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PORTABLE EQUIPMENT FOR ADVANCED CHARACTERIZATION OF FOOD TEXTURE FIRST PART - EQUIPMENT

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Abstract: *The main objective of the paper is the harmonization of instrumental testings of food texture with methods of human sensory analysis as they are defined and described in reference standard ISO 11036. Lack of dual standardized system of advanced food texture characterization in admission of instrumental methods and means besides human sensory methods of characterization and the impossibility of numerical quantifying, with high-resolution of human perceptions, subjective assessment of texture characteristics and low reproducibility of testing, makes human sensory tests remain far behind those of texture establishing. The paper presents a concept of multifunctional electronic equipment, with force and displacement sensors and complex devices for an advanced characterization of food texture.*

Key words: *texturometer, modular electronic device, force sensor, displacement sensor*

1. Introduction

ISO 11036 standard [1] and ISO 5492, [2] define texture of solid and semi-solid food as all the mechanical, geometrical and surface properties of product, perceptible by touch or mechanic receptors, visual and auditory, where it is appropriate. According to this reference standard properties that can be received tactile or by mechanical receptors are reactions of tested material to a certain type of mechanical load being divided into primary characteristics such as: hardness, cohesion, viscosity, elasticity and adhesiveness and secondary characteristics such as fracturability, chewiness, gumminess.

Currently, in establishing the texture of raw material or finished food product are contributing more the objective interpretation, automated of their response to various mechanical loads exerted on them by instrumental way than subjective interpretation, human sensorial of their response to mechanical tests, [3],[4],[5],[6].

Using advanced instrumental analysis of food texture conclusions can be drawn on elastic, plastic, visco-plastic behavior, tensile strength, state crunchy, brittle state, pasty state, state creamy gelatinous state, state of grain, condition of fiber, toughness, extrusion capacity, thereof, [7],[8],[9],[10],[13]. Also by the texture instrumentally measured, it can be appreciated fruit ripeness, deadline for

storage of fruits and vegetables, level of cheeses [12] and meat products maturation, level of dryness, doneness of bakery and pastry.

2. Materials and Methods

The current situation regarding the establishment of texture and textural state characterization of solid and semi-solid foods

2.1 An example of establishing texture on the way of human sensory

Currently, for food texture characterization based on primary and secondary parameters are used by assessors, in most cases, reference scales described in detail by ISO 11036, [1]. The disadvantage of this system of characterization consists of its subjectivity and in extreme low resolution quantification of intermediate state between two graduations of the assessment panel. These two drawbacks are added to the impossibility of acquisition and automatic data processing. For example: Annex A1 of reference standard ISO 11036/2007 provides for the assessment of food hardness a scale of increasing hardness with numbers from 1 to 9 for as many specific foods. On this scale, the hardness value of 1 is assigned to cream cheese and 9 value to candies. Between these extremes are foods such as egg white with value 2, cheese with value 4, nuts value 6, etc.

The situation is somewhat similar to the beginning of the last century when it was used to estimate the hardness of materials a hardness scale of minerals after Mohs with 10 units, hardness value 1 is assigned to talc and value 10 to diamond.

Currently, there are a variety of means for advanced hardness testing of metallic and nonmetallic materials and accurate numerical expression, high resolution, of this property. Probably a close route will be covered and by the instrumental equipment of measurement and quantification the structural parameter of hardness characterizing the food texture.

Example above only refers to one of the five primary texture parameters, namely hardness. For all other primary parameters situation of appreciation on human sensory way of texture is similar in terms of subjectivity and reproducibility of the assessment of food hardness.

2.2 Establishment of texture on instrumental sensory way

Characterization of texture by mechanical instrumental testings and their automated interpretation of electronic sensory response is achieved at present by two types of equipment. The firsts are mechanical testing machines, loading motorized with small task, equipped with force sensors and displacement sensors, texture of food being defined by different characteristic sizes that are determined or calculated from characteristic curves of type force - displacement obtained by electronic processing of values supplied by the force sensor and the displacement sensor.

In the market, this type of equipments are actually classic machines for materials testing with low loads, from current production machinery of manufacturing companies for testing materials, equipped with various specific devices such as: platters, pliers, knives, penetraters, hooks for covering a diverse and specific issue of food texture determination.

