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USE OF FLOUR-GRAPHICS TECHNIQUE IN THE COMPATIBILITY PARAMETER *EXTENSOGRAPH* BRABENDER AND *FLOURGRAPH E7*

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ABSTRACT

The flourgraphic technique used in the study of flour quality has led to the emergence of new devices. The devices used in the present study were *Extensograph* Brabender and *Flourgraph* E7 (new) and *Flourgraph* E6 (new) and the *Farinograph* Brabender. Constructive models is differs little and so appeared purpose of the studies, present objective. The objective of our study was to identify relationships between the values of measured variables characterizing such rheometric elements as: properties of dough formation and its viscoelastic properties. The values will be obtained, in parallel, with *Extensograph* Brabender and *Flourgraph* E7. Kneading the dough was made with *Flourgraph* E6 and *Farinograph* Brabender, respectively. Three types of flour were used in the study: semolina flour from durum wheat (F1), type 650 white wheat flour (F2), and type 000 white wheat flour (F3). Parallel determinations were made using the same method. The parameters obtained were energy [cm^2], resistance to extension [BU], [HE], extensibility [mm], maximum resistance [BU], [HE] ratio and maximum ratio. The values obtained were analyzed by applying a statistical algorithm which yielded very good correlation indices, generally ranging between 0.8 and 0.9. The correlations were positive, strong and moderate. According to polynomial regression and strong positive correlations, which means that high x variable (determined from *Extensograph* Brabender) scores go with highly (determined from *Flourgraph* E7) variable scores and vice versa. This demonstrates that the two pairs of equipment used to assess the viscoelastic properties of dough are a good choice.

Keywords: Wheat flour, dough rheology, viscoelastic properties

INTRODUCTION

In 1930 one of the first special instruments was designed for physical testing of wheat flour doughs, the so called Brabender Extensograph (**Bloksma and Bushuk, 1988; Kahramam *et al*., 2008**).
A few years later, C.W. Brabender (1934) introduced the extensograph in research laboratories of wheat flour quality control (**Preston and Hoseney, 1998).**
The extensograph was developed to evaluated the qualities that govern the behavior of dough at the fermentation stages and during its mechanical handling (**Moss, 1980; Rapsen and Preston, 1991; Zaharia *et al*., 2014**).
Measuring the tensile properties of dough is one of the most important techniques used to assess the quality of flours used for bread making. **Müller** presented in **1961** results of the analysis based upon the curve of the effort to stress. The difference between the resistance to extension for strong and weak flour are shown in the mass effective changes.
Rheological measurements are relevant tools in the food industry for physical characterization of raw material prior to and during processing, and of final food products (**Tabilo-Munizaga *et al*., 2005).** Flour can be classified according to extensograph results as "short", "buky", "extensible" or "pliable" (**Rapsen and Preston, 1991**). The extensograph can be used to study, pH action **(Tanaka *et al*., 1967 b**), influence of oxidants and related compounds **(Bloksma and Bushuk, 1988),** potato pulp (**Iancu *et al*., 2011),** of food fiber **(Sharoba *et al*., 2013**), and other materials, such as: ginseng (**Song *et al*., 2007)** and orange peel powder (**Astha and Masih, 2014).**
The quality parameters for the wheat flour dough were assessed with farinography, extensography, amylography and texture profile analysis (**Bahareh *et al*., 2013**). Rheological studies on the various factors influencing variables rheometer dough were made **(Tong *et al*., 2010;** M**cCann and Day, 2013).**
The extensograph known in same countries, was conceived at a time on advances in the mechanization and automation of the baking process had created conditions that made the uniformy of ingredients, especially flour.

