MILLING PROPERTIES OF SOME ROMANIAN RYE VARIETIES

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Abstract: The milling properties of cereals can be investigated through their milling at laboratory aggregates. The milling indices can be calculated on the basis of the experimental results. In this article we have investigated the milling properties of four Romanian rye varieties. The milling has been made at the Buhler laboratory aggregate using a modified technical scheme (with pre-grinding). The values obtained for the milling indices calculated are inferior to those mentioned in the literature for wheat. The experimental results pointed out the contribution of the main physical properties of rye to the intrinsic milling value, as well as the importance of some factors related to the milling aggregate, to the technical scheme used.

Keywords: *rye, milling properties, Buhler laboratory aggregate*

INTRODUCTION

The milling value is given by a series of milling indices for whose determination it is necessary to equip the laboratories with experimental milling devices.

The methods used in performing the experimental milling tests are shown in *Approved Methods of the AACC* and *Standard Methods für Getreide, Mehl und Brot*. In chapter 26 [8] ("Experimental (Test) Milling") of Approved Methods of the AACC are described several experimental milling tests for soft and rough wheat, tests that have been performed with Quadrumat Jr and Buhler laboratory aggregate. In *Standard Methoden für Getreide, Mehl und Brot* [6] are shown, besides the methods used in the experimental determination of the soft, rough and alac wheat, those methods used to determine the milling properties of rye using Buhler laboratory aggregate. Nevertheless, we estimate that complete standardizing of the procedures used in performing experimental milling cannot be done out of objective reasons (the particularity of cereals in different geographical areas, different milling devices etc.).

It is important that the cereal quality testing devices should ensure a series of elements that could enable the comparison of results obtained after the tests with those obtained in the industrial milling.

The general analysis of the milling technological process is made on the basis of a qualitative and quantitative milling balance.

The basic demand at the reception of cereals as raw material in the milling industry refers to the necessity that they ensure the possibility of getting a maximum quantity of quality flour at the best production price. The phrase that expresses this quality of a cereal lot is "milling value". The literature defines "extrinsic milling value" and "intrinsic milling value" [3]:

- - "extrinsic milling value" refers to the cereal lot that is not prepared for the milling, before the cleaning process; anything that is not "healthy, clean or sellable" is to be cast out of the cereal mass;
- - "intrinsic milling value" refers to the clean cereal lot that is ready to be ground.

The intrinsic milling value is influenced by the physical properties of cereals: size and size uniformity of grains, 1,000 kernel weight, volume of 1,000 kernel, specific mass, glassiness and hectolitre mass. It can quantified by means of some milling indices that express the utilization potential of the respective cereals in the milling industry: the value index of ash, the value index of flour ash, the index of the ash curve, the contents of starch in bran, R-coefficient.

The data in literature referring to milling properties of rye are less, the majority of works making references to milling properties of wheat.

The objective of the article is to achieve a systematically study of the milling properties of some Romanian rye varieties of large cultures.

MATERIALS AND METHODS

The rye varieties analyzed are Orizont, Gloria, Suceveana (autumn varieties), Impuls (spring variety), provided by S.C.A. Suceava.

The experimental milling has been made at the Buhler laboratory aggregate using a technical scheme made of one passage of pre-grinding, three break roller passages, three reduction passages [1]. The technical characteristics of the Buhler laboratory aggregate are shown in table 1.

The ash curves of flour and bran have been made according to the method described by Moraru and Tarabiono. By means of these curves, we have calculated the index of the ash curve: for the extraction area of 30% and 70 % we have measured the value of the Lx cord. In the same time, we have measured Dx for the extraction of 50%. The index of the ash curve has been calculated with the relation IC = Lx – 2Dx. The method is described by Moraru.

The value indices of ash, flour (AWZf) and bran (AWZt) have been calculated function of the ash contents of flour, bran and the extraction of the two milling products in accordance with Moraru's method (1988): $\frac{c_F}{Ex_F} \cdot 10^5$ (AWZf), $\frac{c_T}{Ex_T} \cdot 10^5$ (AWZt).