With these testing machines and adaptation of specific devices it provides a wide range of mechanical tests such as: compression, tensile, crushing, bending, shearing, twisting and penetration. Automatic interpretation of the response of the two sensors allows a quite advanced texture characterization of a large raw materials and food products variety under different conditions.

The second type of equipment is represented by automatic systems that determine visco-elastic or visco-plastic properties by measurement of parameters such as: resistive shear modulus, rotary element speed variation of a specific geometry immersed in the food investigated, changing of electric current power supply for a motor that drives a rotatable element of specific geometry submerged in the tested food.

3. Results and Discussion

Portable universal equipment for mechanical testing of food and electronic sensorial measuring of its texture response

The equipment described above are laboratory equipment with complicated structure and kinematics, they also means bringing food to device and not device to food. These facts are also the main disadvantage of these equipments for testing and characterization food texture. Another disadvantage is the cost of the laboratory equipment for food texture analysis, price being situated in the tens of thousands euro / unit. The problem solved by the equipment described in the paper is to provide a portable and universal electronic structure which allows a wide range of mechanical tests such as: compression, bending, shearing, penetration, carried out on raw materials in the field of vegetables and fruits, meat and sausages, hard cheese, bakery and pastries products, all these tests using to the definition of food texture and to obtain numerical values expressing resistance of food tested to different types of mechanical tests. Also, using the equipment described by authors solve the problem of interpretation, harmonization and correlation of resistance characteristics of foods tested with international standard reference on human sensorial analysis of food texture. On the portable test equipment conceived, designed and built by team of authors represented in Figure 1, Figure 2 and Figure 3, can be fitted by simple operations, in a few seconds, six different devices used for determining food texture according to ISO 11.036/2007 [1] but also for advanced characterization of food behavior to other types of mechanical testing than those stipulated in the standard. These devices will be presented in the second part of the paper entitled: Specific devices

From a functional viewpoint the portable device has a kinematic of loading and unloading carried out with a manual drive screw - nut and two parallel jaws that at nut rotation towards the right mechanically load the test food and at nut rotation to the left download it mechanically, lower mobile jaw of the device being equipped with an electronic displacement sensor, and fixed upper jaw with a power electronic sensor. Food texture assessment is done by interpreting the values that compose force-displacement characteristic curves or force-penetration depth curves obtained by mechanical testings of food with equipment designed by the authors and equipped with specific devices. The results are automatically displayed in a calculation unit which is connected with electronic

unit measuring of force applied and measurement of food deformation or appropriate of depth penetration of a penetrator in it.