Haubelt Laborgerate GmbH was found în January of 2006. Haubelt has been designed to test rheological properties of wheat and wheat flour. The factory is producing rheological flour quality testing instruments called *Flourgraph* E6 and *Flourgraph* E7 (**CFW, 2007**). *Flourgraph* E6 and *Flourgraph* E7 have emerged on the profile market in 2010 (**ICC Standard No. 179(E6), 180(E7))**.
All of the above mentioned equipment have been internationally validated as references **ICC** standard since more than decades and since basic rheological instruments are capable of proving the essentials, or fundamental details of the materials rheological properties, **ICC** continuously struggles to study, validate and publish new standard methods for such equipment as the Haubelt Flourgraph E7(**Jbeily *et al*., 2014 b).** Thus using the *Flourgraph* E6, preparing dough for E7. For *Flourgraph* E6 and *Flourgraph* E7 were made research and concluded was that the values obtained for many flours studied and several laboratories (ring test) have described a linear regression i.e. Repeatability and reproducibility are good (**Jbeily *et al*., 2014 a, b).** Principle which is based on functioning of these devices in range Brabender and Haubelt is the same. Constructive models is differs little and so appeared purpose of the studies, present objective.
For statistical interpretation used The Pearson correlation coefficient measures the strength and direction of the relationship between two variables.

MATERIAL AND METHODS

Was used in the determination, semolina flour from durum wheat (Mill Cibin, Romania) had the following characteristics: moisture was determined (%) (**ICC Standard No. 110/1 (1976)**) (13.6%); wet gluten (%) (**ICC Standard No. 106/1-(1976)**) (32%); gluten deformation (mm) **(SR 90:2007)** (3.2mm); gluten index **(SR 90:2007)** (58); Falling Number (s) (**ICC Standard No. 107/1**) (350s); titratable acidity (SH^o) **(SR 90: 2007)** (2.1 SH^o); water absorbtion from flour (%) **(ICC-Standard 115/1, 1998, AACC Method 54-21, 1995, ICC- Standard-180, 2010)** (53%), the white flour type 650 (Mill TITAN, România) had the following characteristics humidity 13.9%; wet gluten 32%; gluten deformation 4 mm; gluten index 55.68; Falling Number 290-300s; titratable acidity 2.2 SH^o, water absorption from flour 56,9%, used same method like semolina flour durum wheat, ash content(%)(**ICC Standard No. 104/1, (1990)**) (0.649%); and the white flour type 000 (Mill Boromir, România) had the following characteristics humidity 14.5%; wet gluten 29%; gluten deformation 5.5 mm; gluten index 49; Falling Number 330s; titratable bile acidity 2.3 SH^{o} ; ash 0.480%; water absorbtion from flour 55%, utilizing the same methods.

For dough rheological characteristics was used *Farinograph* Brabender (Duisburg, Germany) **(AACC Method 54-21, 2000)** characteristics were determined according to the **AACC Method**. The following parameter were determined in a Brabender farinograph was water absorbtion (%) of water required to yield dough consistency of 500 BU(Brabender Unit).

If used *Flourgraph*-E6 Haubelt (Haubelt model, Berlin, Germany) (**ICC Standard No 179. (2010))** dough consistency must be 500 HE (Haubelt Unit).*Extensograph* Brabender (Duisburg, Germany) and *Flourgraph* E7(Haubelt model, Berlin, Germany), gave the resistance to constant deformation, extensibility, the ratio, energy, maximum resistance, ratio number and ratio number max, in conformity table no.1

Table 1 Name of parameter *Extensograph* Brabender **(AACC Method 54-10, 2000)** and *Flourgraph E7* **(ICC Standard 180 (2010).)**

Brabender Extensograph (B)	UM	UM	Flourgraph E7 (E)	Symbol
Energy	cm^2	cm^2	Energy	-
Resistance to extension	*BU	**HE	Resistance to extension	R
Extensibility	mm	mm	Extensibility	E
Maxim Resistance	BU	HE	Maxim Resistance	R_m
Ratio number	-	-	Ratio number	γ
Ratio number(max)	-	-	Ratio number(max)	γ_{max}

*Brabender Unit; **Haubelt Einheit(Unit)

