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CONTRIBUTIONS TO A NEW METHOD FOR DETERMINING FOOD GUMMINESS

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Abstract: *The paper presents a method and a technique for measuring food gumminess determined on instrumental sensory way versus this texture property determined by human sensory. This purpose it is conducted a comparative study between the values obtained according to SR ISO 11036/2007, with gumminess values defined on the electronic sensorial way. The researches made possible the realization of a conversion curve that allows the transition from gumminess units measured electronic instrumental, under conditions of high reproducibility, to classical gumminess units determined by a panel of 5 points. A test for assessing the gumminess, performed with a total of seventeen volunteers, strongly emphasized the subjective nature of gumminess assessment on human sensory way. In this regard it has been observed a significant influence of the color on the test, modified with high purity beta carotene and its taste, modified with commercial vanilla.*

Key words: Texture Profile Analysis, Gumminess, Resistive torque moment

1. Introduction.

Food texture issues and secondary parameter of gumminess

Texture of food represents all geometrical, mechanical and surface properties of a product perceptible by touch or mechanics receptors and where appropriate, visual and auditory [1]. In turn, mechanical properties of semisolid or solid foods can be divided into five types of primary parameters and four secondary parameters [2] as follows:
Primary parameters are: hardness, cohesion, viscosity, elasticity, adhesion. Secondary parameters are: fracturability, masticability, number of mastication, gumminess. Given that instrumental sensory measurement is more performant that human sensorial assessment of primary and secondary parameters of texture, in terms of sensitivity, detection limit and precision, current trend is an advanced replacing of human assessments by more precise measurements made with electronic sensory equipment [3], [4], [5], [6].
This problematic concerns a team from the Faculty of Food Engineering of Suceava, already existing notable achievements in the promotion of modern equipment for the sensorial- electronic assessment of several primary and secondary parameters of food texture [7], [8].
In terms of secondary parameter of the texture, the gumminess, this is defined [1] as a property related to the primary parameters for hardness and cohesion of

semisolid food when their hardness is reduced.

Food gumminess appreciation is by the effort required for decay of product inside the mouth before swallowing in a proper state. For this purpose the sample is placed in the mouth and tongue pressing the palate, human sensorial evaluated by force necessary for its disintegration. Selectivity to determine gumminess is provided by a given reference scale in Table 1, [1]

Table 1.

Gumminess reference scale [1]

Popular terms	Score Annotation	Reference product	Sample size	Temperature
Mild intensity gumming	1	40% mixture of flour with water	1 spoon	room
	2	45% mixture of flour with water		
	3	50% mixture of flour with water		
High intensity gumming	4	55% mixture of flour with water		
	5	60% mixture of flour with water		

The analysis on this way of gumminess assessment has the following disadvantages:

- Evaluation score on human sensory way contains only 5 outs units leading to poor selectivity of method;
- Gumminess assessment by an human assessor lead to subjective errors amplified by the fact that for calibration is used flour of different types;
- Chewing a dough of flour and water by the taster-assessor to establish the gumminess score, does not give accurate results and expected values as more than the appraisal score overlap with primary texture parameter values;
- Cohesion, viscosity, elasticity, adhesion, and untextured taste parameter, all these parameters being simultaneously present in the dough;

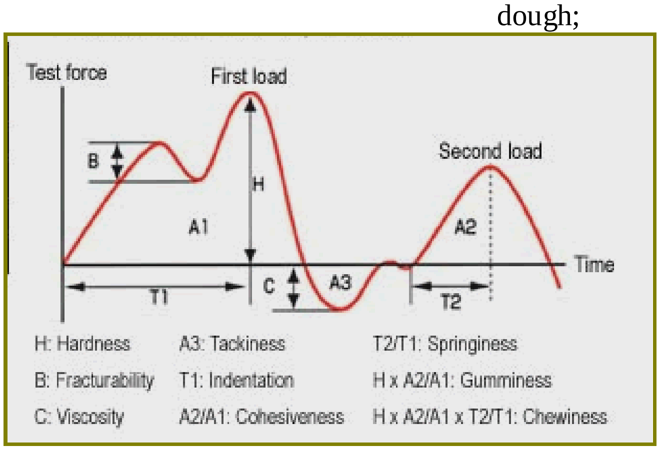


Fig. 1. Identification and quantification elements of primary and secondary parameters of texture profile analysis (TPA) performed in coordinates force - time [9]

Since the instrumental measuring is more performant in terms of sensitivity and detection limit than human assessment of primary and secondary parameters of texture, but also because the first is objective, ensuring a high reproducibility of determinations, the current trend is to replace as more advanced human evaluations with instrumental means of measurements. In this respect, an important step was made by determining gumminess value from the texture profile analysis (TPA), represented in coordinates force F - time t [3], [4], [5], [6], Figure 1. Within TPA, gumminess G is defined as the product of hardness H and the ratio of the area A2 of the surface under the curve of the second stage of deformation and the area A1 of the surface under the curve of the first cycle of deformation.

