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ORIGINAL ARTICLE

MICROMILL DESIGNED FOR THE MEASUREMENT OF THE WHEAT KERNEL GRINDING RESISTANCE, IN THE GRINDING PROCESS

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In the era of global slowdown and recession, saving energy becomes a ”must have” characteristic of every industrial consumer. In the industrial milling process of the wheat, 60-75 % of the total specific energy consumption is used in the grinding process. The measurement of the grinding resistance of the wheat kernel can estimate the energy consumption in the grinding process and can lead to a diminution of the total energy consumption, in the milling process.

Key words: wheat, grinding resistance, resistant moment, milling process

1. Introduction

The wheat grain mechanical resistance is usually assessed on the basis of kernel hardness tests as described by Pomeranz and Williams (1990). Penetration tests and crush resistance tests are performed using one single wheat kernels but have to be replicated with many kernels to obtain statistically representative results. But the measurements are not very accurate because of the shape and the size of the wheat grain.

This is the reason why a grinding resistance appreciation was performed by a micromill reproducing the same conditions of the industrial milling process.
The industrial grinding of the wheat is using two rollers with differential speed. The grains are at the same time under the compression and the shearing efforts. There are no shearing efforts and maximum compression efforts when the rollers have the same speed. The shearing effort appears when the rollers have a differential speed. In the grinding process, the speed ratio (k) between the fast speed roller and the low speed roller is from 1:1.5 to 1:2.5. The energy consumption during milling depends on the mill adjustments (Scanlon and Dexter 1986). The new designed micromill determines the grinding resistance of the cereal grain by simultaneous measurements of the compression efforts and the shearing efforts.

2. Materials and methods

Five Romanian common wheat, Apache, Apullum, Boema, Dropia and Flamura varieties (harvest 2008), were used in the study.
The physico-chemical characteristics of the wheat were evaluated as follows: the moisture content using the SR ISO 712 : 2005; the wet gluten content and hardness using the NIR technique (Inframatic, model 8600, Perten Instruments AB); test weight using the SR ISO 7971-2 : 1995; thousand kernel weight using STAS 6123/1 : 1963; vitreous kernel using the STAS 6283-2/1984.
The quality indices of the studied wheat varieties are depicted in Table 1.

The micromill is used in the grinding process of the wheat and of the middling too, for the appreciation of the grain resistance in the milling process, in the same conditions as in the milling industry.

Table 1. Quality indices of the wheat varieties

Cultivar / Indicator	Apache	Apullum	Boema	Dropia	Flamura 85
Test weight [kg/hl]	81.1	84.1	81.9	83.8	83.6
Vitreous kernel [%]	38	40	33	36	37
Hardness [%]	114	116	119	122	123
Gluten content [%]	22.2	20.3	23.3	25.3	25.1
Moisture content [%]	10.2	10.4	10.1	10.2	10.3
Thousand kernel weight [g]	34.03	37.78	42.07	42.03	42.34
The number of the grains in 100 g	2639	2372	2137	2137	2119

The micromill is equipped with rolls measuring 50 mm in length and 90 mm in diameter. The rollers are either smooth or corrugated (Fang, 2002; Campbell, 2003). The smooth rolls are mainly used in the final reduction and refining steps with soft wheat semolina. The adjustment of the roller characteristics can be done for each type of milling product (grain, semolina, bran).

The grinding resistance is represented by one single value for one pair of rollers, instead of two values (one for the slow roller and the other one for the fast roller) obtained by other measurements (Pujol *et al.*, 2000). This single value is significant for the comparative appreciation regarding the energy consumption in the milling process, for different wheat cultivars 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 (Campbell, 2007). The appreciation of the grinding resistance is made by measurements of the resistant moment of the kernel, between the rollers, in the breaking process.

