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CORRELATIONS BETWEEN QUALITY OF FLOUR T-500 CHARACTERISTICS AND BREAD VOLUME

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Abstract: *The quality of flour and its quality characteristics (quantity of gluten, quality of gluten, physical and chemical properties of gluten, the ability to release a gas etc.) influence the quality of flour and that of bread. If we take into consideration whether one type of flour is of quality or not, a correct answer will be given only when its rheological characteristics are well known. The aim of the present study is to determine how quality characteristics of wheat flour T-500 can influence bread volume, showing that the quality characteristics of eight different types of wheat flour T-500 are established according to the analysis result of the rheological characteristics of the kneaded dough. Thus, according to the obtained results, the dependence between the examined parameters of flour (the content of moisture, the content of ash, acid level, amylographic number, moisture gluten, extensibility, extensibility resistance, the relation Re/E, energy of dough) and bread volume, is determined with correlation. There is a positive correlation between certain parameters of the examined flour and bread volume.*

Keywords: *wheat flour, quality characteristics, dough, volume, bread*

1. Introduction

The quality characteristics of the flour depend on the relation of the chemical ingredients in the flour and the quality of those ingredients. The flour which is used for the production of bread must have such a proportion and properties of proteins and starch, to be able to fix enough quantity of water when the dough is being knead. The quality of the flour is determined according to the quality of gluten and starch. [1]
From technological aspect the most important proteins that are in the flour are: gliadin and glutenin. These two proteins with adding water are growing and sticking each other making gluten (stick), which is making the structure of the dough (Figure 1).
There are starch grains, proteins as albumin and globulin between those bubbled and sticks molecules. In this way the so called wet gluten is produced. This wet gluten which connects all the physical characteristics of gliadin and glutenin fraction in it is considered for the most responsible for the quality of the baker's products. [2, 3, 4]

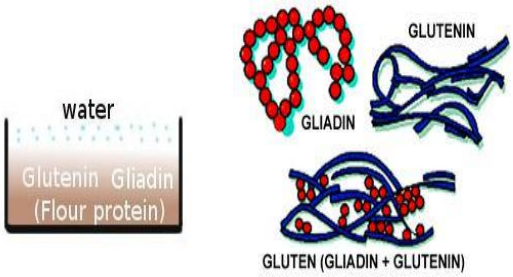

Fig.1. Production of gluten [5]

Creating of the gluten is a characteristic of the wheat flour, which is considered to have the most quality gluten, while the quality of other flour gluten is different or does not exist. [2]

Rheology studies complex viscous-elastic systems, among which the dough is one of the most remarkable. The dough, indeed, is not a hard body, because it shows elastic properties, and is not a liquid, although it has properties of a liquid. During the rheological examination, the size of the deformation of the shape, volume or weight is measured according to the used power in a certain time interval. [6, 7]

For examination of the properties and reactions of the dough for mixing and extensibility, different measurement instruments are used, whose task imitates the conditions in the production. The most famous are: instruments as registering mixers (farinograph and mixograph) and instruments for extensibility of the dough (extensograph and alveograph). [8]

Farinograph is an instrument for measuring physical properties of the dough and that depends on the gluten. It is used for measuring the resistance power of the dough when it is mixed. This method gives a data for the ability of the dough to absorb water, the time needed for the growth of the dough, stability of the kneaded dough, the level of softening of the dough when it is kneaded, and also data for the quality number and quality group. [1]

The surface of the gotten triangle of faring graph (cm^2) is determined with planimetres. For the certain surface of the triangle, in the chart according to HANKOCZY-u the quality number of the dough is seen, and that number is suitable for a certain quality group (A1, A2, B1, B2, C1, C2). The surface of the triangles is between 0 to 50 cm^2, quality number from 100 to 0. [9, 10]

