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STUDY ON THE INFLUENCE OF SAMPLES' DIMENSIONS ON THE ANALYSIS OF SMOKED CHEESE TEXTURE PROPERTIES

*Elena SĂNDULEAC (TODOSI SĂNDULEAC)[1], Gheorghe GUTT[1], Andreea IANOVICI (IANOVICI IORDACHE)[1]

[1]*Faculty of Food Engineering, Stefan cel Mare University of Suceava, Romania*
sanduleacelena@yahoo.com, g.gutt@fia.usv.ro, andreea_iordache88@yahoo.com
*Corresponding author
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Abstract. *One of the main objectives of this study is to determine the optimal geometry of the probe in order to provide an advanced sensitivity of testing and also to ensure a high reproducibility of data and to establish the influence of the sample's dimensions on the analysis results of texture parameters. In the study on the modification of the texture parameters values depending on the sample dimension, the force-displacement curves were plotted for smoked cheese, which was kept refrigerated at the temperatures between 6-8°C. Regarding the type of texture profiling test the penetration test was carried on utilizing probes with different geometries and sizes, and the cheese samples were of different sizes. Six different types of penetrating devices were used: artificial finger, cone, ball, compression disk, V-knife and blunt knife. The cheese samples were cut into a parallelepiped shape with sides varying from 20 mm, 25 mm, 30 mm, 35 mm to 40 mm and different thicknesses: 7 mm, 9 mm, 11 mm, 13 mm, 15 mm, 17 mm. The samples were mechanically tested with the penetrating devices resulting force-displacement curves.*

Key words: *cheese, curve slope, force-displacement curve, sample size, sensitivity, texture*

1. Introduction

Smoked cheese belongs to the category of cheese with scalded paste made from whole cow's milk or normalized, pasteurized cow's milk by adding selected lactic cultures and rennet coagulation, based on the technological process of blanching the curd, smoking with bio hardwood resin and followed by its maturation.

Cheese texture may be defined as a composite of sensory attributes resulting from a combination of physical properties perceived by the sense of sight and touch [1]. A number of factors, both compositional and process parameters, are known to influence texture of cheese [2].

A good knowledge of textural properties is important for all the stakeholders in the food chain, for manufacturers, processing, marketing and consumers.

Texture was defined by a series of authors, but the definition given by the SR ISO 11036:2007 standard is the most representative because it best highlights the texture notion of a food product: „texture represents all mechanical, geometrical and surface properties of a food product, discernible through touch or mechanical receptors and where appropriate, through visual and auditory receptors"[13].

Many scientists, engineers and technologists have made contributions in the mechanical properties evaluation to understand the texture subjectively [4], while scientists of materials have developed rheology and fracture mechanics for understanding material properties of food products [5]. The most recent reviews, some researchers [6], [7] have examined specific issues related to food texture, including sensory and instrumental measurements.

To overcome the limitations of human sensory perception of food in terms of texture, instrumental methods were developed [8] and a great effort has been made in improving measurement tools and techniques for a significant prediction of textural properties [9], [10].

Because human sensory perception of texture largely depends on the mechanical behavior of food, which will determine the dynamics of breakdown during mastication [11], most of the objective measuring research are based on the mechanical/rheological properties of food

The types of experiments can be classified as fundamental, empirical and imitative methods [12].

Penetration test for texture determination measures the force required for a device to penetrate instrumentally a food product or a raw food material. Penetration of food products causes irreversible or reversible deformation.

Puncture tests are some of the simplest techniques for measuring the texture properties widely used [12].

One of the main objectives of this study is to determine the optimal geometry of the probe in order to provide an advanced sensitivity of testing and also to ensure a high reproductibility of data and to establish the influence of the sample’s dimensions on the analysis’ results of texture parameters.

