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METHODOLOGICAL ASPECTS OF FOOD TEXTURE MEASUREMENTS USING TPA TEST

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A b s t r a c t. Acceptable texture in food products is an important component of their quality. A lot of reports on the texture profile analysis of a number of commodities can be found in literature. Conditions under which these tests have been performed vary to a great extent with regards to specimen dimensions, deformation level and compression rate. The aim of this paper was to evaluate the effects of various test conditions on the parameters of texture profile analysis (TPA). Three different types of processed meat products were investigated. The tests were performed using standard INSTRON device at the cross-head speeds of 5, 10 and 20 mm min^{-1}. Cylindrical samples, 10 mm in height and 10, 15, and 20 mm in diameter were compressed to three levels of deformation: 25, 50 and 75%. As a result curves of twin compression could be plotted and values for hardness I, hardness II, elasticity and cohesiveness were obtained. These parameters, except cohesiveness, were modified by dividing them by the initial cross-sectional area of the sample. The results of the present investigation showed that TPA parameters were influenced by the diameter of samples and compression ratio in all the three types of meat products. Thus, TPA parameters of meat products are not comparable if the tests are performed at distinctly different condition. It was stated that the speed of compression had a marginal effect on the TPA parameters. The present investigations showed that there is a need to continue work on the optimisation of conditions for texture measurement using the TPA testing.

K e y w o r d s: texture, TPA test, methodology

INTRODUCTION

The basic criterion for food evaluation is its quality. At present it is assumed that good quality food should not only be faultless but it should also possess sensory features required by the consumers. A very important property determining the quality of food is the texture.

For the evaluation of food texture numerous measuring methods are used, i.e.: mechanical, sensory and chemical. Difficulties in determining texture resulted in the development of many instrumental methods of measurement. These methods differ from one another significantly and in many cases it is impossible to compare the results of tests performed by various authors. Moreover, researchers perform tests in different measuring conditions for a given method and this makes comparative evaluation of results and their interpretation impossible. Another factor is the fact, that the investigations are carried out with application of non-standardised and often prototype apparati.

One of the methods of texture measurement applied most frequently is texture profile analysis (TPA) carried out by means of the INSTRON apparatus. Results obtained as a double squeezing curve contain the following parameters: hardness, brittleness, cohesiveness, adhesiveness, elasticity, gumminess and chewiness. The Voisey's [9] and Breenea's [3] research work indicate considerable ambiguity on the conditions of food measurements performed with the TPA method. In many cases lack of information in regard to the definitions of such measuring parameters as loading speed of the sample, its shape and dimensions, degree of deformation, can be found. In general in some works there is no information on the measuring conditions.

Basic shape of the sample for the TPA test is assumed to be cylindrical; however Bourne and Comstock [1] as well as Casiraghi *et al*. [4] applied cubes of various dimensions. In the case of cylindrical samples, a significant variability of dimensions is observed. For instance, Mittal *et al.* [6] applied a sample 10 mm in diameter, and Seman *et al.* [7] - a sample 73 mm in diameter. Also the height of samples differs. Fox and Hanenian [5] used samples 10 mm high, and Brady and Hunake [2] - samples of 25.4 mm high. The diameter-height ratio varies from 1.0 to 4.0 in various research works. Various speeds of sample loading are used as indicated in literature. For instance, Sofos *et al.* [8] loaded the sample at 5 mm min^{-1}. Deformation degree most frequently used is 75% but Bourne and Comstock [1] applied sample loading up to 93%, and Mittal *et al.* [6] - only to 25%.

The objective of the present investigation was evaluation of the influence of sample size, deformation degree and loading speed on the course of measurements performed with the TPA method.

