ANALYSIS OF THE GRINDING RESISTANCE RELATED TO THE VITREOUSNESS OF THE WHEAT GRAIN, IN THE FIRST BREAK PROCESS, WITH A NEW DESIGNED MICROMILL

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REZUMAT. Vitrozitatea grâului este o parte importantă a calităţii grâului şi un factor major care afectează ruperea cerealelor. Spargerea bobului de grau în timpul măcinării depinde de caracteristicile calitative ale grâului şi de proiectarea şi funcţionarea morii cu valţuri. Cercetarea prezintă utilizarea unui micromill nou, conceput pentru testarea rezistenţei la măcinare a unui soi de grâu moale şi o varietate de grâu dur. A fost stabilit un model matematic pentru evaluarea consumului de energie în procesul de măcinare a două soiuri de grâu.

Cuvinte cheie: bob de grau, rezistența la măcinare, vitrozitate, moment rezistent, energie.

ABSTRACT. The wheat viteousness is an important aspect of the wheat quality and a major factor affecting breakage of the grain. Breakage of the wheat grain during First Break roller milling depends on the qualitative characteristics of the wheat and on the design and operation of the roller mill. This research is using a new designed micromill for testing the grinding resistance of a soft wheat variety and a hard wheat variety. A mathematical model was established for the assessment of the energy consumption in the grinding process of the two wheat varieties.

Keywords: wheat grain, grinding resistance, vitreousness, resistant moment, energy

1. INTRODUCTION

One of the fundamental means of classifying wheat is through its endosperm texture. It impacts significantly on the milling process affecting among other things flour particle size and milling yield. The vitreous kernel has a smooth surface and is brittle, translucent, and transparent when cut. Starchy grains are differentiated by a total absence of translucent zones and they exhibit a white and opaque endosperm related to the existence of air pockets that diffract and diffuse the light (Hoseney 1986). Vitreous durum wheat kernels produce higher semolina yield and lower percent of flour than their soft counterparts. In addition, the semolina protein content from vitreous durum wheat kernels is higher than that from soft wheat grains (Dexter et al 1988). Wheat grain vitreousness is thus a key factor of the milling performance and the end-use quality of pasta from durum wheat semolina. The genotype, nitrogen fertilization and location are interacting factors affecting vitreousness, with genotype being the most important (Hadjichristodoulou, A. 1979).

2. MATERIALS AND METHODS

The investigations were carried out on Romanian winter wheat varieties (*Triticum aestivum, ssp. vulgare*) Dropia and Pegasus, harvested in 2009. The preparation of the samples colected carried out according to the chess-board pattern method, after cleaning with an Sadkiewicz Instruments Scourer.

The physicochemical characteristics of the wheat were evaluated as follows: the moisture content using the SR ISO 712 : 2005; the wet gluten content, protein content using the NIR technique (Inframatic, model 8600, Perten Instruments AB); vitreous kernel using the STAS 6283-2/1984 (farinotom apparatus, Pohl). The quality indices of the studied wheat varieties are depicted in Table 1.

Before milling, 30 grams of each dry wheat sample was tempered overnight to reach 16 % (optimum) moisture content, wet basis; this toughens the bran and germ and softens the endosperm, making the separation of endosperm from germ and bran easier. The samples of Dropia wheat variety (27 % vitreousness) were tempered for 5 hours to 16 % moisture content. The samples of Pegasus variety (73 % vitreousness) were tempered for 9 hours to the same level of moisture, 16 %. The samples have been grounded grain by grain.