The *Extensograph* and *Flourgraph* E7 procedure: It is done/made according to **AACC** and **ICC**. The level of water absorption in the presence of 2% salt is determined by using a *Farinograph Brabender* respectively *Flourgraph E6* Haubelt. Dough consistency after 5 minutes will be 500 BU *(Farinograph* Brabender*)* or HE *(Flourgraph E6)*. Dough is then mixed in a farinograph and then stretched in an extensograph. Dough weight is 150 ± 0.1g. It is given a characteristic long rounded shape. The dough stretched by the extensograph hooks is kept for 45, 90, 135 minutes to allow the temperature to stabilise prior to tensile testing. Tensile behavior is recorded as a curve and the final results are stored as pdf files in the computer. The temperature for testing and thermostatic control is 30 ± 2^{o}C.

The following algorithm was used for statistical interpretation and comparison of results It is done/made according to Pearson correlations coefficient and Student t-test.

RESULTS AND DISCUSSION

The aim of this study is to identify relationships between the values of measured variables characterizing such rheometric elements as: dough formation(water absorbtion, compared, (%)), values will be obtained by the pairs *Farinograph* Brabender and *Flourgraph E6.* Viscoelastic and stretch properties (compared, Energy (cm^2), Resistance to Extension (BU, HE), Extensibility (mm), Resistance maximum (BU, HE), Ratio number and Ratio number maxim) will be obtained by the pairs *Extensograph Brabender* and *Flourgraph E7.*

Extensograph hydration capacity is determined starting from preset values. At the end of the mixing process, after 5 minutes, doughy consistency is 500 BU or HE. Figure 1 compares hydration capacity values for the flours studied. The results show different extensograph hydration capacity values. Hydration capacity is an important technological property of flour, which lends consistency to dough. Hydration capacity influences dough strength, whose values are entered into a recording system. Dough strength allows for more dissipation in the 300 mL farinograph mixer than in the 100 mL *Flourgraph E6* mixer. The hydration capacity values obtained by using the Brabender *farinograph* and the *Flourgraph E6* are compared, and the results featured in Figure 1. The difference in values was found to be 2.9 mL for F_1, 0.7 mL for F_2 , and 3.6 mL for F_3.

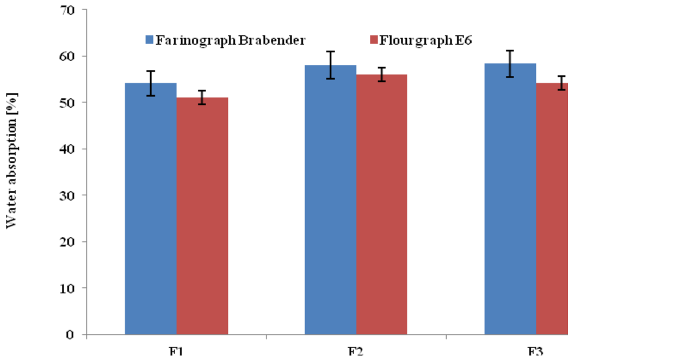

Figure 1 Comparative presenting a water absorption at the end of mixing value, obtaining with *Farinograph* Brabender and *Flourgraph* E6.

It may be said that the images are sufficient to support the idea of this study. The relationship between the energy values obtained by the two devices is shown in figure 2.