MATHERIALS AND METHODS

The present investigation was carried out on three kinds of pork butcher's meat: frankfurter, smoked sausage and smoked pork ham. When selecting kinds of meet, degree of crumbling was considered. Preparation of material for the study included slicing the meat into 10 mm slices and cutting out cylindrical samples of 10, 15, and 20 mm diameter. TPA test was performed with the INSTRON 4302 apparatus equipped with a measuring head of operation range up till 1 kN. Measurements were performed with three speeds of the measuring head displacement: 5, 10, and 20 mm min^{-1}. The samples were squeezed to obtain 25, 50 and 75% of deformation. All the measurements were repeated ten times. The measurements allowed to plot diagrams which were the basis for determining the following parameters characterizing texture of the studied materials: hardness I, hardness II, elasticity and cohesiveness. Hardness I was defined as the force required for the first compression, and hardness II was the peak force for the second compression. Elasticity was the distance the sample recovered in its height after the first compression. Cohesiveness was the ratio of the two total areas under compression curves. The above parameters, except cohesiveness, were modified by dividing them by the initial sample cross-sectional area. The values obtained were statistically analysed with the application of variance analysis. Significance of differences was checked with the Duncan's limits of faithfulness.

RESULTS AND DISCUSSION

The present investigations imply that the values of the TPA test parameters obtained for the individual kinds of meat differ significantly in various measurement conditions. For instance hardness I for frankfurters is 12.6-46.1 N mm^{-2}, for ham is 5.2-32.4 N mm^{-2}, and for sausage: 6.9-49.2 N mm^{-2}. Similar variability was obtained for hardness II. In the case of elasticity and cohesiveness, the minimum and maximum values obtained differ to a far lesser degree.

The results of investigations are shown in Figs 1-4. Influence of sample size, sample deformation degree and speed of loading on hardness I were presented in Fig. 1. This figure indicates that the sample size influences the values of hardness I obtained independently of the kind of material used. For all the studied kinds of meat hardness values were increased with the sample diameter increase. In the case of the samples with D/H =2, the values of hardness I were higher by approximately 30% for frankfurters and sausage and by 50% for ham when compared to the values obtained for the samples with D/H =1. The present investigations indicate a considerable influence of sample deformation degree on the values of hardness I. An increase in the sample deformation degree from 25 to 75% caused a quadruple increase of hardness I for sausage and more than double increase for ham. For frankfurters initially an increase and then decrease of hardness were observed. The investigations demonstrated a slight difference in hardness I for the