This mode of expression leads to errors of quantification and inappropriate expressions of gumminess value in physical units. For example, the use of TPA in coordinates force - time leads to the following nonsense, at least in terms of gumminess quantification and expression in physical units:

$$G = H \cdot \frac{A_2}{A_1} = H \cdot \frac{\int_0^{t_1} F \cdot dt}{\int_{t_2}^{t_3} F \cdot dt} \quad (1)$$

which in physical units of expression leads to next dimensional formula:

$$[G] = [N] \cdot \frac{[F] \cdot [s]}{[F] \cdot [s]} = [N] \quad (2)$$

It is obvious that gumminess can not be expressed in physical units Newtons. Besides the disadvantages of replacing human sensory assessment [1] by instrumental methods [9], [10], [11] and the latter aspect notified under TPA [12], [13], [14] is also a reason for seeking new solutions in order to express accurately the gumminess as secondary parameter of texture. Poor sensitivity and human subjectivity of appreciation and also shortcomings of instrumental sensory determination, based on TPA, of food gumminess were the basis of authors motivation for conducting experimental research from this paper.

It started from the consideration that gumminess is actually an expression of the viscoelastic behavior of semisolid foods and as such may be determined by specific rheological means such as for example resistive measuring of mechanical resistive moment of a special propeller submerged in food tested or measuring the change in rotation of propeller, at constant active mechanical moment for its rotation.

2. Method and procedure for advanced characterization of food texture

In developing the method and procedure for determining semisolid food gumminess, the team of authors considered the definition of gumminess by standard reference [1], namely that it is a property related to primary parameters of hardness and cohesion of semisolid food when their hardness is reduced. We also considered that it is difficult for a food taster to assign values located in a score between 1 and 5 to a tested food, after he chewed in the mouth five different consistency dough, see Tab.1. It was also considered that the method and recommended procedure to allow automatic electronic measurement of gumminess values and that determinations to provide a resolution of reading and a high reproducibility of measurements and the fact that these instrumental measurements can be converted with a curve conversion in gumminess units, defined by the standard of reference [1].

For gumminess measuring it was used an experimental stand, Figure 2, which comprises an especially stirrer with propeller speed automatically adjusted on electronic way so that regardless of resistive opposite of tested food, propeller speed does not deviate from setpoint.

Gumminess of tested food is expressed by the resistive moment value of mixing propeller, measured with a torque cell with resistive sensors at a certain speed of propeller, digital display on alphanumeric display of the mixer.