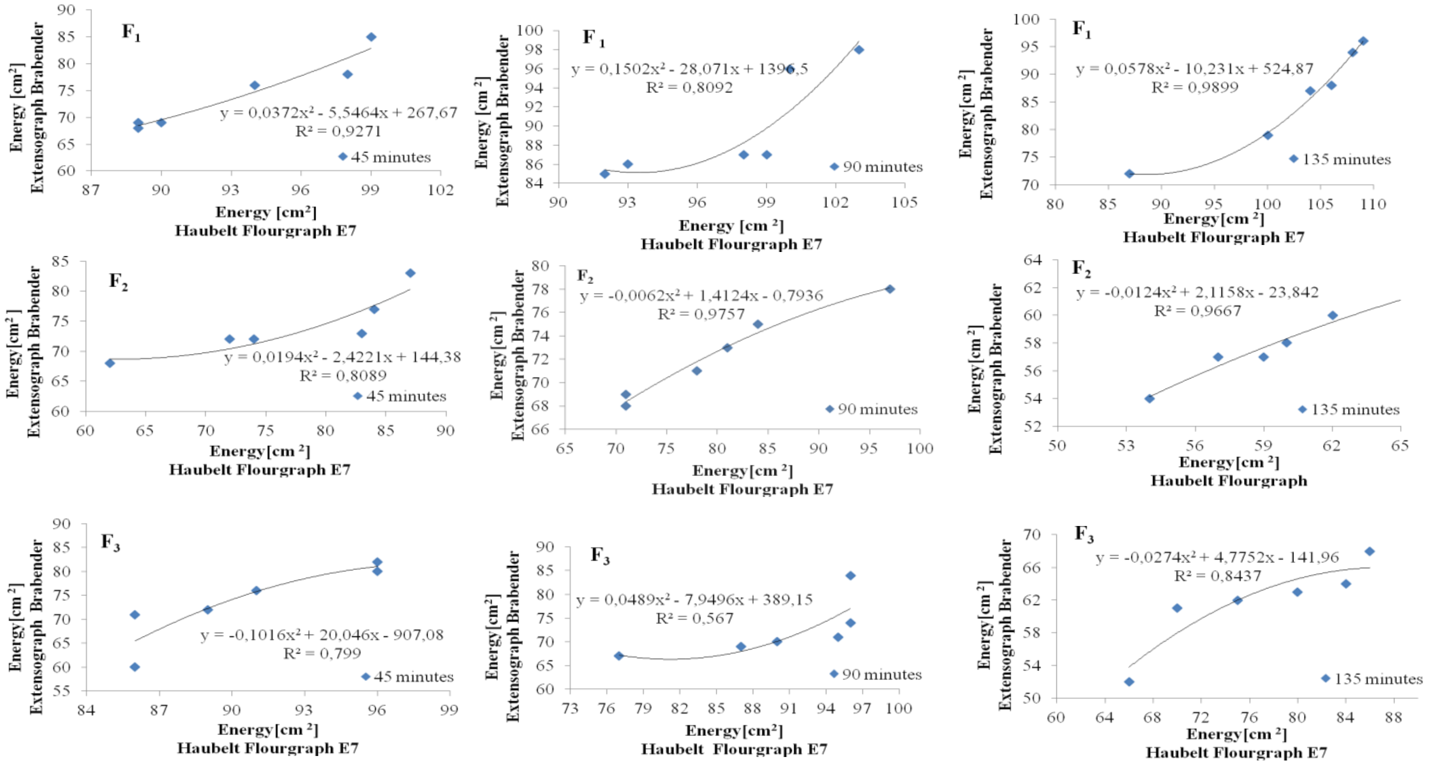

Figure 2 Scatter plot comparison and relationship between Brabender *Extensograph* and *Flourgraph* E7 value, for Energy using same method, for wheat flour F_1; F_2; F_3.

The quality of flour after 45, 90, 135 minutes was found to be good for F_1 and F_2 and average for F_3. A good correlation of values can be seen in one area of the scatter plot. The area under the curve, which is proportional to the energy required to stretch the test piece to its rupture point. This parameter, expressed in cm^2, is a convenient single figure for characterizing flour strength. The stronger the flour, the more energy is required to stretch the dough **(Dapcevic *et al.*, 2011)**.

The best correlations obtained were: 0.98 for F_1 after 135 minutes, 0.9757 for F_2 after 90 minutes, and 0.84 for F_3, after 135 minutes. The best correlation for all the flours studied and for the given energy values was obtained after 135 minutes of thermostatic control. The lowest correlation coefficients were obtained for F_1 after 90 minutes of thermostatic control, for F_2 after 45 minutes and for F_3 after 90 minutes.