The R-coefficient which indicate the variety potential to achieve flour extraction and its quality expressed through the ash contents of flour compared to the ash level of the grain was calculated with relation $R = Ex_F \cdot \frac{c_{bob}}{c_F}$.

The starch content in bran has been identified through the polarimetric method [7]. The physical indices of the rye varieties have been identified as follows: the hectolitre mass STAS 6123/2-73, the 1,000 kernel weight – STAS 6123/1-73, glassiness STAS 6283/2-84, the volume of 1,000 kernel – the method with kerosene [4], the apparent specific mass [4]. The medium dimensions of grains have been determined on the basis of dimensional parameters [3, 4]. We have made three determinations, calculating the mean, the standard deviation, the range and the coefficient of variation. The results have been processed using Statistics for Windows 4.3.

Table 1. *Technical characteristics of Bühler laboratory milling*

Technical characteristics	Technical passage						
	Pre-ground	1st Break (B1)	2nd Break (B2)	3rd Break (B3)	1st R (C1)	2nd R (C2)	3rd R (C3)
Notches / cm	7	7	8	9,5	-	-	-
Drall, %	5	5	6	8	-	-	-
Roll spacings, mm	0,6	0,6…..…………………..…0,15				0,1……………0,1	
Length / Diameter, mm	40 / 130	40 / 130	90 / 130	70 / 130	90 / 130	70 / 130	40 / 130
Roll relative place	T / T	T / T	T / T	T / T	-	-	-
Outlying speed ratio	1 : 2	1 : 2	1 : 2	1 : 2	1 : 2	1 : 2	1 : 2
Sieves face, m^2	-	0,143	0,143	0,143	0,143	0,143	0,143
Size sieves	-	30 VIII	30 VIII	30 VIII	VIII X	VIII X	VIII X
Action	N = 0,5 kW Φ_{motor} = 80 mm $\Phi_{rapid\ roll}$ = 260 mm n_{motor} = 1405 rot/min $v_{rapid\ roll}$ = 5,87 m/s						

RESULTS AND DISCUSSION

The extraction of products achieved at every technological passage is summarized in the quantitative balance shown in Table 2.
The evolution of the flour extraction, from every technological passage for each rye variety can be seen in Figure 1.
From the analysis of the experimental results mentioned above, we could see that the highest extraction has been made in C1. For the spring varieties (Impuls), the flour extraction made at M1 has been smaller compared with the autumn varieties, but the quantity of short obtained as rejection at C3 has been bigger. For this variety, the roller mill length provided with smooth rollers cannot process to a large extent the intermediary products that feed M1, so that part of these products are rejected at M3, getting in short instead of getting in flour. The flour extraction made at the reduction passages is close enough to the one achieved at the break roller passages (Figure 2).

Table 2. *The quantitative and qualitative balances for experimental milling**

Technical passage	Technical passage							Products		
	Pre-ground	% unto B1	B2	B3	C1	C2	C3	Flour	Bran	Short
Pre-ground	100	-	-	-	-	-	-	-	-	-
B1	-	100	71.6	-	22.1	-	-	6.3	-	-
B2	-	71.6	-	49.7	12.5	-	-	9.4	-	-
B3	-	49.7	-	-	6.4	-	-	7.2	36.1	-
C1	-	41	-	-	-	22.8	-	18.2	-	-
C2	-	22.8	-	-	-	-	15.8	7	-	-
C3	-	15.8	-	-	-	-	-	3.4	-	12.4
Total	100	-	71.6	49.7	41	22.8	15.8	51.5	36.1	12.4

* the values mentioned in the table represent the average extraction of the 4 rye varieties that have been analyzed.

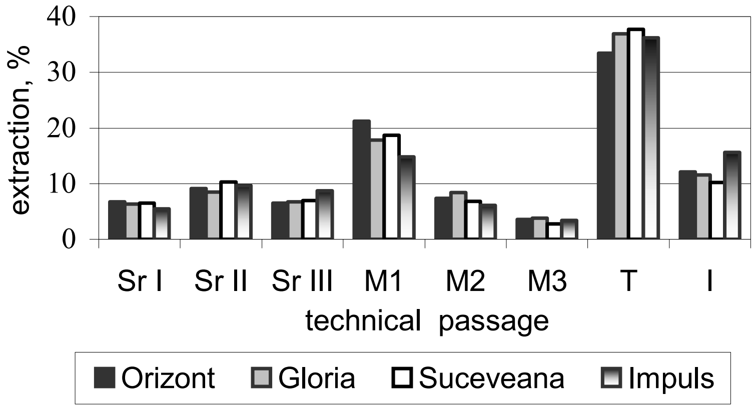

Figure 1. *The evolution of the product extraction at the technological passages of the Buhler laboratory aggregate*