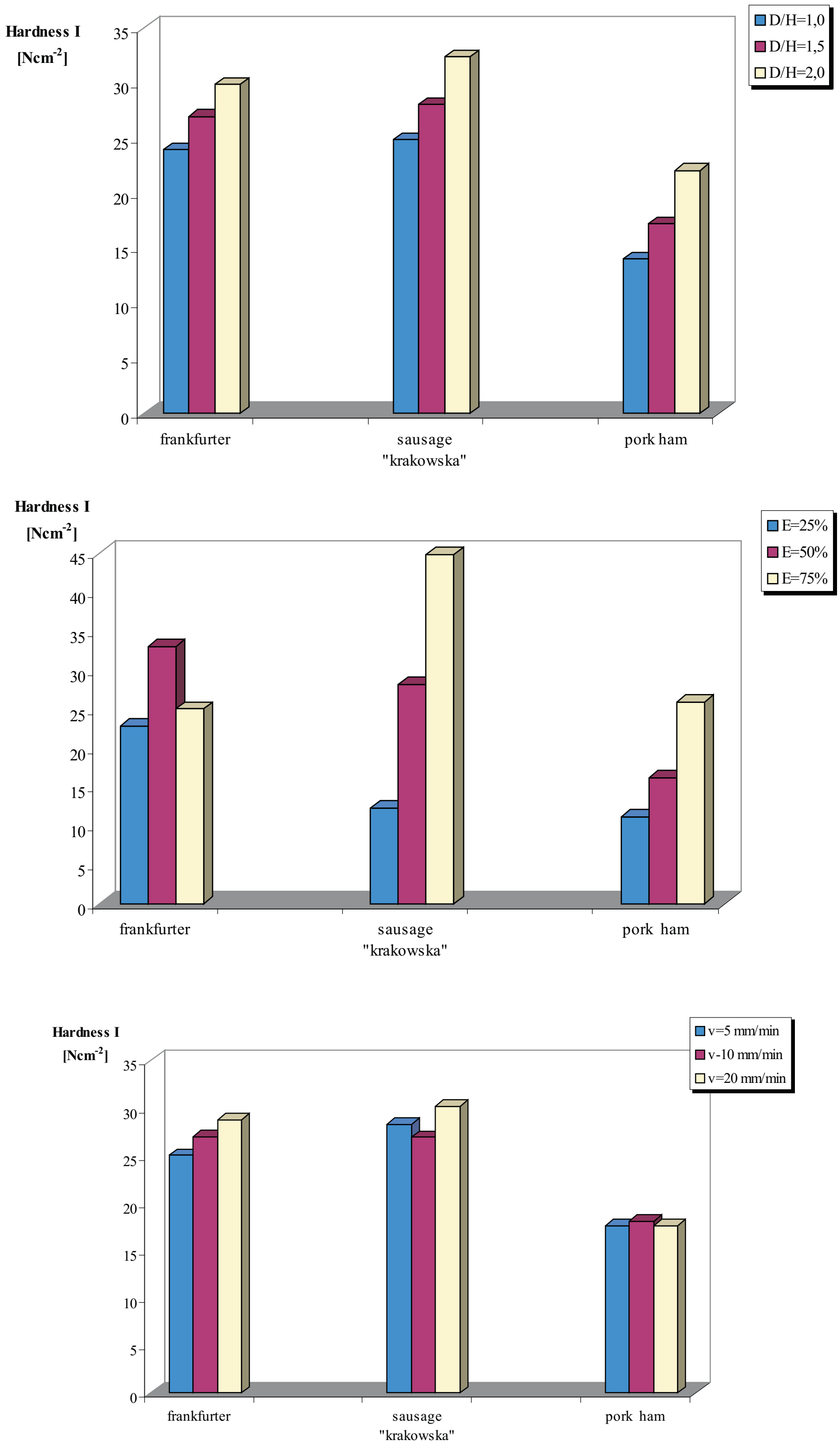

Fig. 1. Influence of sample size, sample deformation degree and sample loading speed on the hardness I values.

