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QUALITY IMPROVEMENT FOR THE PRODUCT "GINGERBREAD", IDENTIFICATION OF THE OPTIMUM NUMBER OF TEXTURE MEASUREMENTS AND COMPRESSION INTENSITY IN LABORATORY ANALYSIS

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Abstract

The texture analysis of gingerbread, a bakery product based on flour and many other ingredients, which vary according to its area of origin, within the plant's laboratory, contributes to the improvement of the product quality. In terms of efficiency and effectiveness, the results obtained recommend the minimum number of texture measurement tests needed to be performed, as well as the sample compression rate, in order to obtain relevant results. A TexVol TVT-300XP/XPH texture meter, manufactured by the company Perten Instruments, Sweden, was used, equipped with a 15 kg load cell. The tests were performed using the spherical tip penetration device, with a sphere having a 1-inch diameter, to imitate the mode in which the gingerbread cookies are tested by thumb pressing. To determine the minimum number of texture tests at the level of the laboratory, the two-cycle testing protocol was employed, and, to determine the compression rate, the one-cycle protocol was used. A conclusion was drawn, monitoring hardness, sample deformation energy, cohesiveness, and springiness. The results obtained with regard to the product "gingerbread" can be used in drawing up the work protocol for texture analysis within the plan laboratories which analyse the product "gingerbread".

Key words*: *gingerbread, hardness, deformation energy, cohesiveness, springiness

INTRODUCTION

Lawless and Heymann define texture as "all the rheological and structural (geometric and surface) attributes of the product perceptible by means of mechanical, tactile, and where appropriate, visual and auditory receptors" [7].
This definition emphasizes the strong connection with human perception, using the senses. Sensory characteristics, among which those related to texture, have become very important for the perception of a product by the consumers, and any products which do not meet these requirements and expectations, regardless of their nutritional quality, will not be accepted and will not be successful products. One such example is the one described by Rosenthal A.J., in which the food products specially conceived to provide the nutritional principles needed by American soldiers during World War II were ill-received and caused much discontent [9]. New terms were defined for sensory analysis. One in-depth study on the sensory perception of texture was conducted by Foegeding et all [3]. As part of sensory analysis, texture analysis also became important when it was understood that the perception of food from a hedonistic viewpoint does not only refer to aspect, smell, and taste.
A multitude of specific tests and instruments were elaborated. Whether or not they stood the test of time is due to the mode in which these tests can be corelated with sensory perception. Numerous scientific works aim to explain sensory perception and to discover the mechanical aspects of sensory analysis, as well as to identify the parallels with the texture, which is assessment instrumental in view of elaborating the most accurate tests possible, as close as possible to the consumer's perception [4],[5],[6].
From a statistical viewpoint, the greatest possible number of experiments is needed, to make sure that their average describes the

experiment in the most accurate way, but this is not economical, in terms of materials, as well as in terms of the time awarded for the experiments. Further on we will identify the optimum number of texture measurements regarding the quality parameters which characterize the product "gingerbread", as well as the intensity of compression, which need to be used in the laboratory, in view of attaining control along the flow, as well as in view of continuously improving the product, an essential management principle to be followed in the food industry, in order to obtain competitive products.

MATERIALS AND METHODS

To manufacture gingerbread, the raw materials (Table 1) used in industrial manufacturing were employed, as well. The leavening acid, sodium acid pyrophosphate (SAPP) is an important component of double acting baking powder as well as self-rising flour. SAPP reacts in stages and is desirable in baking applications for its slow action [1].

Table 1. Gingerbread manufacturing recipe

No.	Raw material	Quantity, g
1	TOTAL FLOURS	258.07
2	Sodium bicarbonate	3.41
3	Ammonium bicarbonate	1.68
0	SAPP 28	1.68
4	Clove	0.91
5	Cinnamon	3.70
6	Salt	0.82
7	Lecithin	1.73
8	Plant oil	17.30
9	Sorbitol	13.94
10	Glycerine	2.31
11	Honey	9.13
12	Inverted sugar syrup	137.44
13	Caramel	27.87
	TOTAL	**480.00**

Source: Original.