2. Materials and methods

We took cheese samples with rectangular shape with a square base with l=20mm and different heights (7mm, 9mm, 11mm, 13mm, 15mm and 17mm).Afterwards, noting the slope of the sensitivity curve, it was chosen an optimum thickness of 15mm and it was modified the square side (cuboid base) - 25mm, 30mm, 35mm and 40mm respectively, in order to highlight the sample size influence on texture profile analysis results.

It was used the Mark 10 Texturometer, at the rate of application of 10 mm/min, a Mesur Gauge specific software for data interpretation and also a serie of other penetrating devices designed and obtained in the Food Safety Research Laboratory of Food Engineering Faculty of Suceava.

For the purpose of determining the highest sensitivity (noted with „S”) the tangent of the α angle was used corresponding to the curves of various penetrators with the abscissa (penetration depth- h) or mechanical work:

$$S = tg\,\alpha = \frac{F}{h} \quad (1)$$

$$W = \int_{0}^{F_{max}} F dh \quad (2)$$

It was used penetrating devices with various shapes and dimensions (artificial finger, ball, compression disk, cone, blunt knife and V knife) such as the following:

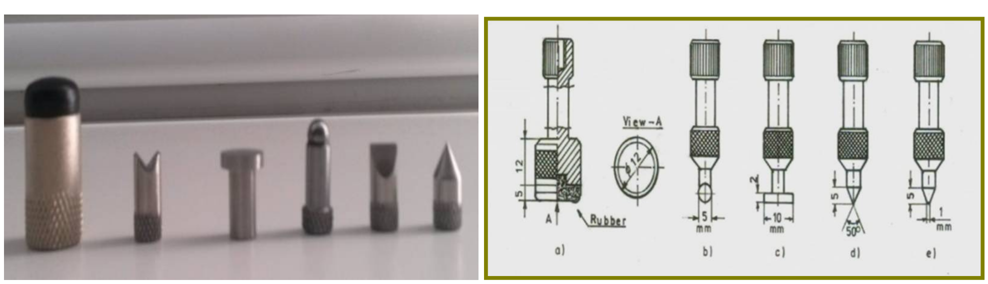

Fig. 1. Penetrating devices: a- artificial finger, b-ball, c-compression disk, d-cone, e-blunt knife, f- V knife