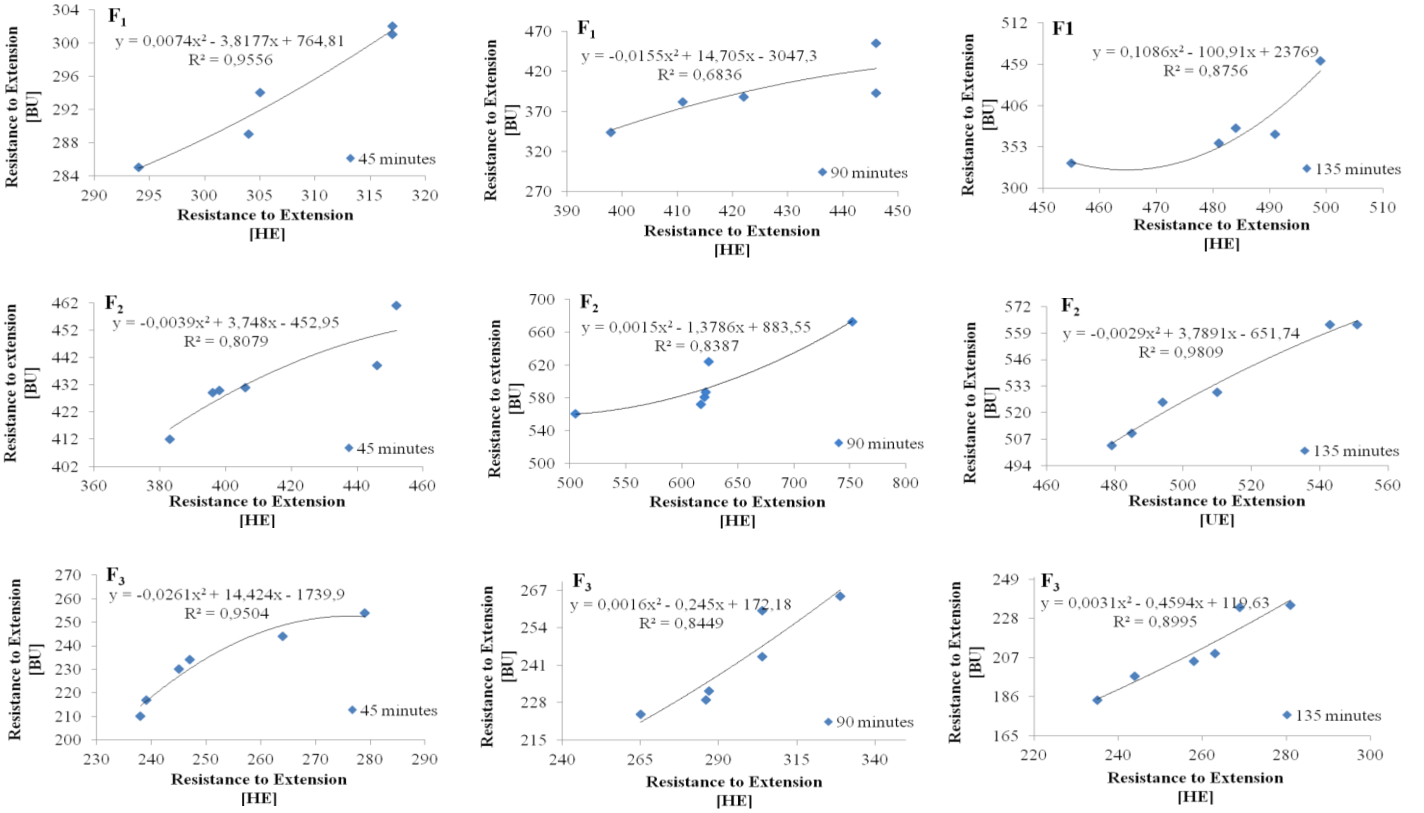

Figure 3 A scatter plot comparison and relationship between Brabender *Extensograph* and *Flourgraph* E7 value, for Resistance to Extension using the same method, for wheat flour F_1; F_2; F_3.