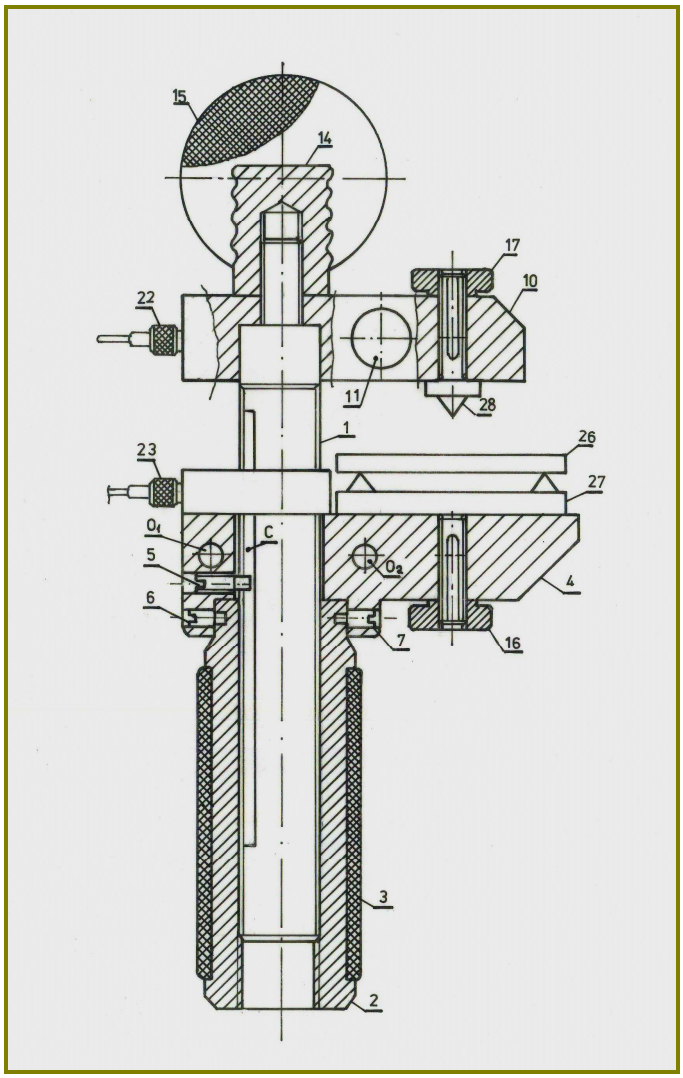

Figure 1. Cross-section on side view of the portable device for determining the texture of food and advanced characterization of their behavior to the mechanical testings. 1-screw, 2-nut, 3-liner rubber, 4-lower jaw, 5,6,7,8-screws, 9-displacement sensor, 10-upper jaw, 11-electronic dynamometric cell, 14-nut, 15-spherical rubber body, 16,17-knurled screws, C-guiding channel, O_1. O_2-holes, [11]

Constructively portable device consists of a screw 1 provided with a guide channel C, a nut 2, a rubber jacket 3, a lower jaw 4 provided with four screws 5,6,7 and 8, two holes O_1 and O_2 and an incremental position sensor 9, upper jaw 10, an electronic dynamometric cell 11, two guide screws 12 and 13, a nut 14 on which is molded a spherical body rubber 15, two knurled screws 16 and 17 for mounting specific test devices, two knurled screws 18 and 19 for mounting on a metal

stand 20 provided with four rubber supports 21, two electrical connectors 22 and 23, an electronic unit 24, and a computing unit 25.