3. Results and discussion

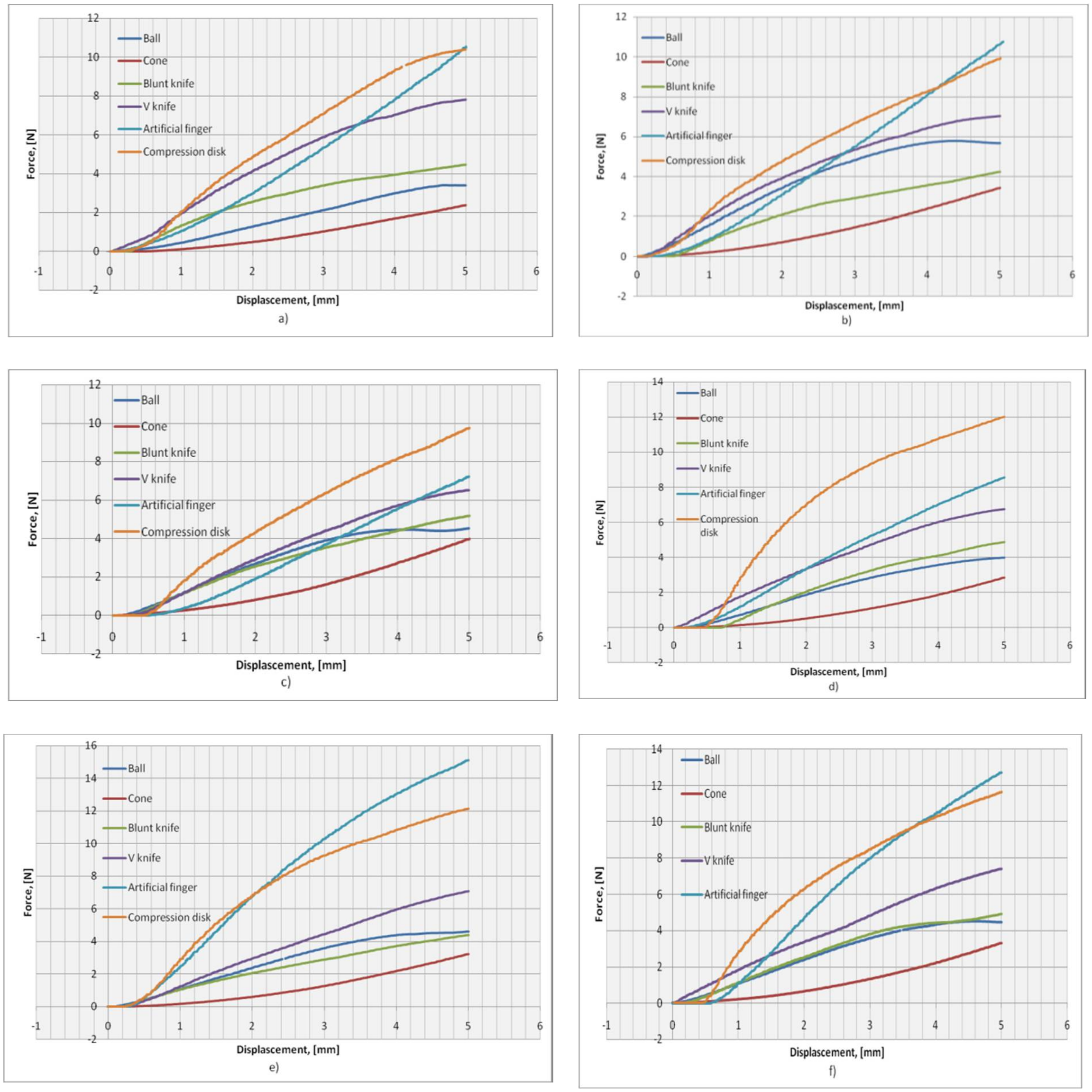

Fig. 2. Families force-penetration curves made with different samples of cheese penetrating with dimensions 20x20 mm square side and the thickness of samples to:
a) 7 mm, b) 9 mm, c) 11 mm, d) 13 mm, e) 15 mm, f)17 mm.

Figure 2 shows force-displacement curves on a penetration depth of 5 mm using various penetrating devices having different shapes: ball, cone, blunt knife, V knife, artificial finger, compression disk and the smoked cheese samples were cut into parallelipipedic shape with the square side l=20X20 mm and different thickness (7 mm, 9 mm, 11 mm, 13 mm, 15 mm, 17 mm). Force-displacement curves shows that the highest sensitivity, given by the force/displacement ratio, is when the thickness of the sample measures 15 mm.