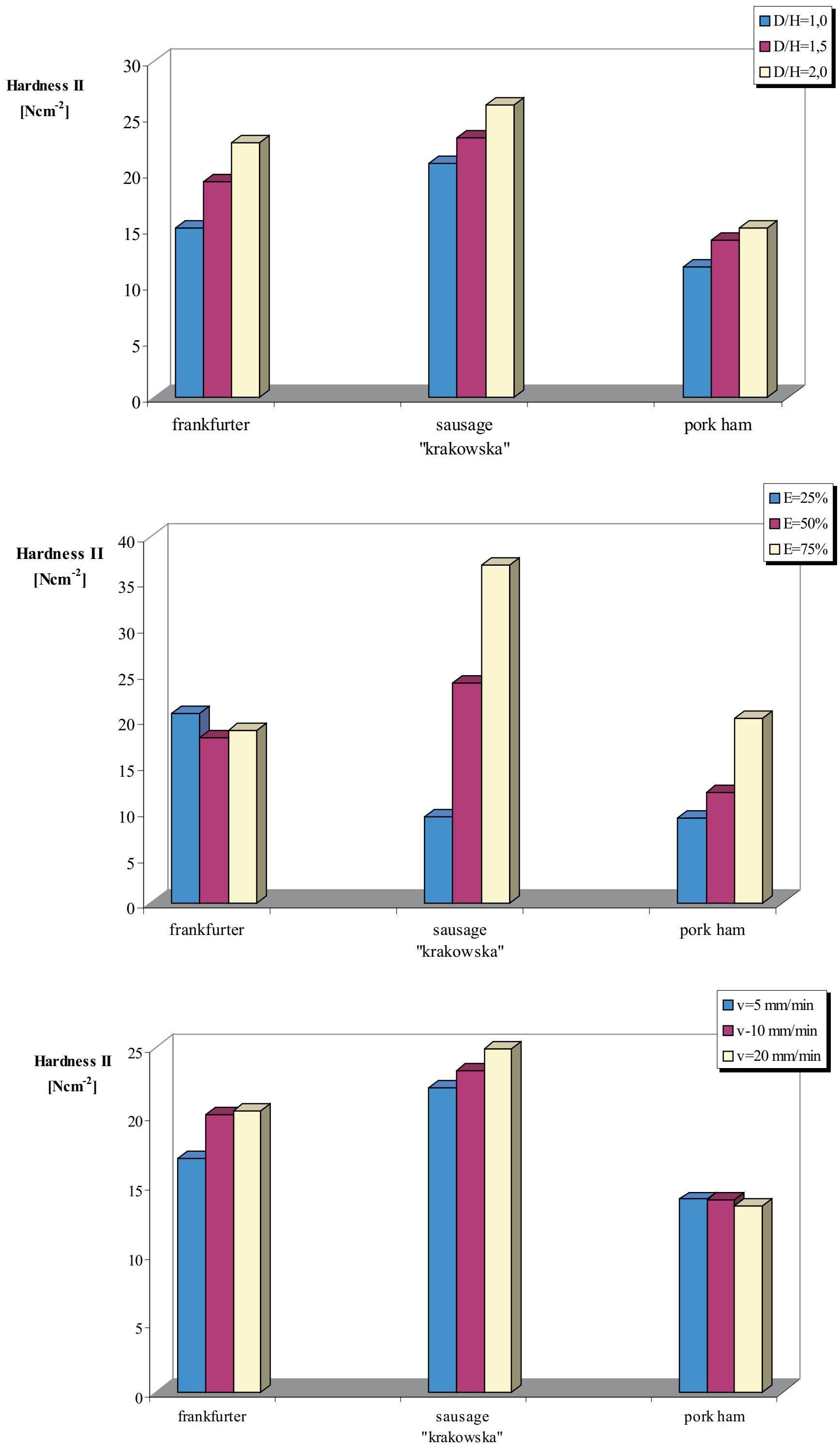

Fig. 2. Influence of sample size, sample deformation degree and sample loading speed on the hardness II values.