The average milling indices, calculated on the basis of the results obtained through rye milling are shown in Table 3, and those for every variety are shown in Figure 3.

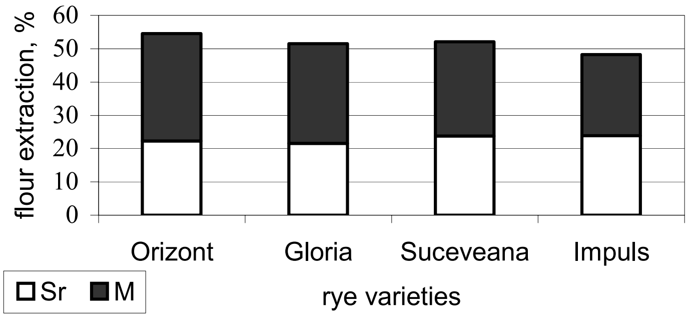

***Figure 2.** The evolution of the flour extraction at the break roller and reduction passages*

***Table 3.** The medium milling indices for rye*

Milling indices	Simple statistics		
	Mean ± SD	Confidence Level	CV
Value index of bran ash, AWZt	6370 ± 784	1789	12,3
Value index of flour ash, AWZf	1184 ± 29	68	2,46
R - coefficient	153 ± 16	35	10,36
Indices of the ash curve, IC	38,2 ± 6,5	13,6	16,8
Starch contents in the bran, %	38,4 ± 1,4	3, 3	3,67

SD = standard deviation, CV = coeffficient of variation

From the analysis of these data, it is to understand that Orizont and Impuls have the best behavior during the milling process. The highest R-coefficients, that indicate the potential of the variety to achieve flour extraction and its quality expressed as the ash contents of flour compared to the ash contents of the grain, have been obtained for Impuls and Orizont (170.7, respectively 160.9), and the smallest for Gloria (135.2). The values obtained for these indices are inferior to those mentioned in the literature for wheat [2]. The high values of the index of bran ash, AWZt, and the smallest ones of the flour ash AWZf, show a good separation of the endosperm from the layers. As for the chart, these indices equal 700-800 for AWZf, respectively 10,000 for AWZt. Smaller values for AWZt and higher for AWZf in rye milling are due to the high degree of adherence of the endosperm to the layers; but also to the impossibility of achieving moistening at the level of wheat, 15 – 15.5% at B1 because of the compositional particularities of rye which determine, in the case of moistening, a high plasticity that make more difficult the milling process.

The degree of separation of the endosperm from the layers has been appreciated through the determination of the starch contents in bran. The presence of starch in bran indicates the presence of the endosperm; the smallest percentage, and therefore the best utilization of the rye grain, has been obtained for the same Orizont.

In Figure 4 we show ash curves for flour (b) and bran (c) function of the extraction for Orizont. The parameters that allowed tracing these curves are mentioned in Table 4.

Comparing the flour extractions determined practically with those theoretically calculated (Table 4), on the basis of ash balance in the raw material (rye) and the finite products obtained, we can notice that the flour practical extractions are higher due to the participation of a part of layers – bran in the formation of flour. In the theoretical milling curve (a), represented as the “extraction – ash contents” curve (Figure 4), is pointed out, in the first part, the ash contents of the endosperm represented as a dotted horizontal line, and in the second part it is pointed out the ash contents of the mixture formed of endosperm and bran, represented by the line inclined to the value of 100%. The practical results are represented by a curve whose extremities coincide with those of the lines mentioned before. We can say that the first flour percentage extracted lack bran whereas the last fractions of bran lack flour. The extraction of the following bran fractions is practically impossible to achieve without driving along some fine particles of bran. These are considered to be mixtures of pure flour with pure bran. So, at the beginning and the end of the milling, the practical efficiency is close to the theoretical one, and in the central area there are two mixed products. On the basis of the ash curves for flour (b) and bran (c) we can calculate flour mixtures with different ash contents which is very important in the industrial practice [5].