The extensograph examines the physical properties of the dough and it's reaction of fermenting and mechanical treatment. The picture, for the quality of the dough which is received as a result or a faring-graph, is completed. The above mentioned properties are registered on a diagram (extensogram). On the extensogram are shown: energy (A), extensibility power (E) as well as resistance power of the extensibility (Re), that characterizes the quality of the gluten stick. From all these indicators the proportion between the resistance power of the extensibility and extensibility (Re/E =k) can be calculated, and thus a data for the dough behavior in the process of production is received. [1]

Amylograph is a tool which is used for determination of the quality of the starch and the action of α -amilasys, and with such an examination data for the process of cauterization of the starch from which depends humidity, elasticity, porosity, look and freshness in the middle of the bread are received. [11]

In this paper the received results from the rheological examination of of eight different types of wheat flour T-500 are presented and the dependence between the

examined parameters of the flour and the volume of bread is determined.

2. Matherials and methods

The examinations are made in the laboratory in AC."Zito Vardar" – Veles, Republic of Macedonia. Subject of examination are eight different types of commercial available wheat flour T-500. In every type of the flour the following parameters are determined: content of the humidity [12], content of the ash [13], acid level [14], content of the wet gluten [15] and rheological properties with: amylograph Brabender, farinograph Brabender Duisburg and extensograph Brabender (Figure 2). [9, 10, 15]

From each of the examined wheat flour wheat bread T-500 is produced according to the same recipe (the same percent of additive 0.5 %, yeast 3 %, salt 1.8 %). The quantity of water is changed according to the power of soaking water on the representative types of flour.

The order of the basic information of the production is given in the Table 1.

Fig. 2. Amylograph Brabender, farinograph Brabender Duisburg and extensograph Brabender

Table 1.

Sequence of the main production operations

	Whole wheat bread T-500	
Technological procedure	**Time (minutes)**	**Temperature (°C)**
Preparation of raw materials	10	room
Mixing of dough (I + II speed)	9	room
Dough fermentation	30	room
Dividing the dough into pieces	3	room
Curvature of the pieces	2-3	room
Resting of the pieces	10	room
Finishing formation of dough	1	room
Finishing fermentation	38-45	70
Bread baking	30	200-250
Cooling of the bread	180-300	room

One of the most important and used indicator for the quality of the bread is its volume. The volume of the bread is determined with measurement of the volume of the bread according to length and height (the shorter line) of the bread. The given values are multiplied and in that way it is given how much is the volume of the bread [15]. There is a correlation among the examined parameters of the and the volume of the received bread, and Pearson coefficient of correlation (R) [16] is determined, and then a statistic substantiality for the level of substantiality 0.05 is determined [17].

3. Results and discussion

The given results from the analysis of the commercial wheat flour T-500 marked as samples from 1 to 8 are shown in Table 2. In Table 3 the received values for Pearson coefficient of correlation (R) and statistic substantiality ($p < 0.05$) are given.
From the shown results it is concluded that the examined flour content of humidity is between 12.24 % to the flour 3 and to 14.00% to the flour 5. The received values are in compliance with the rules for the minimum conditions for making operations, quality and types of flour, the way and methods for taking samples, as methods for analysis of the quality of the flour [14], according to which the relative moisture in the flour that is put in operations mustn't be bigger than 15.00%.

Table 2.