Dough resistance to extension is plotted in Figure 3 and exhibits good correlation coefficients for the flours studied. While the dough was kept for its temperature to stabilize, the value of this parameter increased, and then it began to decrease after 90 minutes.

The best correlation was obtained after 45 minutes of thermostatic control for F_1 (R^2= 0.9556), after 135 minutes for F_2, (R^2= 0.9809) and after 45 minutes for F_3 (R^2= 0.9809).

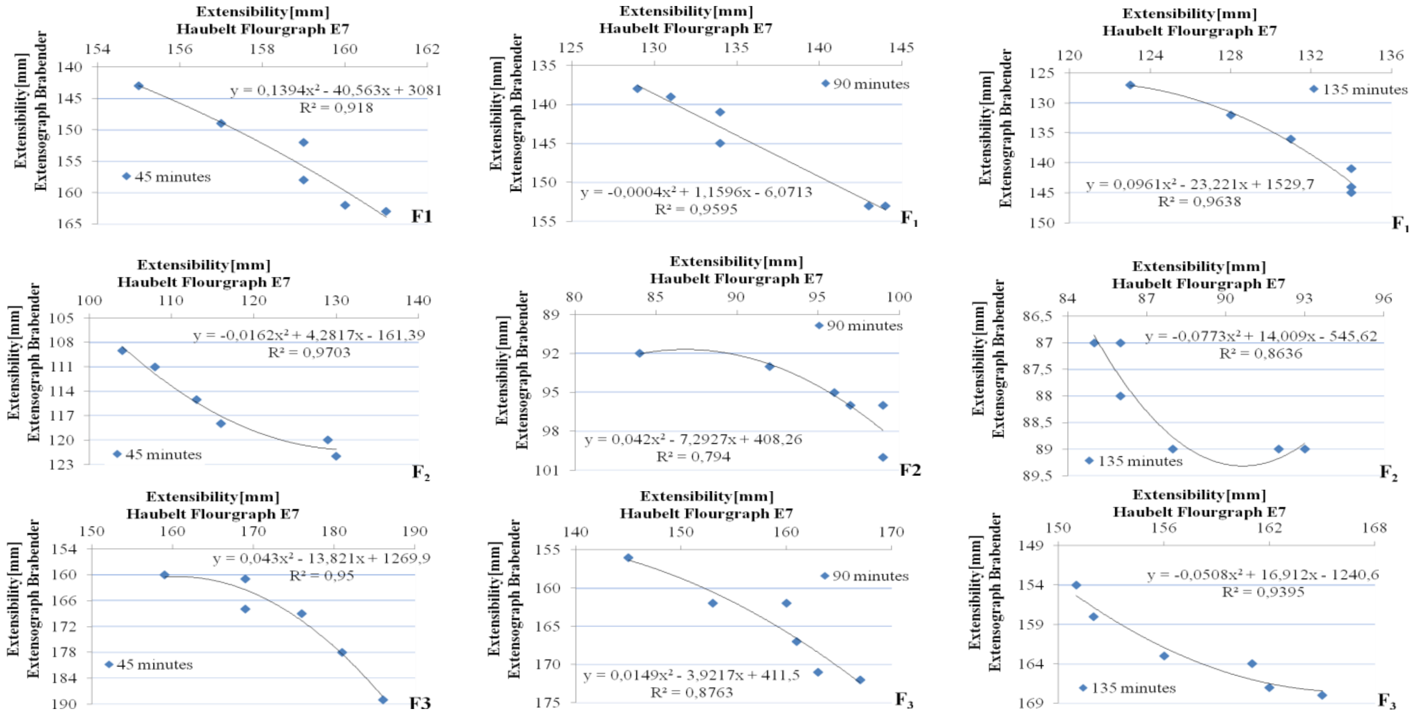

Figure 4 A scatter plot comparison and relationship between Brabender *Extensograph* and *Flourgraph* E7 value, for Extensibility using the same method, for wheat flour F_1; F_2; F_3.