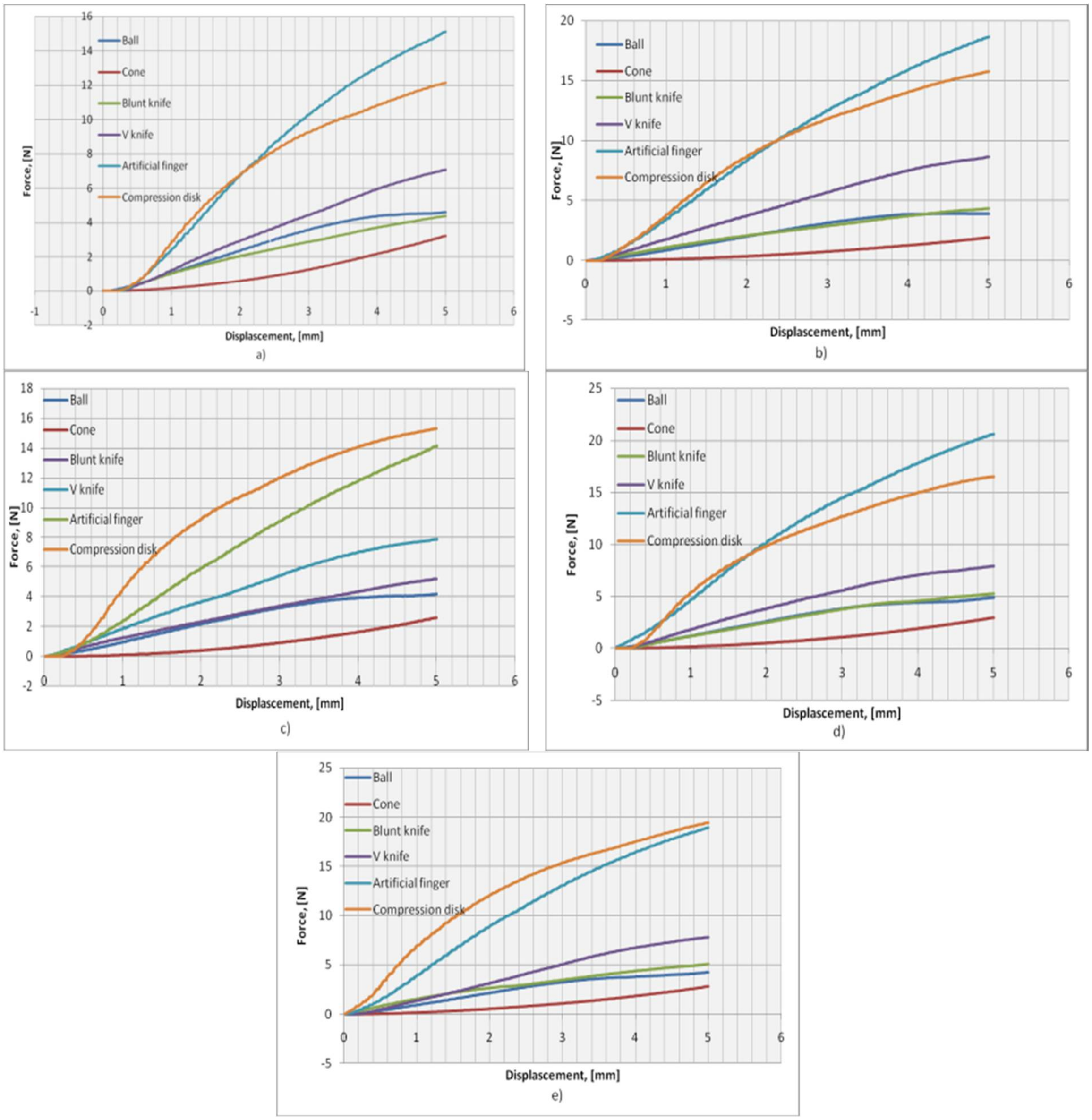

Fig. 3. Families force-penetration curves made with different penetrating the cheese samples with a thickness of 15 mm with sides: a-20 mm, b-25 mm, c-30 mm, d- 35 mm, e-40 mm

Figure 3 shows force-displacement curves on a penetration depth of 5 mm using various penetrating devices having different shapes: ball, cone, blunt knife, V knife, artificial finger, compression disk and the thickness of the smoked cheese samples was 15 mm and its sides 20 mm, 25 mm, 30 mm, 35 mm, 40 mm. The highest sensitivity is in the case of the sample with the side of 35 mm.