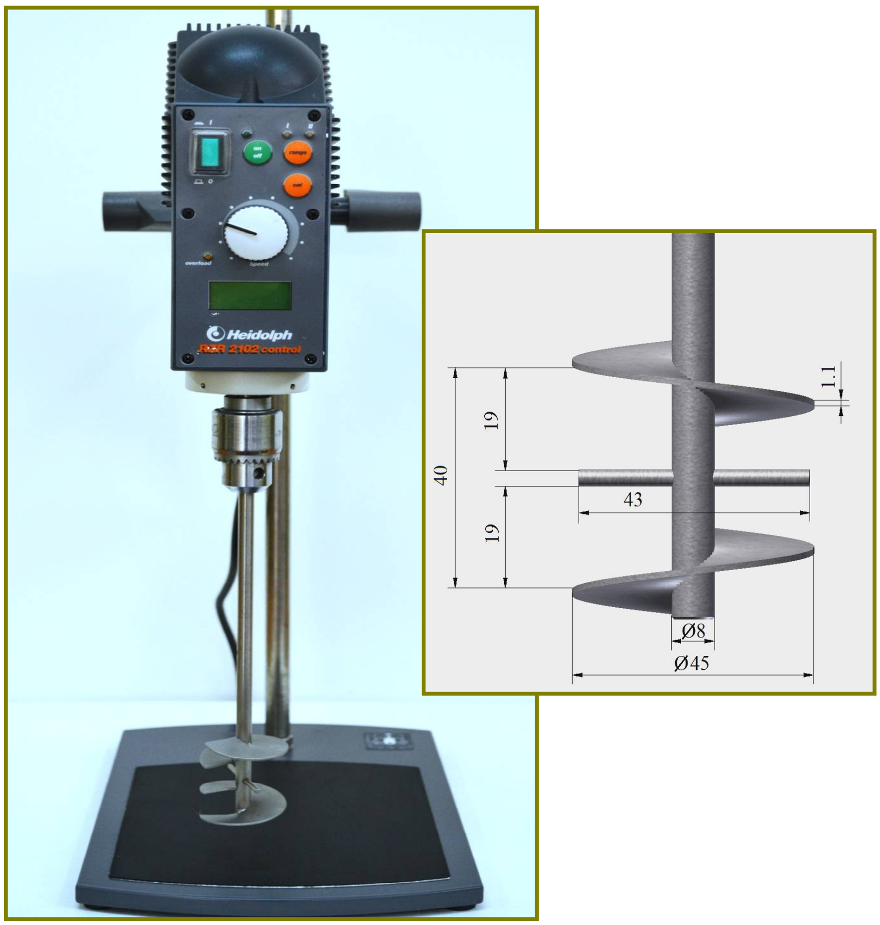
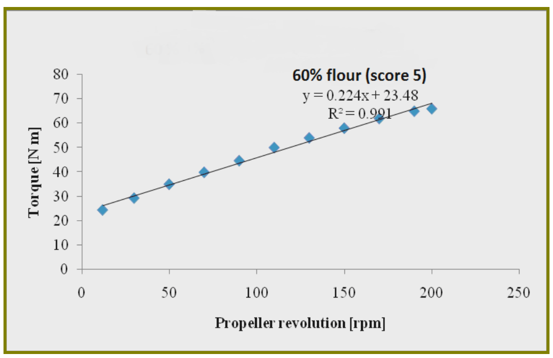


Fig.2. Schematic diagram of the experimental stand used for determining gumminess of semisolid food and view of the propeller used in experimental research.

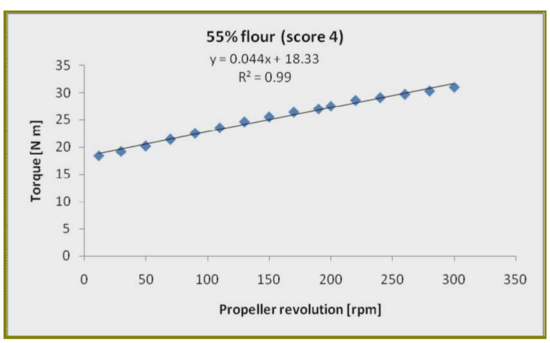
Propeller used for mixing is a particularly type, with two opposed turns, allowing the movement of food during one rotation of turns with one of the turns from the bottom up and top down with another so as to achieve an effect as close to the mastication a semisolid foods in the mouth.

3. Experimental for method and procedure validation and advanced characterization of food texture and achievement of conversion curve

The stand described was used for experimental research and propeller with turns in opposite of Figure 2 and samples of white wheat flour weighing 100 g, type 3 000, each reference sample having different concentrations of flour (different values of the evaluation score) as Tab.1. Measurements of resistive torque moment were performed at different speeds of propeller, Figure 2, a, b, c, d, e and linear regression equations were determined, correlation factor R values ranging between 0.97% and 0 , 99%.



a)



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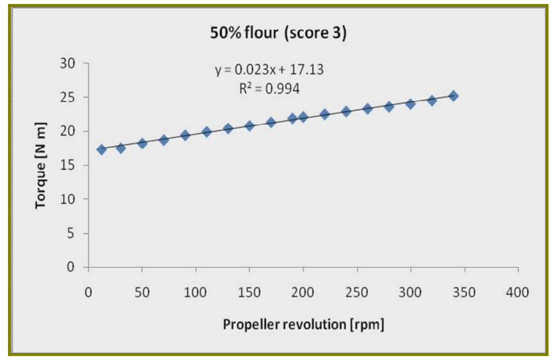

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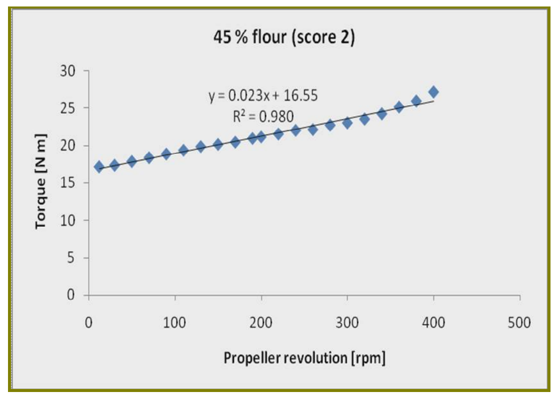