Table 1. *Quality indices of the wheat varieties*

Indicator \ Variety	Dropia	Pegasus
Hectolitric weight [kg/hl]	77,6	77,4
Vitreousness [%]	27	73
Wet gluten content [%]	21	32,4
Moisture content [%]	11,3	10,1
Falling number [s]	260	333
Protein content [%]	10,8	15

The first break was performed by the new designed micromill which can perform in the grinding process of the wheat and of the middling too, for the appreciation of the grain resistance (specific surface energy consumption) in the milling process, in the same conditions as in the milling industry. The adjustment of the roller characteristics can be done for each type of milling product (grain, semolina, bran). The grains are in the same time under the compression and the shearing efforts.The energy consumption is represented by one single value for one pair of rollers. This single value is significant for the comparative appreciation regarding the energy consumption in the milling process, for different wheat varieties or different batches, but also for different characteristics of the rollers: the size of the gap, roll disposition sharp-to-sharp, sharp-to-dull, dull-to-sharp or dull-to-dull, the corrugations number/cm, the differential speed ratio, profile and inclination (Fang, C., Campbell, G. 2002a, 2003a).The micromill is equipped with rolls measuring 50 mm in length and 90 mm in diameter, 0,3-0,7 mm roll gap for the first breaking step, 9 corrugations/cm, roll disposition sharp-sharp (S/S), 2,5:1 differential speed ratio, 8% inclination and 30/60^0 (α/β) profile.To ensure the proper balance and the efficiency of the breaking operation was used the test sifter from Retsch Gmbh with six assortment of sieves (1,25 mm, 630 µm, 400 µm, 315 µm, 250 µm and 160 µm). The wheat grinding in the first breaking step gives the variation of the cereals resistant moment in the process. The resistant moment of the particles grounded between the rollers, is measured by a tensometric cell, conected to a PC computer and managed with a software program. The measurements of the resistant moment of the kernel, between the rollers, in the first breaking step lead to the appreciation of the energy consumption (kJ/kg).

3. RESULTS AND DISCUSSION

The resistent moment obtained for both wheat varieties is represented in the Fig. 1. The highest values are coressponding to the hard wheat variety Pegasus (73 % vitreousness).

It was made the same experiment for Dropia and Pegasus samples, using three different distances between the rollers: 0,3 mm, 0,5 mm and 0,7 mm. The obtained data are giving the possibility to study an evolution model for the resistant moment (Y) related to the distance between the rollers (X). This model will indicate the highest consuming energy variety of wheat, related to the vitreousness of the samples.

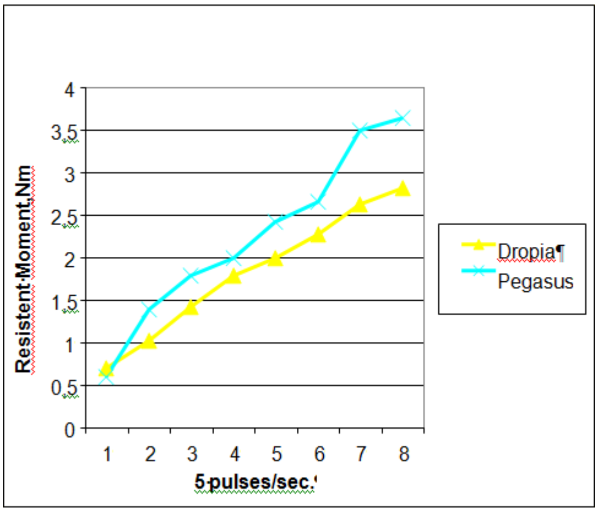

Fig. 1 *The resistant moment for the two wheat varieties*

a) Dropia variety (soft wheat)

The statistical values are depicted in Table 2 and represented in Fig. 2.

Table 2 *Data distribution for Dropia variety*

Resistant moment, Y			Rollers gap, X [mm]			Total
			(0.1; 0.3]	(0.3;0.5]	(0.5;0.7]	
Interval		Average	0.2	0.4	0.6	
10.440	8.682	9.561	3	0	0	3
8.682	6.923	7.803	2	0	0	2
6.923	5.165	6.044	1	0	0	1
5.165	3.407	4.286	1	0	0	1
3.407	1.649	2.528	1	5	4	10
1.649	0.620	1.134	0	3	4	7
Total			8	8	8	24