Characteristics of wheat flour T-500 and obtained bread volume

* AU - Amylograph units, BU - Farinograph units, EU – Extensograph units

Quality parameter	Sample of wheat flour T-500							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Moisture (%)	12.99	13.30	12.24	13.50	14.00	13.50	13.60	13.70
Ash (%)	0.50	0.55	0.55	0.50	0.50	0.52	0.55	0.52
Acid level (mL)	2.00	2.20	2.40	2,50	2.30	2.30	2.40	2.10
Wet gluten (%)	18	23	23	23	23	24	23	19
Water absorption (%)	56.50	55.50	68.50	56.80	66.7	57.00	59.00	56.50
Degree of softening (BU)	190	100	105	90	100	80	90	110
Quality number	34.10	47.40	46.70	57.70	51.00	65.40	60.30	47.90
Quality group	C1	B2	B2	B1	B2	B1	B1	B2
Extensibility (mm)	95	115	100	125	95	124	121	105
Resistance to extension (EU)	40	200	230	190	270	480	280	90
Resistance to extension / Extensibility (Re/E)	0.42	1.74	2.30	1.52	2.84	3.87	2.31	0.86
Energy (cm^2)	6.00	37.20	35.00	34.50	36.40	87.20	48.50	13.20
Amylograph number (AU)	480	480	460	460	520	500	500	520
Sample of wheat bread T-500	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Bread volume (cm^3)	2050	2400	2500	2380	2430	2610	2600	2130

From the given values of the content of ash in the certain samples of flour it can be determined that the samples of flour 2, 3 and 7 are remarkable for the biggest content of ash (0.55 %), and with the smallest content of ash from 0.50 % in the samples of flour 1, 4 and 5. The received values for the content of ash in all the samples are in the borders from 0.46 % to 0. 50 %, that are in compliance with the prescribed ones for the wheat flour T-500 [14]

In the relation to the acid level in the examination, the received values do not exceed the allowed maximum for this type of wheat flour (level of acid to 3.00). [14]
In Table 2 the values for amylograph number in the amylogram units are shown. With the read values as a base (from 480 to 520) it is considered that all types of flour have a normal ability for clustering and the production of bread in optimal area, does not show friability, with color of core characteristic for that product (amylograph unit between 260 and 650). [18]

Table 3
Correlation between the volume of the bread and the appropriate parameters of the flour and statistic substantiality

Quality parameter	Coefficient of correlation R	p - value
Moisture (%)	0.26	0.53
Ash (%)	0.48	0.23
Acid level (mL)	0.46	0.25
Amylograph number (AU)	0.39	0.15
Wet gluten (%)	0.53	0.17
Extensibility (mm)	0.46	0.25
Resistance to extension (EU)	0.61	0.11
Resistance to extension / Extensibility (Re/E)	0.60	0.12
Energy (cm²)	0.59	0.13

The received value of the coefficient of correlation between the content of moisture, the content of ash in the flour, the acid level of the flour and amylograph number in the examined samples of flour and the volume of the bread given in the Table 3 shows that there is a technical positive correlations with a weak dependence between the changeable ones. (Figure 3-6).

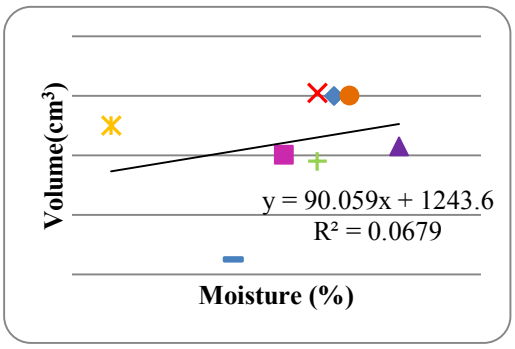

Fig. 3. The dependence of the volume of bread from the content of moisture in the flour

The received values for p are bigger than 0.05, so it can be considered that the received results are not statistically important for the level of substantiality of 0.05.

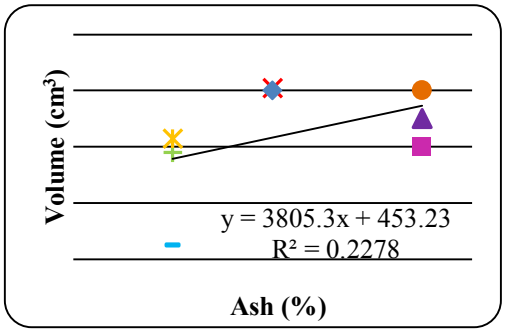

Fig. 4. The dependence of the volume of bread from the content of ash in the flour