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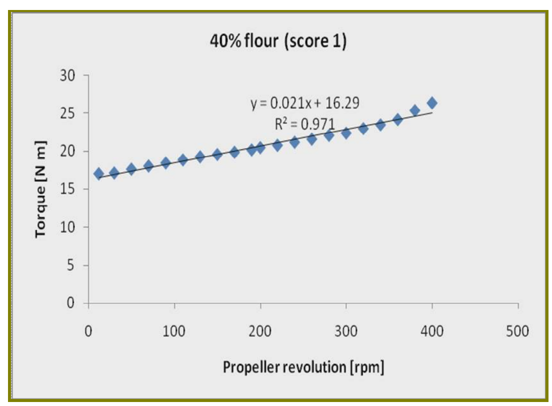

e)

Fig.3. Representation of resistive moment evolution according to the speed at different concentrations of flour [1] and Tab.1. a. concentration of 60% flour, b-concentration of 55% flour, c- concentration of 50% flour, d-concentration of 45%, e- concentration of 40% flour.

In Figure 4 is shown the cumulative representation of resistive moment evolution depending on speed at different concentrations of flour - water according to [1]. On the graphical representation is highlighted a speed of 150 rpm. This speed was chosen as representative on the one hand all the time dependencies resistive moment- speed are linear to this value, on the other hand, choosing a lower speed that value would have a less reading resolution of resistive moment, while choosing a higher value would not have been possible only up to max speed. 200 rpm., because the sample with the highest concentration of flour (60%) over this speed dough separates from cylindrical glass vessel and rotates with the propeller.

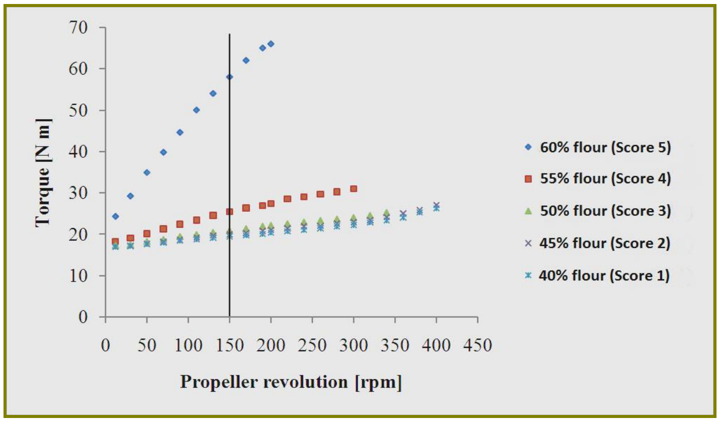

Fig.4. Graphic cumulative representation of resistive moment evolution depending on the speed at different concentrations of flour-water according to [1] and tab.2. highlighting resistive moment at 150 rpm

It also watched as the evolution of stirring and flour hydration in time can lead to changes in resistive moment. Testing was carried out with flour concentration of 50% (score3) obtaining the distribution in Figure 5 of linear type, regression equation presenting a correlation coefficient of 0.99 which shows a good constant of mechanical resistive moment.

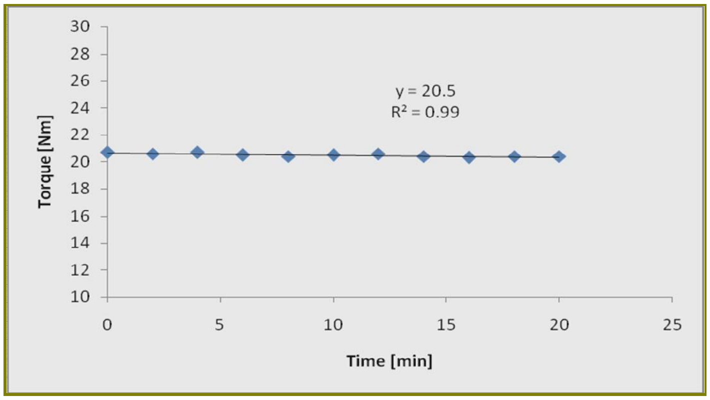

Fig.5. Variation in time of resistive moment of dough with 50% flour and 150 rpm of propeller stirrer.