For texture tests, the TexVol TVT-300XP/XPH texture meter manufactured by the company Perten Instruments, Sweden, was used. The instrument was equipped with a 15 kg load cell.

The test device used for both studies was the one with spherical point penetration, with a 1-inch sphere diameter. The device was used to imitate the mode in which gingerbread is tested by thumb pressing, with the sphere imitating the human thumb in shape and size; the relatively large size of the sphere and the limited compression of the product made the mechanical deterioration of the product to be limited [8], [10]. For this reason, a test containing two compression cycles was selected for the study of the optimal number of determinations. The device's circulation speed was of 10 mm/s, the recession speed 10 mm/s, the compression distance 30% of the height, the period of recovery between the two successive tests 10 seconds. This test was defined by several researchers using compression tests and they bear the generic name of Texture Profile Analysis [2]. A number of 16 mechanical tests were performed on 16 pieces of gingerbread with a glazing made of sugar, gelatine, and titanium dioxide, and on a second assortment, which also includes surface decoration with surrogate chocolate sprinkles.

As the purpose of the second experiment was to determine only the compression distance, the testing protocol with a single testing cycle was used.

The 1 inch-diameter ball device was used in the experiment. The speed of the testing device was of 1 mm/s. Industrially manufactured gingerbread was used, prepared according to the same recipe. Some were simple (coded TD), others were coated in glaze (TDG), whereas the last ones were glazed and decorated with surrogate chocolate sprinkles (TDGS). The movement of the device into the product was set at 25, 30 40,50, 60, and respectively 70% of the product height. Each test was conducted on 8 samples.

RESULTS AND DISCUSSIONS

These gingerbread assortments, with glazing, respectively with glazing and surrogate chocolate sprinkles, were selected because the glazing, and in particular surrogate chocolate sprinkles, are quite significantly variable in terms of thickness, which caused the samples to be non-homogeneous from the point of view of structure and texture. The samples were subject to a testing regime consisting of two successive compressions, of 30% from the height of the samples 3, 4 to 16 tests were randomly selected. The average was calculated, as well as the standard deviation of samples (STD%). The texture characteristics defined for this type of determinations are very numerous. We selected hardness as a force needed to achieve deformation, deformation energy (Area 4) as the surface below the curve, cohesiveness as a ratio between two surfaces contained between the two tests, and springiness as a ratio between the routes covered by the test device to achieve the compression indicated in the two cycles. The variation of these statistical indicators, depending on the number of tests conducted for assessment, is presented in Figures 1, 2, 3 and 4.

Upon analysing the graphs, we note a wider variety of statistical parameters when the number of tests performed is reduced, which is statistically normal. For a better appreciation of the size of standard deviation, it was expressed as a percentage as compared to the arithmetic mean of the measured value. In the case of these measurements, we can note that the reliability interval (standard deviation) in which 95% of the measured values are found, is quite large for this product.

Only for product cohesion, the standard deviation will have values representing 10% of the measured average.

For mechanical work, hardness, and springiness, the standard deviation also has values close to 25% of the average measured values.

The high value of the standard deviation indicates a non-homogeneity of the samples or the presence of measuring errors, whatever they may be. From the analysis of the data, we note that the average measured size has a rather low variability, and we see it stabilizing if 6 or more samples are taken into account.

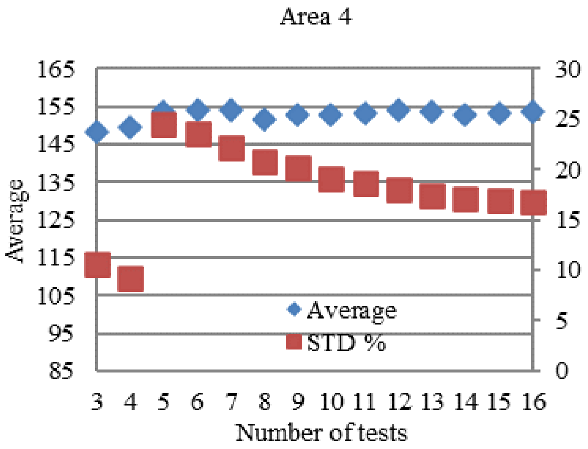

Fig. 1. Variation of deformation energy (Area 4) according to the number of tests
Source: Own results in the laboratory.

