetric deformation. This is accompanied by the rise of pressure change value according to height of ground meat sample which ensures lowering of relative volumetric deformation. Initially, effect of the first factor was stronger than of the second one, and later - vice versa.

Similar change character of relative volumetric deformation as dependent on samples dimensions and pressure was noted during pressure heating of ground meat samples, showing different height. This is due to ununiformity of samples inner heating (in height), as temperature fields are applied from end and side surfaces. While heating of samples, that have height dimensions lower than diameter, the central layer of meat emulsion is heated due to heat transfer from end surface. With rise of samples height, temperature of end surfaces rises too, and their relative volumetric deformation is consequently increased. When height value is equal to diameter, end surfaces are heated to maximum temperature point which does not rise with further height increase, because the heating process is already carried out by heat transfer from side surfaces. On the other hand, height increase stimulates development of friction forces due to side pressure of meat emulsion. Along with height increase, tension, induced by deformation of central layers, decreases closer to the surface of a sample, i.e. relative volumetric deformation of meat emulsion(having large volume and placed in a non-elastic mold)is to a great extent determined by deformation of surface layers.

For studied pressure range $(0 \div 0,5) \cdot 10^5$ Pa linear dependence of the relative volumetric deformation on the applied pressure value was established, which corresponds to hypothesis of G.E.Limonov.

CONCLUSIONS: Deformation charater of meat and meat products - expansion or shrinkage, depends on moisture content, water-binding ability and on the degree of raw material comminution. Deformation value is influenced by temperature, samples dimensions, mold elasticity.

Analysis and summary of investigation results, concerning volumetric deformation of meat and meat products during heating will alow to formulate initial requirements for designing and development of new artificial sausage casings, and also of equipment for molding and heat-treatment of sausage items. Investigation into interrelation of volumetric deformation, process parameters and quality traits of final products permits to optimize the process, to reduce losses and enhance quality of final products

REFERENCES:

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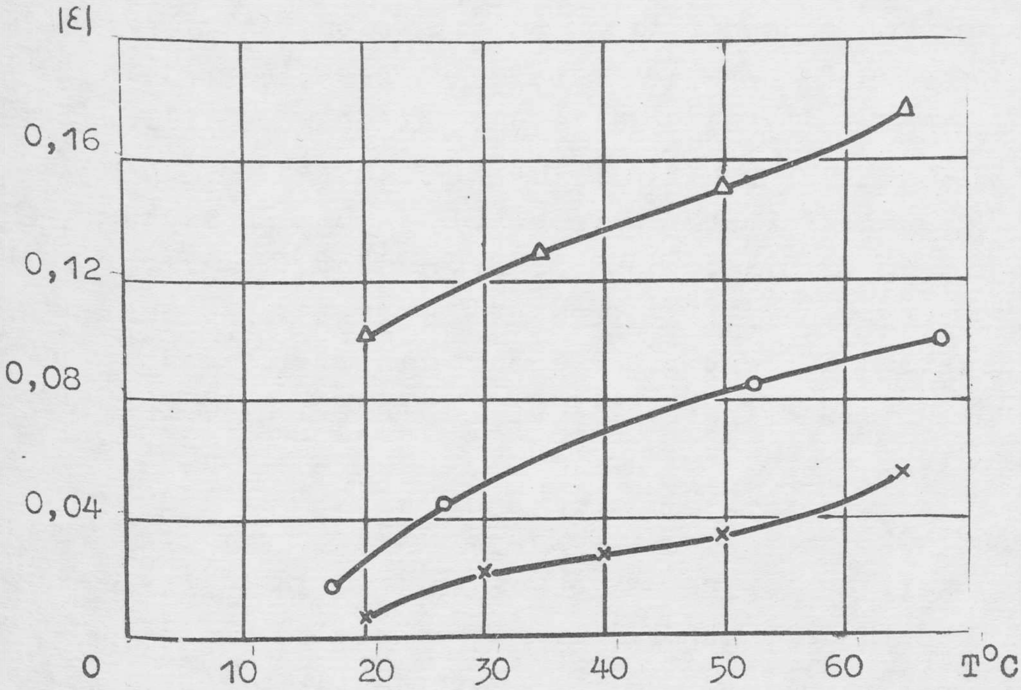

Fig 1 Dependence of relative volumetric deformation on temperature for ground meat

-Δ- - fibrous casing
-o- - saran casing
-x- - sample inmetal mold