The dough extensibility (E) expressed in mm, which represents the distance of stretching before rupture (**Dapcevic *et al.*, 2011).** The polynomial regression values obtained are plotted in Figure 4. The correlations were found to be positive, very good, between the values obtained for all the flours studied and at the set thermostatic control times. The lowest correlation was obtained for F_2 after 90 minutes and the best for F_2 after 45 minutes of thermostatic control.

The maximum resistance (R_{max}) or the resistance at constant deformation usually corresponds to the height of the curve at 50 mm from the beginning of stretching (R_{50}**) (Bordei, 2007).** The latter is preferably expressed within the cereal testing laboratories since it represents the resistance at a fixed extension for all tested doughs. This parameter is expressed in Brabender units (**Dapcevic *et al*., 2011).**

In table 2 data are shown for, maximum resistance and Pearson Correlations coefficients. For F_1 the maximum resistance has been correlated thus: at the 45 minutes is a strong positive correlations at the 90 minutes is a strong positive correlations and at the 135 minutes is a moderate positive correlations. For F_2 the maximum resistance has been correlated thus: at the 45 minutes is a strong positive correlations, at the 90 minutes was a strong positive correlations and at the 135 minutes is a strong positive correlations. For F_3 the maximum resistance has been correlated thus: at the 45 minutes is a strong positive correlations, at the 90 minutes is a strong positive correlations and at the 135 minutes is a strong positive correlations.

Table 2 Experimental value and theoretical statistical interpretation correlations index for Resistance maxium

Sample	Device	Proving time [min] 45 Real value Resistance maxim	45 R^2	45 r	90 Real value Resistance maxim	90 R^2	90 r	135 Real value Resistance maxim	135 R^2	135 r
F1	B	348.3 ± 12.32 [BU]	0.8006	0.8948	435.6 ± 34.62 [BU]	0.918	0.9581	438 ± 39.38 [BU]	0.363	0.6025
	E	389.33 ± 14.38 [HE]			501.8 ± 11.02 [HE]			545.5 ± 43.34 [HE]		
F2	B	471.5 ± 16.43 [BU]	0.9484	0.9739	600.6 ± 22.79 [BU]	0.620	0.7876	544.66 ± 21.36 [BU]	0.9708	0.9853
	E	475.5 ± 26.84 [HE]			635.8 ± 62.13 [HE]			523.5 ± 25.21 [HE]		
F3	B	323.33 ± 11.97 [BU]	0.6824	0.8261	323.12 ± 2.64 [BU]	0.7078	0.8413	284 ± 17.11 [BU]	0.9362	0.9676
	E	363.16 ± 11.9 [HE]			339.66±56 [HE]			339.33±28.88 [HE]		

B – Brabender *Extensograph*; E – *Flourgraph E7*. The significance threshold was α = 0.05 and standard deviation represented on the graph was calculated based on 6 flourgrams and 6 extensograms

Table 3 Experimental value and theoretical statistical interpretation correlations index for Ratio number

Sample	Device	Proving time [min] 45 Real value	45 R^2	45 r	90 Real value	90 R^2	90 r	135 Real value	135 R^2	135 r
F1	B	1.96 ± 0.196	0.7693	0.871	2.68 ± 0.352	0.89	0.9434	2.93 ± 0.33	0.574	0.7576
	E	1.9 ± 0.132			3.23 ± 0.2			2.68 ± 0.352		
F2	B	3.75 ± 0.33	0.8313	0.9121	6.3 ± 1.1	0.8361	0.9144	5.93 ± 0.7	0.8138	0.9021
	E	3.58 ± 0.79			6.6 ± 0.39			5.86 ± 0.748		
F3	B	1.38 ± 0.23	0.7408	0.8607	1.43 ± 0.09	0.5618	0.7495	1.302 ± 0.184	0.7735	0.8795
	E	1.5 ± 0.352			1.88 ± 0.33			1.633 ± 0.206		