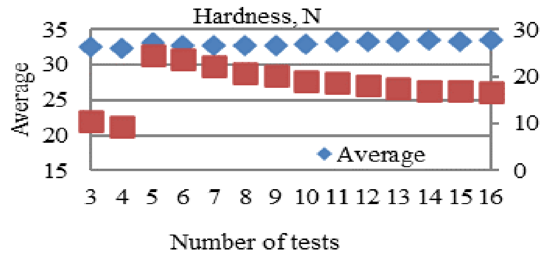

Fig. 2. Variation of hardness according to the number of tests
Source: Own results in the laboratory.

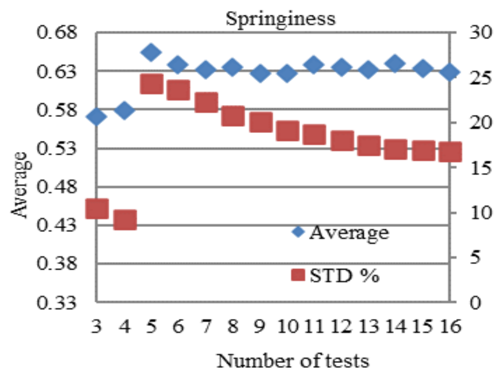

Fig. 3. Variation of springiness according to the number of tests
Source: Own results in the laboratory.

Apart from the optimum number of determinations, another parameter which is just as important is the penetration depth of the test device. An experiment was performed, determining the optimum testing regime, more specifically the optimum depth for the penetration of the test device.

The experiment monitored the mode in which certain texture parameters varied in relation to product compression.

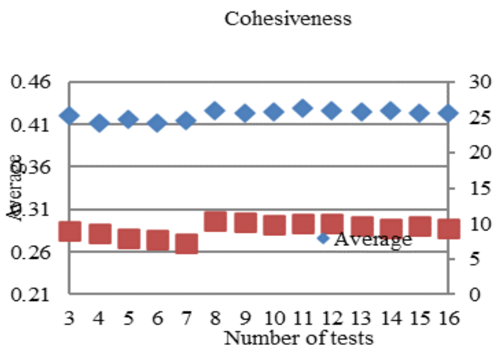

Fig. 4. Variation of cohesiveness according to the number of tests
Source: Own results in the laboratory

In order to identify the compression distance for the sample, several texture measurement parameters were evaluated: hardness, springiness, and mechanical work. We considered these parameters to be representative, and they are sufficient for the product's characterization in terms of texture. Other texture parameters are derived from these, and they were not relevant for the determination. Hardness represents the force registered upon performing the fixed deformation. In the case of this test, this force is identical with the maximum force registered during compression, which indicates that the product did not lose its integrity during testing. The mechanical work is provided by the test device software, in the form of a surface, namely the surface between the curve which represents the variation of the deformation force and the axis along which the distance covered during deformation is registered. As the product of displacement and force is mechanically defined as mechanical work or energy, this value can be associated to the mechanical work needed to distort the product. Springiness refers to a material's capacity to revert to its initial form after deformation. In terms of texture, in the case of this type of testing, springiness is defined as the ratio between the area below the graph upon withdrawing the test device and the area below the graph upon compressing the product.

In Figures 5, 6 and 7, the variation of these textural characteristics is presented.
The fact is noticed that the texture parameters hardness and surface have a similar variation, and springiness presents a different variation model.