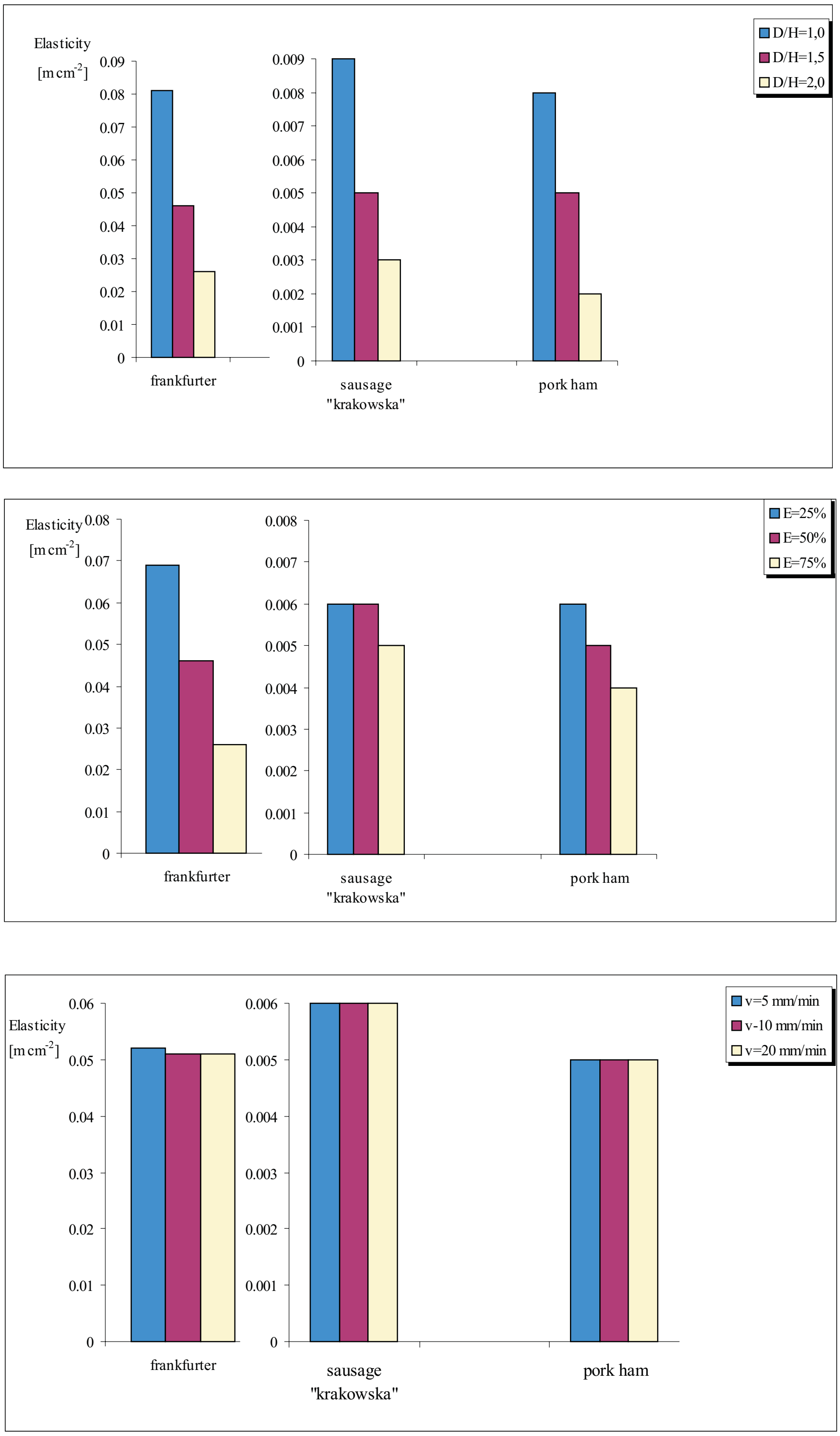

Fig. 3. Influence of sample size, sample deformation degree and sample loading speed on the elasticity values.