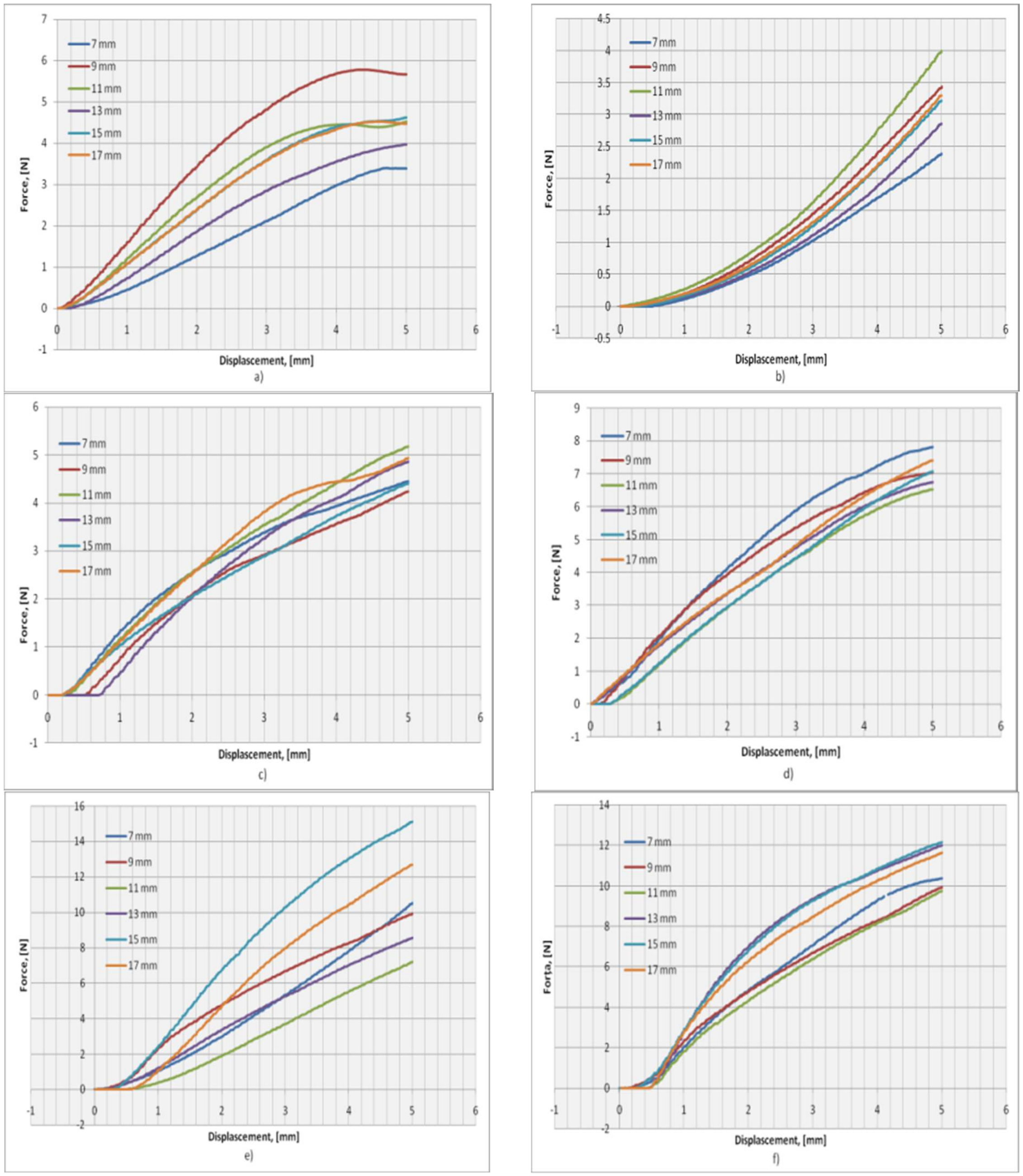

Fig. 4. Families force-displacement curve for samples with thickness of: 7 mm, 9 mm, 11 mm, 13 mm, 15 mm, 17 mm and the side of the square of 20x20 mm made with different penetrating devices: a-ball, b-cone, c-blunt knife, d- V knife, e- artificial finger, f-compression disk

Figure 4 shows the sensitivity variation of the method of textural determination properties (hardness) using the penetration method with different penetrating devices: ball, cone, blunt knife, V knife, artificial finger, compression disk. The highest sensitivity was obtained when using the artificial finger as a penetrating device.