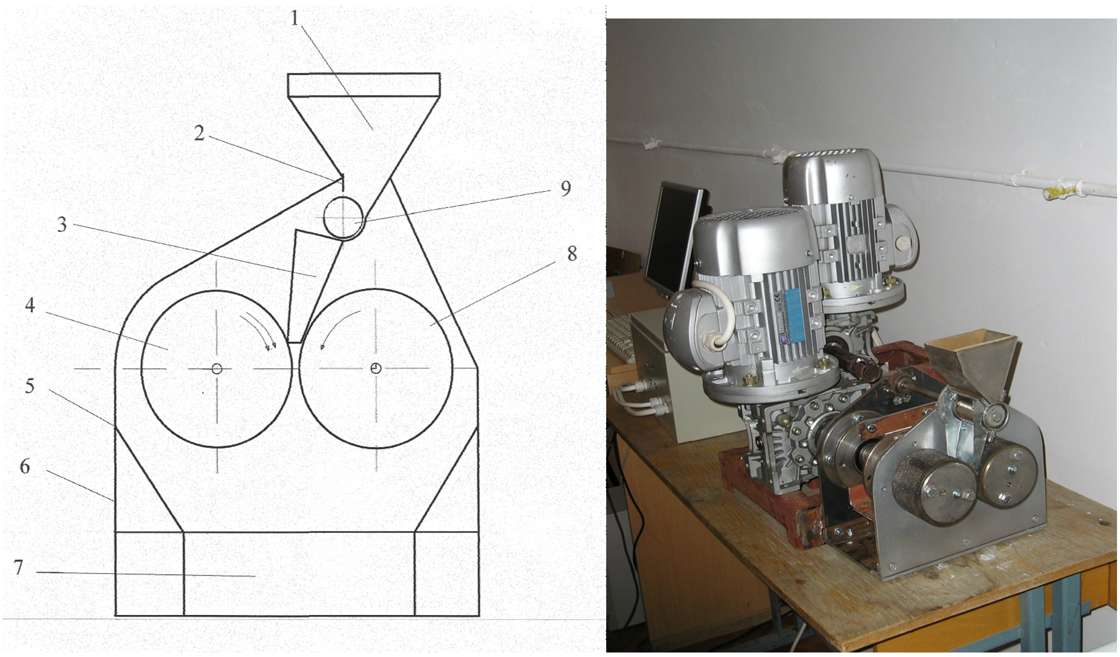

Figure 1. The micromill components

The cereal particles to be milled are fed in the bunker supply 1 (Figure 1). The clamshell 2 assures the feed rate control over the milling stock. The feed roll 9 is designed to distribute uniformly the milling stock over the rolls. The particles of the cereals are sent by the funnel 3 on the corrugated rolls, the fast speed roll 4 and the slow speed roll 8. After the grinding process, the product is collected by the collection box 7 and then analysed to make a comparison between the initial and final granularity of the particles, for obtaining the grinding degree. The micromill has a metal case 6 with a transparent window 5.

3. Results and Discussion

The resistant moment of the particles grounded between the rollers, is measured by a tensometric cell, connected to a PC computer and managed through a software program.

From the results of the experiments (Figures 2, 3 and 4) the curves of the resistance moment variation were obtained using corrugated break rollers with a fast roll speed of 500 rpm, a roll differential speed of 2.5, 5 corrugations/cm, 1 mm roll gap, with a dull-to-dull roll disposition and differential speed (1:2,5).