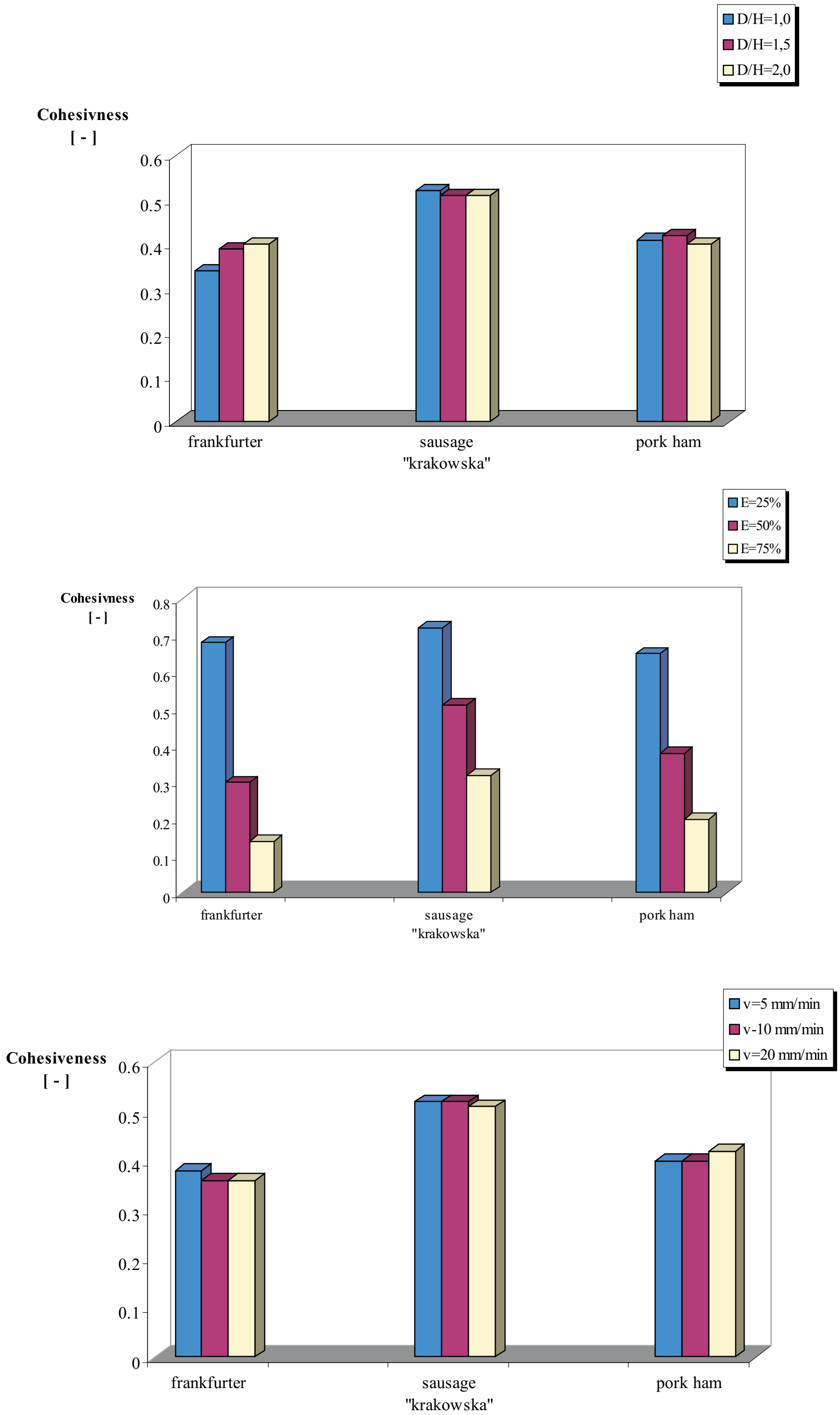

Fig. 4. Influence of sample size, sample deformation degree and sample loading speed on the cohesiveness values.

studied samples loaded at various speeds. Statistical analysis ($\alpha \leq 0.05$) confirmed no influence of the speed of sample loading on the values of hardness I.

Figure 2 presents the influence of sample size, sample deformation degree and sample loading speed on hardness II. An increase in the sample size results in the increase of values for hardness II for all the studied kinds of meat. With the increase of sample diameter from 10 to 20 mm, the increase of value of hardness II by 30-35% was confirmed. The investigations demonstrated that sample deformation degree influenced hardness II for pork ham and sausage samples. No influence of sample deformation degree on hardness II for frankfurter samples was found. However, a slight influence of sample loading speed on the values obtained for hardness II for frankfurters and sausage samples was found and confirmed by statistical analysis ($\alpha \leq 0.05$).

The investigations proved that samples size and the degree of deformation influenced elasticity of the studied meat. However, no influence of sample loading speed on the elasticity value was confirmed (Fig. 3). In all of the kinds of meat, it was observed that an increase of sample diameter from 10 to 20 mm caused more than triple decrease of elasticity value. The increase of deformation rate from 25 to 75% caused more than double decrease of elasticity in the case of frankfurters, about 20% decrease - in the case of sausage and about 50% decrease in the case of ham.

The values obtained for cohesiveness are influenced only by the degree of sample deformation (Fig. 4). In the studied meat a repeated decrease in the cohesiveness value was confirmed with the increase of sample deformation degree from 25 to 75%. Statistical analysis ($\alpha \leq 0.05$) confirmed no influence of sample size and its loading speed on the cohesiveness value.

The present study indicates that the size of samples and the degree of their deformation are decisive factors influencing the modified parameters characterising meat texture. Subject to the assumed conditions of investigations, the results obtained may differ even several times in the case of individual parameters. The above proves that it is advisable to continue this type of investigations to find reasons for this phenomenon.

CONCLUSIONS

The investigations carried out by the present authors allow for the following conclusions:

1. All the studied parameters characterizing TPA test depend significantly on the deformation degree of the sample.
2. Hardness I, hardness II and elasticity depend on the sample size as well.
3. The studied parameters characterizing TPA test are practically not influenced by the sample loading speed.
4. An increase in the deformation degree of a sample and D/H value cause an increase in hardness I, hardness II and the decrease of elasticity of the studied samples.

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