The values of resistance moment read at speed of 150 rpm, for different degrees of gumminess, according with reference standard [1] which are based on different concentrations of flour (Tab.1.), was performed resistive time conversion curve – score of gumminess in Figure 6, with mathematical model describing a type polynomial equation with expression:

$$Y=2.308X^3 - 15.93X^2 + 33.66X-0.82 \quad (3)$$

and correlation factor R equal to 0.994.

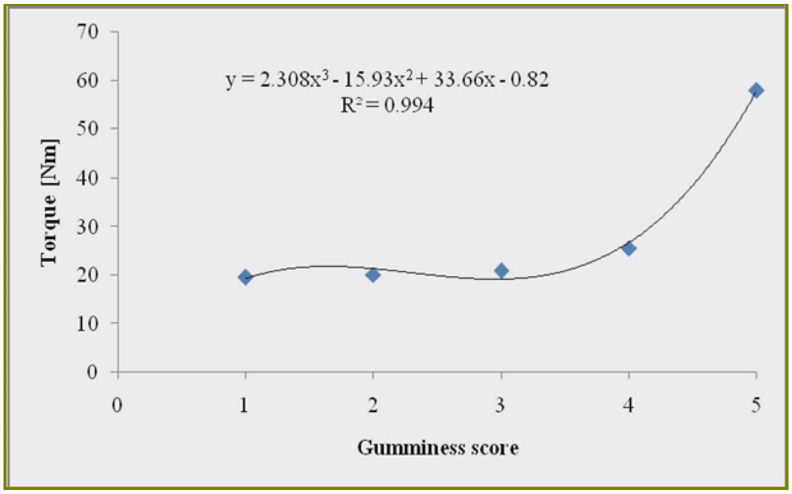

Fig.6. Conversion scale of resistive moment value, measured on the propeller stirrer, in gumminess units as they are defined as the reference standard [1]. All values correspond to the speed of 150 rpm. of propeller stirrer

Replacing in equation (1) the resistive value moment measured for some semi-solid food weighing 100 grams, using a propeller stirrer as described, it can calculate gumminess score as reference standard [1] with a resolution of two decimal. Stirrer interfacing with a computer and using an appropriate software allows direct display of gumminess score value.

4. Testing the correspondence between human sensory analysis and instrumental sensory analysis

In order to establish the correspondence between human sensory perception of gumminess with experimental values obtained by the instrument technique described above it was done a blind test for appreciation with fourteen females and three males with an age between 22 and 26 years. Those seventeen persons were given a teaspoon of dough with different concentrations of flour according to Table 1, to memorize the force required for it disintegration and to grant for gumminess points of appropriate panel**.** Between two different samples of dough they rinse mouth several times with distilled water. After the test described, from the glass vessels containing five type of remained dough (corresponding to the content in flour and water), they leaked the contents by tilting the vessel horizontally and asking panelists to appreciate visual flow rheology with one of the five panel numeric values assigned by evaluating the force necessary for its disintegration by tongue.

Table 2

Results of blind evaluation of dough gumminess without additives, of the same dough with addition of beta carotene and addition of vanilla essence, based on its free flow

No. Per-son	Assessment of dough with 45% flour (panel 2)	Assessment of dough with 45% flour (panel2, additivated with beta carotene	Assessment of dough with 45% flour (panel2), additivated with cu vanilla
1	2	3	1
2	2	3	3
3	2	2	1
4	2	2	2
5	2	3	2
6	3	3	3
7	2	2	2
8	3	4	3
9	3	4	2
10	2	3	2
11	2	3	2
12	2	3	2
13	2	2	2
14	2	3	2
15	2	3	2
16	3	3	3
17	3	4	2

Table 3.

Results of blind evaluation of dough lot gumminess according to[1]

No. Per-son	Assessment of dough with 45% flour (panel 2)	Assessment of dough with 45% flour (panel2), additivated with beta carotene	Assessment of dough with 45% flour (panel2), additivated with cu vanilla
1	2	3	1
2	2	3	2
3	2	1	1
4	2	2	1
5	2	3	1
6	3	3	2
7	2	2	2
8	3	4	2
9	3	4	2
10	2	3	2
11	2	2	2
12	2	3	4
13	2	2	1
14	2	3	2
15	2	3	2
16	2	3	1
17	3	4	2

Next it was used 3 lots of 0.5 kg of the dough with flour 45% (panel 2 according to [1]), concentration and panel of three lots being unknown to panelists. First lot was without additives, the second lot was additivated with 5 ml beta carotene 10% of high purity and the third group was additivated with 10 grams commercial essence of vanilla, dough preparation being done at the speed of 150 rev / min with experimental stand shown in Figure 2.