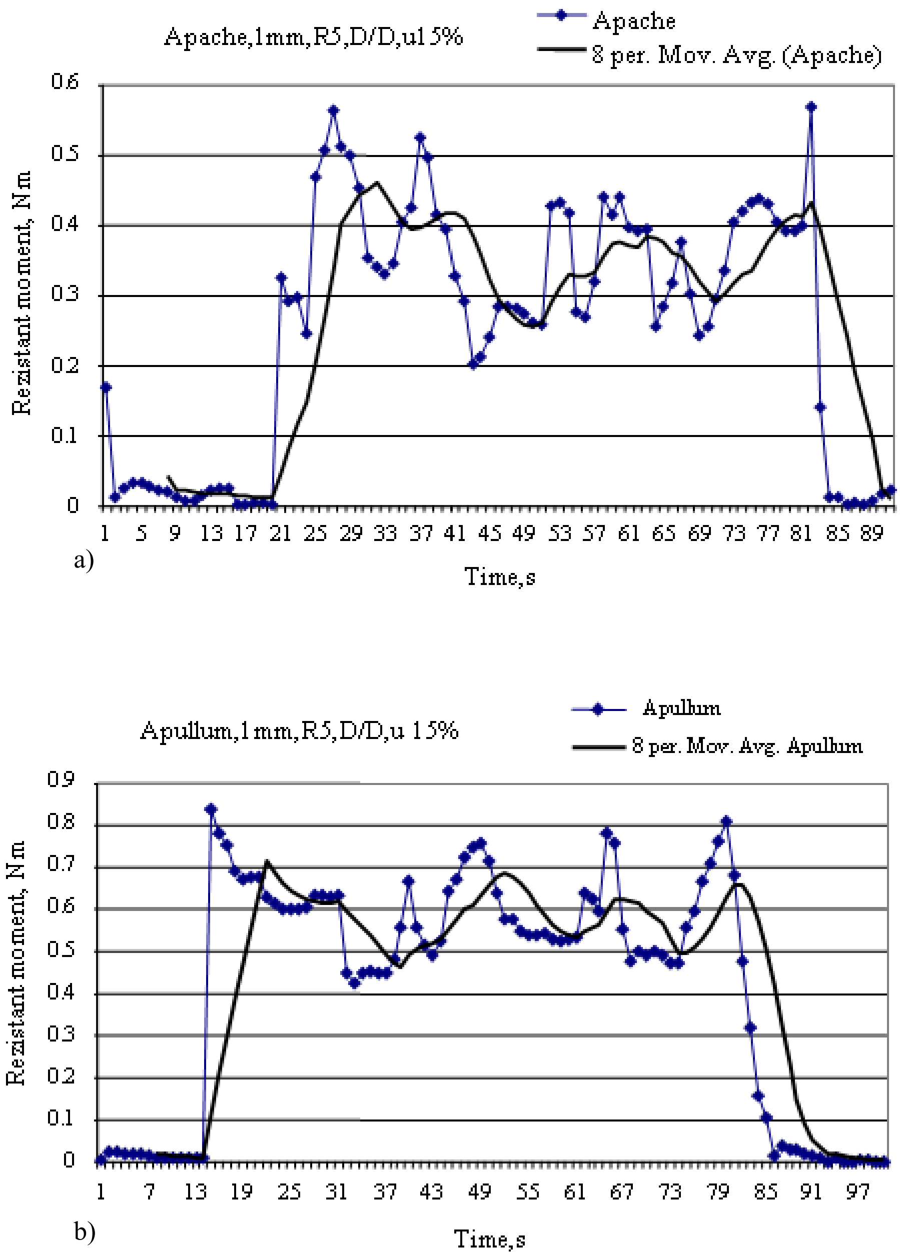

Figure 2. The variation of the resistant moment for Apache (a) and Apullum (b) varieties