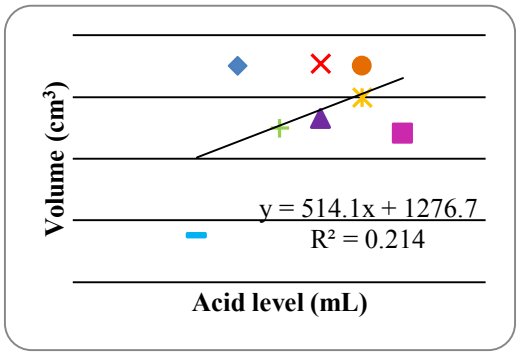

Fig. 5. The dependence of the volume of bread from the content of acid level in the flour

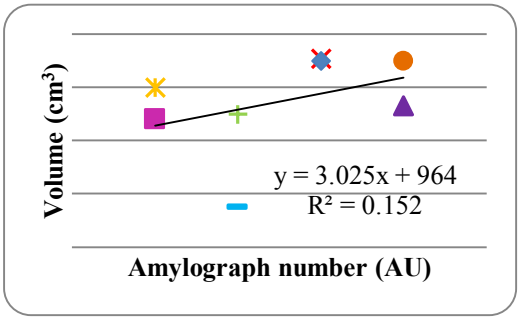

Fig. 6. The dependence of the volume of bread from the amylograph number

From the shown results it is seen that the content of the moisture gluten in the examined samples of flour varies from 18% (flour 1) to 24 % (flour 6). According to the division given from Kaluderski, Filipovic (1998) the content of gluten in the samples 1 and 8 (18 % and 19 %, appropriately) can be tagged as small (from 14 to 20 %) the content of gluten in the samples 2, 3, 4, 5 and 7 (23 %) as

satisfactory (from 21 to 24 %) , and the content of gluten in the sample 6 (24 %) as good (from 24 % to 27 %).

The received value for the coefficient of correlation between the content of moisture gluten in the examined examples of flour and the volume of the bread is given in the Table 3 (R=0.53), and it refers to the moderate positive correlation, which means that there is a tendency with a high variable value for the content of moisture gluten in the flour to go with a high variable value for the volume of the bread and the same in reverse order. (Figure **7**). With increasing of the content of the moisture gluten in the flour, the volume is increased. From the received value for p (0.17) it can be considered that the result is not remarkable for p <0.05 (Table 3)

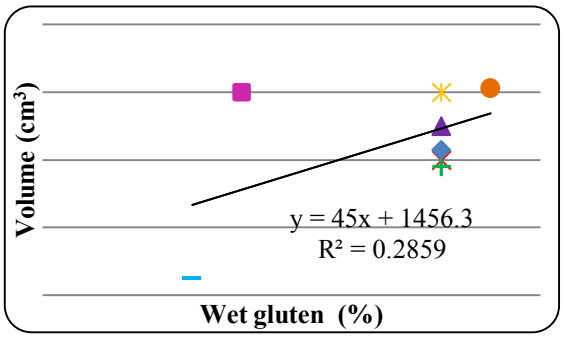

Fig. 7. Dependence of the volume of bread from the content of moisture gluten in the flour

From the obtained extensorgraph and farinograph curves of the commercial wheat flours T-500, the data related to the power of water absorption, the degree of softening of the dough during kneading, extensibility and extensibility resistance, the relative number and energy of the dough, as well as the number and the quality group of the flour (Table 2).

The ability of water absorption of the flour is related to their strength. From the calculated values for power of absorption of water given in Table 2 it is established that the flour 3 has the greatest power of water absorption (68.50 %).

Because more power to water absorption means stronger flour it can be concluded that this flour is stronger than the other analyzed flours. [9]

In terms of the degree of softening the sample 1 (190 FU) is with highest features, indicating poor flour. In strong flours the degree of softening is very small, while in the poor is large. [2]

Based on the planimetric surface of the obtained farinographic curves from HANKOCZY table the following parameters are reported: the quality number and a quality group of the samples are determined [10]. Table 2 shows that with the lowest number of quality 34.10 is the flour 1 (quality group C1), and with the highest 65.40 is the flour 6 (quality group B1). The flour samples 4 and 7 also belong in B1 quality group. The other samples according to the quality number belong to the quality group B2.