B – Brabender *Extensograph*; E – *Flourgraph E7*. The significance threshold was α = 0.05 and standard deviation represented on the graph was calculated based on 6 flourgrams and 6 extensograms

Table 4 Experimental value and theoretical statistical interpretation correlations index for Ratio number max

Sample	Device	Proving time [min] 45 Real value	45 R^2	45 r	90 Real value	90 R^2	90 r	135 Real value	135 R^2	135 r
F1	B	2.26 ± 0.09	0.7562	0.8696	3.01 ± 0.37	0.9602	0.9799		0.7887	0.8881
	E	2.46 ± 0.154			3.78 ± 0.16					
F2	B	4.07 ± 0.13	0.8122	0.9012	6.37 ± 0.45	8398	0.9164	6.03 ± 0.24	0.8497	0.9218
	E	3.32 ± 0.73			6.72 ± 0.77			3.18 ± 0.35		
F3	B	1.93 ± 0.132	0.6964	0.8345	2 ± 0.08	0.9803	0.9901	4.26 ± 0.088	0.5149	0.7176
	E	2.1 ± 0.15			2.22 ± 0.38			2.13 ± 0,07		

B – Brabender *extensograph*; E – *Flourgraph* E7. The significance threshold was α = 0.05 and standard deviation represented on the graph was calculated based on 6 flourgrams and 6 extensogras

In the ratio of resistance to extensibility, high ratio indicates the short gluten properties resulting in low volume of baked products (**Dapcevic *et al*., 2011**).

In table 3 data are shown for, Ratio number and Pearson Correlations coefficients. For F_1 the ratio number has been correlated thus: at the 45 minutes is a moderate positive correlations, at the 90 minutes is a strong positive correlations and at the 135 minutes is a moderate positive correlations. For F_2 the ratio number has been correlated thus: at the 45 minutes is a strong positive correlations, at the 90 minutes was a strong positive correlations and at the 135 minutes is a strong positive correlations. For F_3 the ratio number has been correlated thus: at the 45 minutes is a strong positive correlations, at the 90 minutes is a moderate positive correlations and at the 135 minutes is a strong positive correlations.

In table 4 data are shown for, ratio number max. and Pearson Correlations coefficients. For F_1 the ratio number max. has been correlated thus: at the 45 minutes is a strong positive correlations, at the 90 minutes is a strong positive correlations and at the 135 minutes is a strong positive correlations. For F_2 the ratio number has been correlated thus: at the 45 minutes is a strong positive correlations, at the 90 minutes was a strong positive correlations and at the 135 minutes is a strong positive correlations. For F_3 the ratio number has been correlated thus: at the 45 minutes is a strong positive correlations, at the 90 minutes is a strong positive correlations and at the 135 minutes is a strong positive correlations

CONCLUSION

Through experimental value and theoretical statistical interpretation correlations index for parameter *Extensograph* Brabender and *Flourgraph E7* was made the following conclusions were reached:

- the values of dough hydration capacity were found to be different but close, depending on the mixing bowl capacity, which influences the degree of dissipation of dough strength,
- a good correlation was found between the values of the measured variables characterizing the viscoelastic properties of dough energy, resistance to extension, extensibility, maximum resistance, ratio and maximum ratio,
- the values of the correlation index were found to range between 0.8 and 0.9, with a few exceptions,
- there was found to be a close correlation between the measured rheological properties of dough: ratio, maximum ratio and maximum resistance.
- the maximum values are for resistance maxim, for F_2 (r = 0.9853), ratio number, for F_2 (r = 0.9121) and ratio number max., for F_2 (r = 0.9218) at 135 minutes.

Both devices can be used successfully to characterize dough-like colloidal mixtures as half-finished products in bread manufacturing.

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