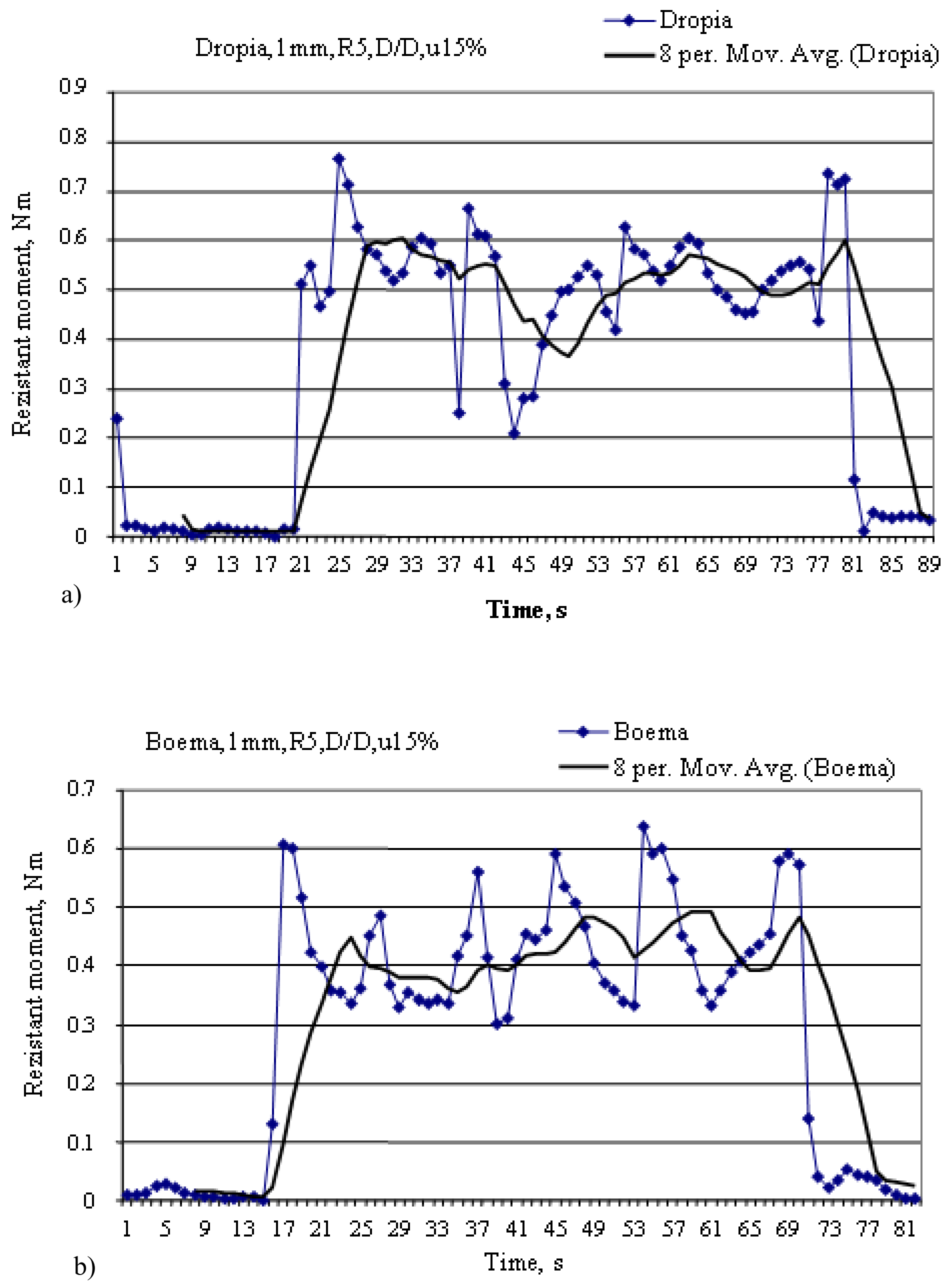

Figure 3. The variation of the resistant moment for Dropia (a) and Boema (b) varieties

Analysing the obtained curves, the following parameters could be determined (Table 2):
- the maximum resistant moment (Nm)
- the average resistant moment (Nm)

Table 2. Maximum and average resistant moment, for the 5 wheat varietes

Wheat Varieties	Apache	Dropia	Apullum	Flamura	Boema
The average resistant moment (Nm)	0.257333	0.366486	0.415877	0.335858	0.296438
The maximum resistant moment (Nm)	0.567999	0.763709	0.838879	0.751937	0.637160

A higher resistant moment was obtained for an increased number of grains; when the gap between the roll decreases, the resistant moment increases. Also, there is a higher resistant moment value for a higher vitreousness of the grain. The Apullum variety has the highest resistant moment, related to the highest value of the vitreousness.

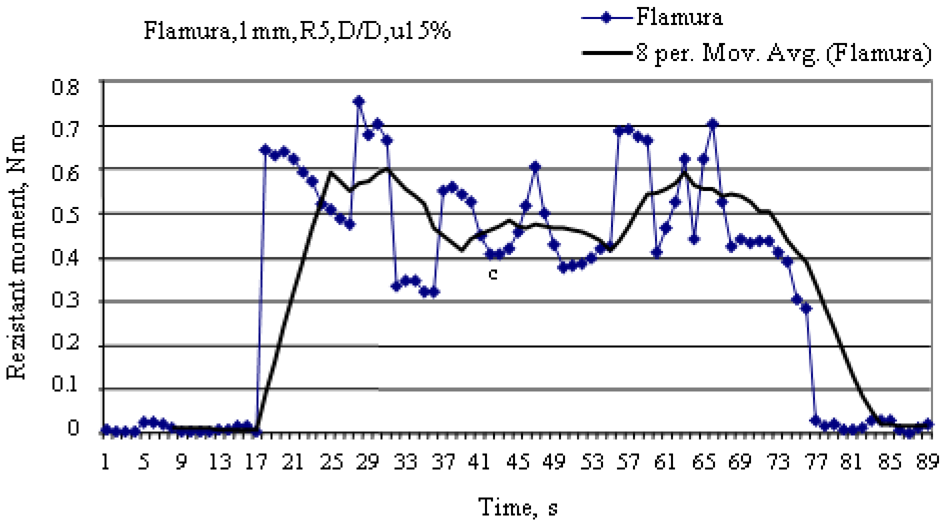

Figure 4. The variation of the resistant moment for Flamura variety

The micromill designed for the determination of the grinding resistance of cereals, can be used in an industrial mill plant, because it has the advantage of obtaining the cumulative compression and shearing efforts the same as in the industrial process.

The resistant moment can be obtained also for the middling grinding process, step which can lead to the economic optimization of the cereal processing.

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

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