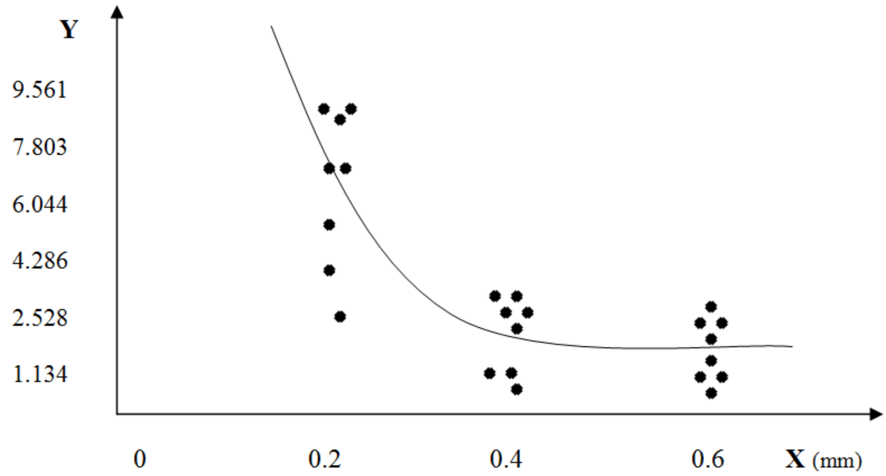

Fig. 2 *Statistical distribution of the resistant moment values for Dropia variety*

From the Fig. 3 it can be seen that the regression function is hyperbolic.

$$Y(X) = a + b \cdot \frac{1}{X} + \varepsilon$$

The parameters of the function are reduced to the liniar model with the substitution Z=1/X. It is obtained a new function:

$$Y(Z) = a + b \cdot Z + \varepsilon$$

$$b = \frac{M(ZY)\text{-}M(Z)\cdot M(Y)}{M(Z^2)\ \ -[M(Z)]^2}$$

$$a = M(Y) - b \cdot M(Z)$$

Where: M(Y)= 3,66;
M(Z)= 3,06;
$M(Z^2)$= 11,34;
$[M(Z)]^2$ = 9,34;
M(ZY) = 14,60;
and : b = 1,70;
a = - 1,54.

So, the hyperbolic regression function is:

$$Y(X) = -1{,}54 + 1{,}70 \cdot \frac{1}{X} + \varepsilon \quad (1)$$

$$R_{ZX} = \frac{M(ZY)\text{-}M(Z)\cdot M(Y)}{\sigma_Z \cdot \sigma_Y}$$

It were calculated the variance and the standard deviation for the two variables:
σ_y^2 = 8,43,
σ_y = 2,90,
σ_Z^2 = 2,01,
σ_Z = 1,42.

R_{ZX} = 0,83 the significance of this value is that there is a 83% representatively for modelling the resistant moment related to the rollers gap .

b) Pegasus variety (hard wheat)

The statistical values are depicted in Table 3 and represented in Fig. 3

Table 3 *Data distribution for Pegasus variety*

			Rollers gap, X [mm]			Total
Momentul rezistent, Y			(0.1; 0.3]	(0.3;0.5]	(0.5;0.7]	
Interval		Mijloc	0.2	0.4	0.6	
11.570	9.602	10.586	3	0	0	3
9.602	7.635	8.618	2	0	0	2
7.635	5.667	6.651	2	0	0	2
5.667	3.699	4.683	1	0	0	1
3.699	1.731	2.715	0	6	4	10
1.731	0.580	1.156	0	2	4	6
Total			8	8	8	24

From the Fig. 3 it can be seen that the regression function is hyperbolic.

$$Y(X) = a + b \cdot \frac{1}{X} + \varepsilon$$

The parameters of the function are reduced to the liniar model with the substitution Z=1/X. It is obtained a new function:

$$Y(Z) = a + b \cdot Z + \varepsilon$$

$$b = \frac{M(ZY)\text{-}M(Z)\cdot M(Y)}{M(Z^2)\ \ -[M(Z)]^2}$$

$$a = M(Y) - b \cdot M(Z)$$

Where: $M(Y)= 4{,}21$; $M(ZY) = 16{,}97$

$M(Z)= 3{,}06$;