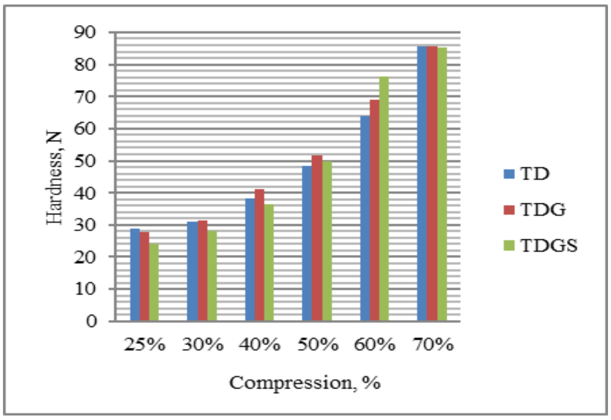

Fig. 5. Variation of gingerbread hardness according to compression distance
Source: Own results in the laboratory.
Note:TD=Simple gingerbread
TDG=Gingerbread coated in glaze
TDGS=Gingerbread glazed and decorated with surrogate chocolate sprinkles

The hardness and surface of the graph saw a continual increase upon compression, the increase being more emphazized as the compression was more intense. Conversely, springiness remained constant, and only on very high deformation values (70%) does it see major growth.
The interpretation is difficult, and it involves the careful monitoring of the variation model for these values. Both hardness, and the surface of the curve saw small variations, up to a 30% distortion, and then they increased.

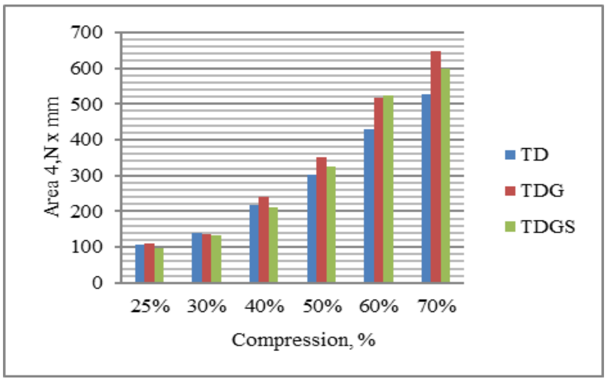

Fig. 6. Variation of gingerbread compression energy in relation to compression distance
Source: Own results in the laboratory.

Note:TD=Simple gingerbread
TDG=Gingerbread coated in glaze
TDGS=Gingerbread glazed and decorated with surrogate chocolate sprinkles

When performing large distortions, the entire sample material was caught under the pressing device and it resisted the advancement of the sample. For small distortions, there was also a lateral slippage, due to the device's spherical shape.

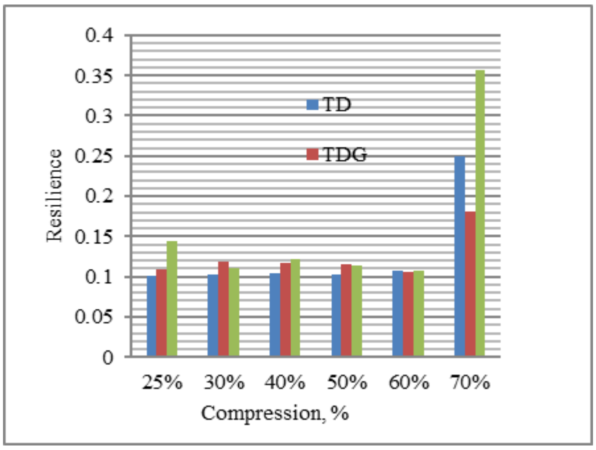

Fig. 7. Variation of gingerbread springiness in relation to compression distance
Source: Own results in the laboratory.
Note:TD=Simple gingerbread
TDG=Gingerbread coated in glaze
TDGS=Gingerbread glazed and decorated with surrogate chocolate sprinkles

Sample springiness varies very little in proportion to the size of the distortion. Springiness, as a ratio of the surfaces delimited by the curves traced upon withdrawal and insertion of the testing device, has low values, of approximately 0.1, up to a 60% compression.

On higher compression, the material was caught between the device and the sample worktop, and upon recovery, it pushed the device with greater energy. In this case, the material changed its behaviour and measurement errors occurred.

CONCLUSIONS

Following this test, we appreciate that the minimum number of tests recommended to be run is 6, in order to obtain representative results.

A 30% compression provides a compression level similar to the one achieved by people at the time of consumption, the material does not undergo major internal fractures, and the displacement of the device is reproducible.

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