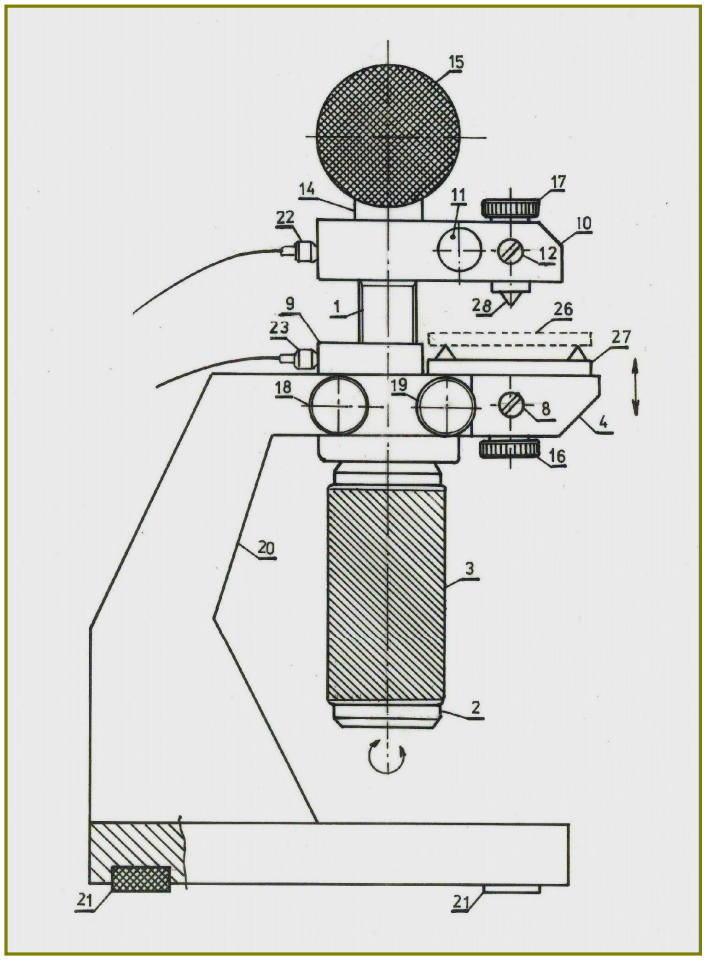

Figure 2. Side view of apparatus for determining food texture and advanced characterization of their behavior to mechanical tests and laboratory version with supporting apparatus stand: 1-screw, 2-nut, 3-liner rubber, 4-lower jaw, 8.12-guide screws 9-displacement sensor, 10-upper jaw, 11-electronic dynamometric cell, 14-nut, 15-spherical body rubber, 16,17,18,19- knurled screws, 20-metallic stand, 21-rubber supports, 22.23-electrical connectors, [11]

On the two jaws of equipment can be fitted by a simple operation of clamping with a knurled nut different testing specific devices for determining a wide range of texture characteristics such as: elasticity, adhesion, fracturability, mastication and a number of mechanical characteristics such as compressive strength, resistance to crushing, bending behavior and resistance to bending, shear resistance, viscoelastic behavior, visco-plastic behavior and resistance to extrusion, characteristics whose values are important in the processing, transportation, storage and sale of food. To work rapidly in series the device according to the invention can be

easily vertically mounted with two screws on a solid metallic table stand.

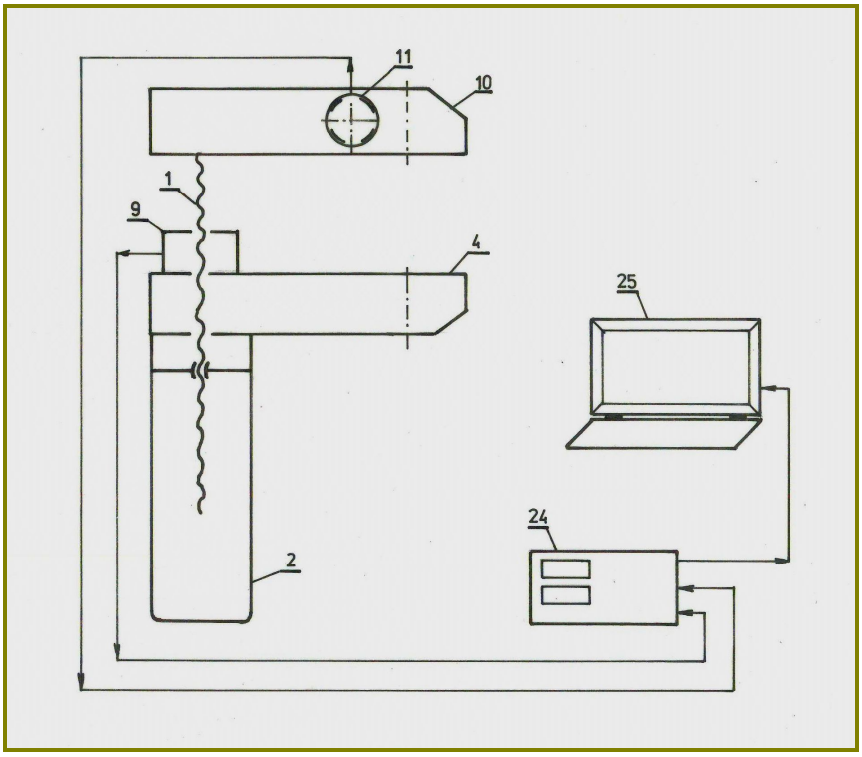

Figure 3. Schematic diagram and kinematic of device for determining food texture and advanced characterization of their mechanical behavior. 1-screw, 2-nut, 4-lower jaw, 9-displacement sensor, 10-upper jaw, 11-electronic dynamometric cell, 24-electronic unit, 25-computing unit, [11]

On the two jaws of the device can be mounted by a simple operation of clamping with a knurled nut various specific devices, for determining a wide range of texture characteristics.

4. Conclusions

Texture tests on instrumental way and automatic interpretation of solid and semisolid food response to specific mechanical stress is now a performant means of objective interpreting with high resolution and reproducibility. Using a portable electronic device of the type described in the paper allows in situ texture tests for a wide range of raw materials and foods allowing the determination and interpretation of primary and secondary parameters of texture.

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