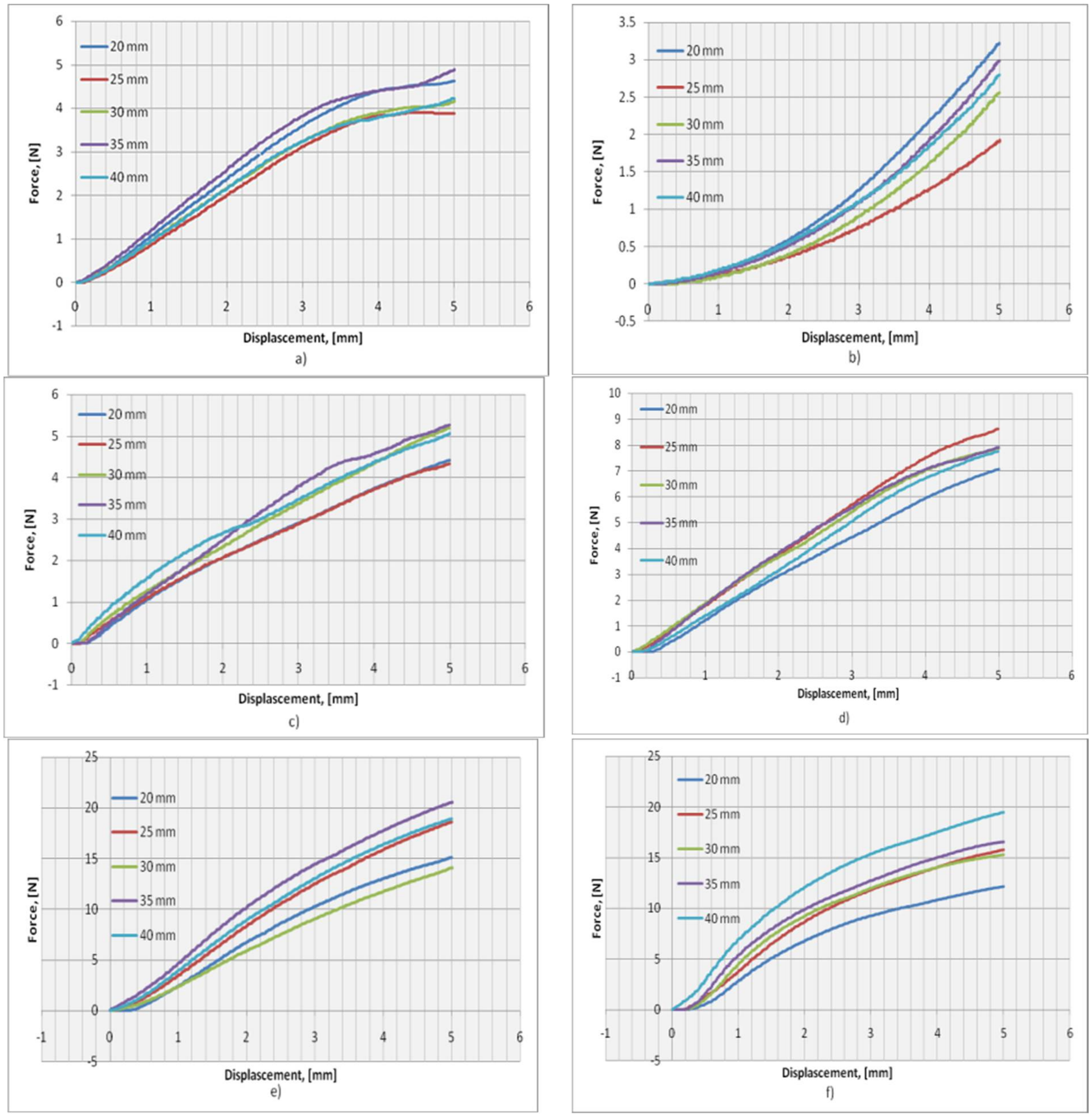

Fig. 5. Families force-displacement curve for samples of cheese with 15 mm thickness and sides of 20 mm, 25 mm, 30 mm, 35 mm, 40 mm, made with different penetrating devices: a- ball, b- cone, c- blunt knife, d- knife V, e- artificial finger, f- compression disk

Figure 5 presents the influence of the cheese sample's side size over the sensitivity variation using the penetration method with penetrating devices having different geometries. The highest sensitivity was obtained when the sample's dimensions where of 15 mm thickness and sides of 35 mm, utilizing the artificial finger as a penetrating device.