The extensograms give the following parasmeters: extensibility and extensibility resistance, and the energy and the relative number is determined (Table 2).

The extensibility specifies the length of the extensogram curve that is extensibility of the dough i.e gluten (mm). For good quality a mean value is required, because excessive extensibility gives molten dough, which is not favorable for obtaining optimal quality product (flour 4 with extensibility 124 mm), while small length means getting short dough, which is also considered as unfavorable (1 and 5 flour with extensibility 95 mm). [1, 2]

Regarding the extensibility, the value of R is 0.46 (Table 3). Although it is technically a positive correlation, the relationship between the variables is weak (Figure 8). From the resulting value of p (0.25) it can be concluded that the result is not significant for p <0.05

The extensibility resistance (resistance to extension) is expressed in EU (extensographic units) shows the amount of the extensogram after 50 mm stretching.

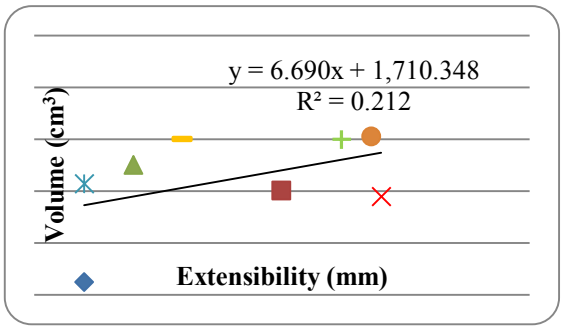

Fig. 8. Dependence of the volume of bread from extensibility

It represents the resistance that the dough gives to extension and for good quality a greater value is desirable because a great height is a sign of strong glue (flour 6 with a resistance to stretching 480 EU). [1]
In terms of extensibility resistance (Table 3), the correlation coefficient is R = 0.61. This is a moderate positive correlation, meaning that there is a tendency of high value variable the extensibility resistance to go higher variable value of the volume of the bread and vice versa (Figure 9).

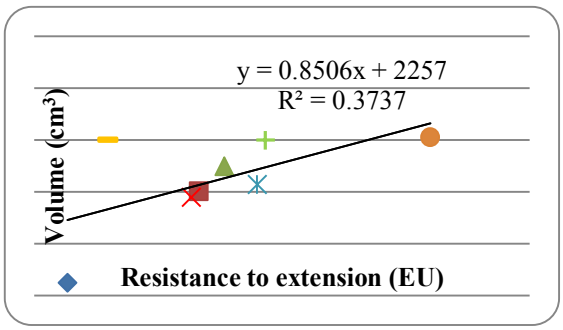

Fig. 9. Dependence of the volume of bread from the extensibility resistance

Figure 9 shows that by increasing the extensibility resistance the volume of the bread increases. The resulting value p (0.11) is greater than 0.05. The result is not significant for p <0.05.
Energy (cm^2) indicates the surface that the extensographic curve forms. That is the energy that is consumed for extension of the dough. It should be greater because it is an indicator of the volume i.e the volume of the dough. If the energy is higher, it is considered that the flour is stronger because more energy is consumed for extension (flour 6 with energy 87.20 cm^2). If the surface is small we have low energy, which means that the flour is low (flour with energy 6.00 cm^2).
The resulting correlation coefficient between the energy consumed for extension and the volume of bread (R = 0.59), suggests a moderate positive correlation, meaning that there is a tendency of high variable value of energy to go with high variable value of volume of the bread and vice versa (Figure 10). By increasing the energy increases the volume. The p-value is 0.13 (Table 3). The result is not significant for p <0.05.