$M(Z^2)= 11{,}34$; And: $b = 2{,}04$;

$[M(Z)]^2 = 9{,}34$; $a = - 2{,}03$

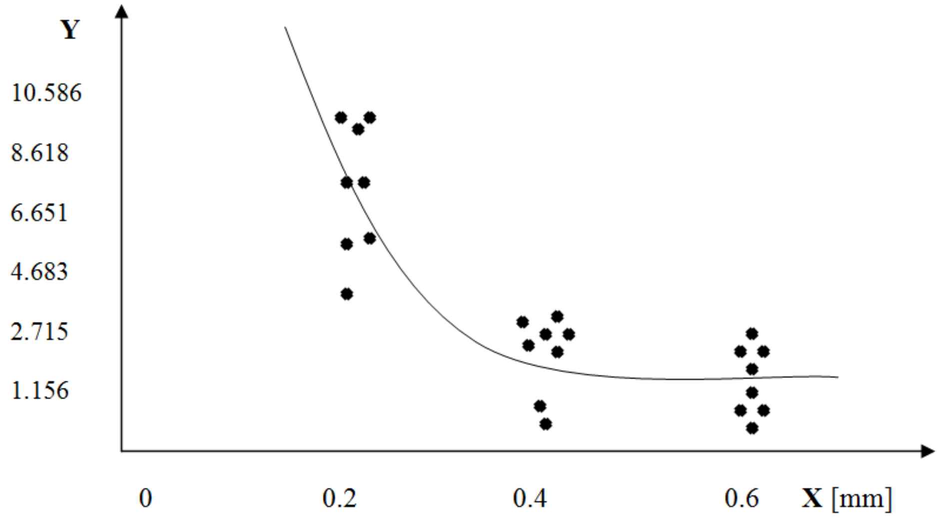

Fig. 3 *Statistical distribution of the resistant moment values for Pegasus variety*

So, the hyperbolic regression function is:

$$Y(X) = -2{,}03 + 2{,}04 \cdot \frac{1}{X} + \varepsilon \quad \textbf{(2)}$$

$$R_{ZX} = \frac{M(ZY) - M(Z) \cdot M(Y)}{\sigma_Z \cdot \sigma_Y}$$

It were calculated the variance and the standard deviation for the two variables:

$\sigma_y^2 = 10{,}47$; $\sigma_y = 2{,}90$; $\sigma_Z^2 = 2{,}01$; $\sigma_Z = 1{,}42$.

$R_{ZX} = 0{,}89$ there is a 89% representatively for mode-lling the resistant moment related to the rollers gap .

The resistant moment for each variety can be calculated using the function (1) for Dropia and (2) for Pegasus, for the same roller gap value. For example, when d= 0,4 mm :

$Y_{Dropia}(0{,}4) = -1{,}54 + 1{,}70*(1/0{,}4) = 2{,}71$

$Y_{Pegasus}(0{,}4) = -2{,}03 + 2{,}04*(1/0{,}4) = 3{,}07$ – a higher resistant moment value for Pegasus then Dropia variety.

4. CONCLUSIONS

The micromill is ideal for testing improved wheat cultivars developed in breeding programs.

The new designed micromill can be used for the assessment of the energy consumption

for the first break, in the laboratory conditions, for the benefice of the students.

Depending on the wheat variety related to vitreousness, it is possible the adjustment of the micromill parameters from the point of view of technological efficiency and the energy consumption. A higher resistant moment was obtained for an increased number of grains (from 1 grain to 8); when the gap between the roll decrease, the resistant moment increase. Also there is a higher resistant moment value for a higher vitreousness of the grain. A higher vitreousness means higher demands in the grinding process regarding the energetic consumption.

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