Table 1.
Mechanical work variation depending on thickness of the samples with the base remaining constant using different penetrating devices, displacement 5mm

Penetrating devices	Sample side [mm]	Sample tickness [mm]	Mechanical Work [N*mm]
Cone	20	7	11.96
		9	17.19
		11	19.99
		13	14.3
		15	16.1
		17	16.5
Blunt Knife	20	7	22.24
		9	21.23
		11	25.89
		13	24.32
		15	22.08
		17	24.65
V- Knife	20	7	39.07
		9	35.19
		11	32.62
		13	33.81
		15	35.4
		17	37.05
Artificial Finger	20	7	52.7
		9	49.7
		11	36.1
		13	42.9
		15	75.6
		17	63.5
Compression disk	20	7	51.9
		9	49.7
		11	48.8
		13	60.1
		15	60.8
		17	58.2
Ball	20	7	16.97
		9	28.36
		11	22.63
		13	19.87
		15	23.11
		17	22.32

Table 1 lists the mechanical work as integral under the curve of the load on the depth of 5mm:

$$W = \int_{0}^{F_{max}} F dh \quad (3)$$

obtained after penetrating the cheese samples having parallelepiped shape with square base and base side 20 mm. The thickness of the samples was modified and mechanical tests were conducted using penetrating devices of different shapes and geometries. It resulted that the maximum value of the mechanical work was recorded in case of the sample with 15 mm thickness and utilizing the artificial finger as a penetrating device with L=75, 6N*m.

Table 2.
Mechanical work variation depending on the sample side with thickness remaining constant using different penetrating devices, displacement 5mm

Penetrating devices	Sample tickness [mm]	Sample side [mm]	Mechanical Work [N*mm]
Cone	15	20	16.1
		25	9.6
		30	12.8
		35	14.9
		40	14
Blunt Knife	15	20	22.08
		25	21.7
		30	26
		35	26.3
		40	25.3
V- Knife	15	20	35.4
		25	43.1
		30	39.4
		35	39.5
		40	38.8
Artificial Finger	15	20	75.6
		25	93.2
		30	70.7
		35	103
		40	94.8
Compression disk	15	20	60.8
		25	78.9
		30	76.4
		35	82.6
		40	97.3
Ball	15	20	23.11
		25	19.4
		30	20.9
		35	24.5
		40	21.1

In Table 2 are registered mechanical work values obtained from tests by penetration with six different devices, changing the side of the parallelepiped and keeping the 15 mm thickness.

The maximum value of the mechanical work in this case was recorded when the artificial finger was used as a penetrator and the square side of the parallelepiped of 35 mm, L=103 N*m.

4. Conclusions

One of the criteria for choosing a certain analysis method is represented by sensitivity. The aim of this study was to establish the sensitivity of the method for determining the texture properties of smoked cheese (hardness) through the slope of force-displacement curves, on a default penetration depth of 5 mm, as well as from the values of mechanical work, which represents the area under the force-displacement curve. Sensitivity is influenced by the sample's dimensions and by the geometry of the penetrating device. By using a large number of penetrators, having various geometries and dimensions, it was possible to conduct a study on choosing the optimal type of penetrator for hard cheese food-type. Considering the experimental results, high anisotropy of cheese and also literature recommendations regarding the need for a more uniform axial distribution of charging units from mechanical testing, the most recommended penetrator for making the texture profile using the penetration method is the artificial finger and the optimal dimension of the sample is a parallelipiped with a square base having l=35 mm and height 15 mm.

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