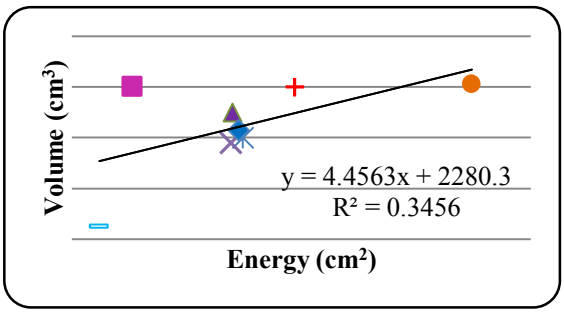

Fig. 10. Dependence of the volume of bread from energy

The relation Re / E provides data on the behavior of the dough during processing and despite the energy gives best indication for quality. Depending on the value, the yield of bread volume, the relation between the diameter and height of bread or the characterization of the physical condition of the dough during processing can be determined. If its value is greater, the dough is shorter, and if it is less, the dough is more elastic. The flour used in baking i.e. to achieve good volume of the bread the relation of 1.5 to 2.5 is considered as the best. [1, 19]

Based on the values of the relation Re / E (Table 2) it is concluded that generally, the flours subject to analyzes are distinguished by a favorable relation (1.5 to 2.5) to achieve a good volume of bread. But, the experience has shown that the most favorable relation is the relation 2.3 (flour 3 and 7). Thus, with the most favorable relations are the flours 3 and 7, which is confirmed by the values obtained for the volume of the bread produced from these flours. From the Table 2 it can be seen that these flours are characterized by lower extensibility and lower extensibility resistance and less energy than the flour 6, but due to favorable relative number they do not differ in terms of the volume compared to the bread produced from the flour 6.

Often, when the relative number is greater than 2.3 the technological process is changed, that is the time of the first growing of the dough (sample 5 and 6), and when the relative number is less than 2.3 additives are added to increase the extensibility resistance (sample 1, 2, 4 and 8).

Resulting correlation coefficient between the relation Re / E and the volume of the bread (R=0.60), indicates moderate positive correlation which means that there is a tendency of high value variable relation Re / E to go higher variable value of volume of vice versa. (Figure 11).

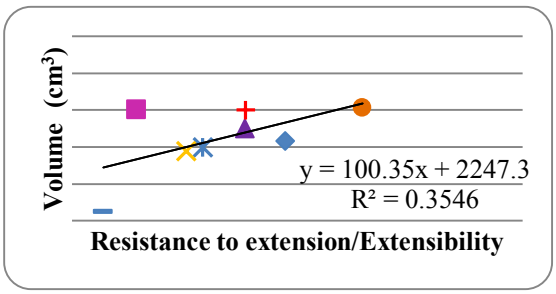

Fig. 11. Dependence of bread volume on the ratio Re/E

By increasing the energy and volume increases too. The result is statistically significant for the significance level of 0.05 (p = 0.12) (Table 3).

4. Conclusion

The bread is thermally cooked dough, usually from wheat flour. If the flour is good and quality, then the bread made from it will be with the required quality characteristics. The analyzed eight commercial wheat flours T-500 meet the conditions prescribed in the Regulations on the minimum conditions for marketing, quality and types of flour, means and methods for taking samples and the methods for analyzing the quality of flour in terms of content moisture, ash content and acid level.

From performed tests it can be concluded that the sample flour 1 belongs to the quality group C1, the flour samples 4, 6 and 7 belong to group quality B1, and the other samples belong to group quality B2.

For the content of wet gluten in the samples it can be concluded that flours 1 and 8 it is a small 14 to 20 %, in the samples 2, 3, 4, 5 and 7 it is satisfactory from 21 to 24 %, and the content of gluten the sample 6 is good 24 to 27 %.

Based on the values of Pearson's correlation coefficient (R) it can be concluded that between the respective parameters of flour (moisture content, ash content, acid level, amylographic number, wet gluten content, extensibility and extensibility resistance, a relative number and energy) and the volume of bread there is a positive correlation. With the increase in the aforementioned parameters the volume increases.

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