The three lots were made two types of sensory evaluation experiments. The first experiment consisted in noting the flow rheology of three lots of dough by comparison with the flow rheology of five types of the dough made according to [1]. The result of evaluation by panelists is shown in Table 2. After the first experiment of dough rheological flow evaluation each panelist received a teaspoon of dough from the three lots described above, being asked to assess the panel according to the methodology described in [1] and to record the result in a table (Table 3). Obviously before each new determination mouth was rinsed several times. The test results are found in Table 3.

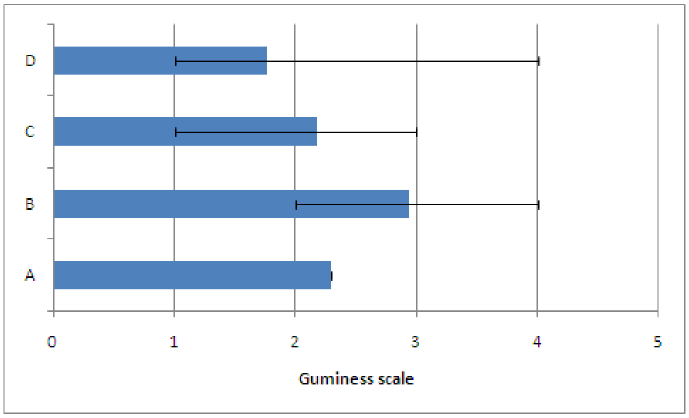

Fig 7. Analysis of variance type ANOVA of values in Table 2 of sensory test based on flow rheology appreciation of dough. A- dough assessment with 45% flour using the experimental device, B - assessment of the dough with flour 45%, C - assessment of dough with 45% flour (panel 2) additivated with beta-carotene, D - assessment of the dough with 45% flour (panel 2) additivated with vanilla

An analysis of variance type ANOVA of values after valuable component for rheological sensory appreciation is shown in figure 7, and the same analysis for assessing sensory appearance (color) and taste is shown in figure 8. In the analysis of variance shown in figure 8 is observed that gumminess measured using the proposed technique and method of human subjects show differences**.** From the statistic point of view there is a significant difference between measured value with the device and values measured by human subjects for dough with 45% flour ($p < 0.05$, dough with 45% flour additivated with beta-carotene ($p < 0.0001$) and dough with 45% flour additivated with commercial vanilla essence ($p < 0.05$).

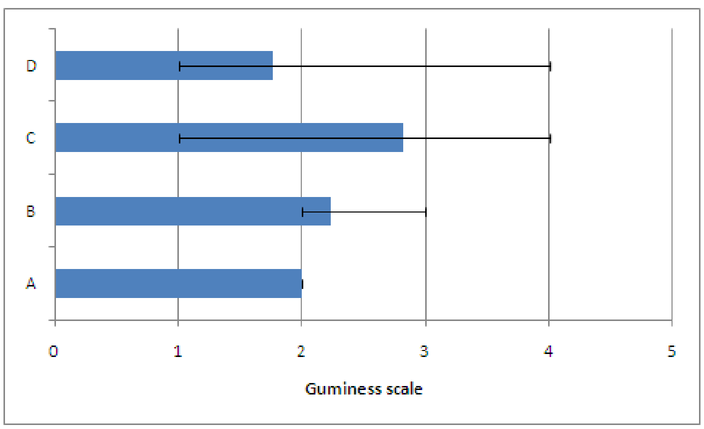

Fig. 8. Analysis of variance type ANOVA of the values in the table 3 of sensorial test on visual and taste appreciation

From the analysis it is clear that taste and color influence human sensory evaluation of food gumminess.

5. Conclusions

Semi solid food gumminess can be determined on instrumental way by electronic measuring of mechanical resistive moment opposed by food to a special propeller with opposite step rotated by a stirrer at a speed of 150 rev / min. A parallel test conducted with volunteers to determine the gumminess on human sensory way in the purpose of comparing the results with the instrumental analysis revealed that instrumental method shows a sensitivity and a better resolution than the human sensorial analysis, differences are even higher as gumminess value is higher. Subjectivity of human sensory assessment gumminess is pronounced, taste and appearance of product tested having a major influence on the verdict of panelist. Gumminess determination from food texture profile analysis (TPA), does not give good results because its expression of value in physical units is incorrect.

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