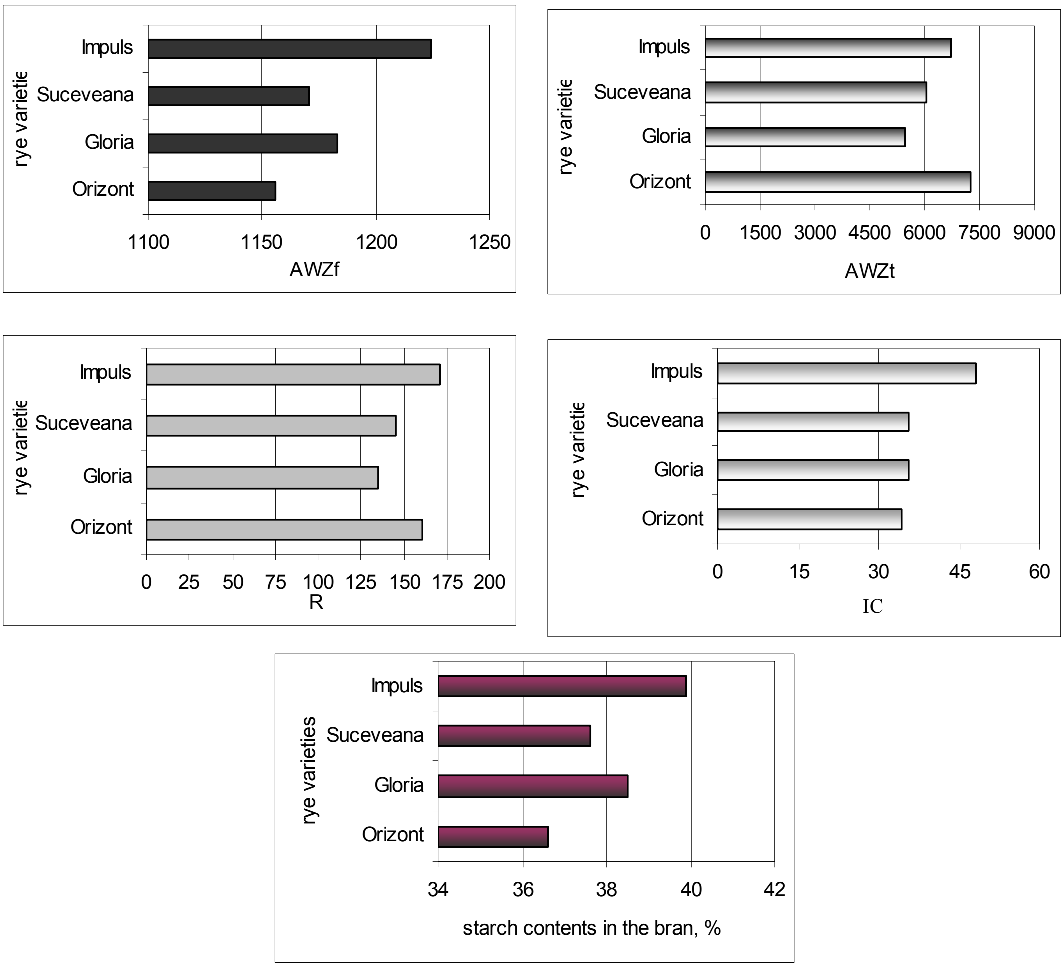

Figure 3. *The milling indices of the rye varieties analyzed*

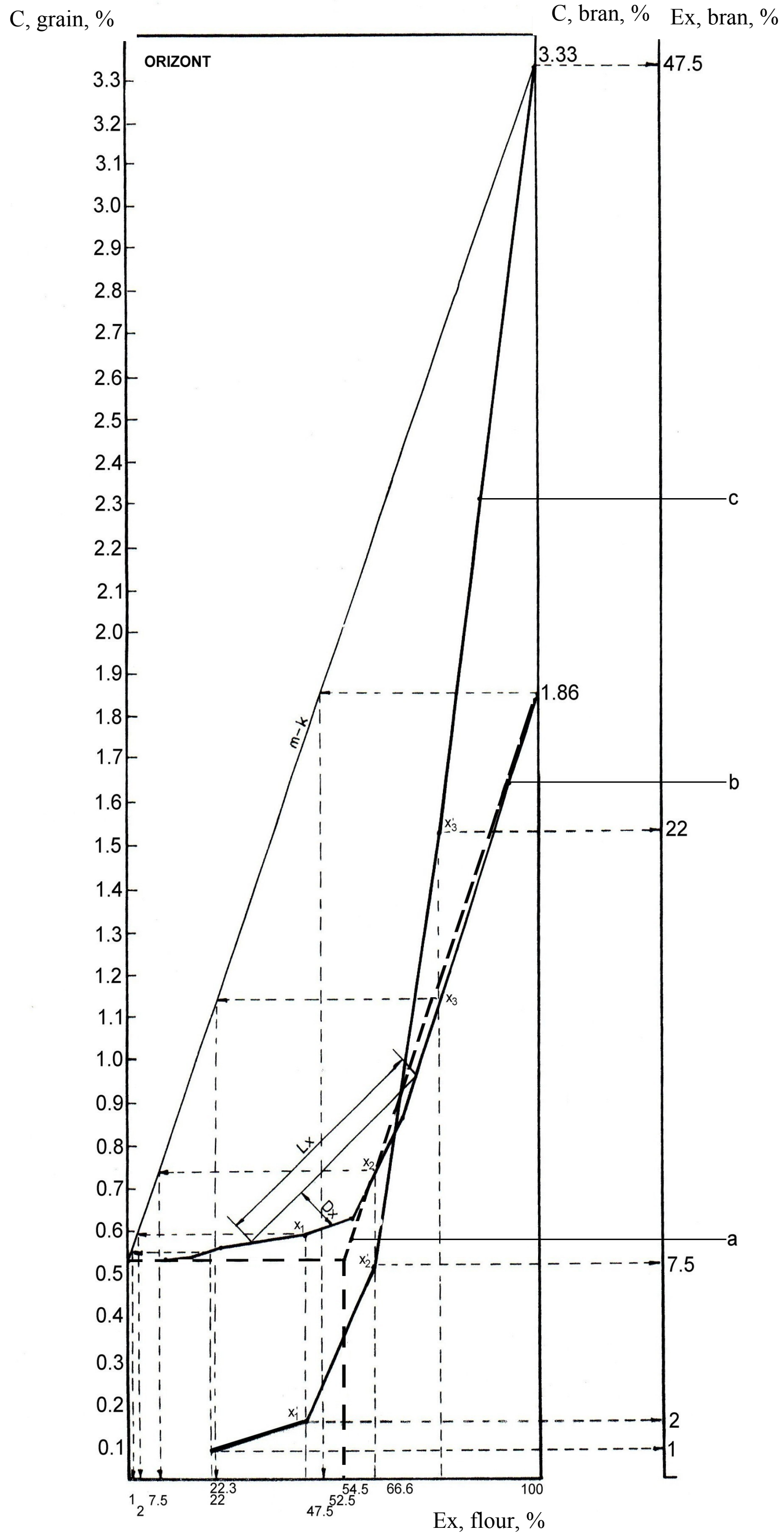

Figure 4. *The ash curves for flour (b) and bran (c), function of extraction – Orizont variety (b'- Mohs curve, a- theoretical milling curve)*

Table 4. *Parameters used for tracing the curves for bran and ash flour*

Parameters	Mean ± SD	Confidence level	CV
m, ash contents of the endosperm, %	0.52 ± 0.014	0.022	2.692
k, ash contents of the bran total fractions (short and bran)	3.09 ± 0.387	0.617	12.52
g, ash contents of the rye, %	1.812 ± 0.213	0.34	11.75
M, extraction theoretically, %	50.51 ± 2.763	4.396	5.47
K, extraction theoretically of the bran, %	49.48 ± 2.763	4.396	5.58

In Table 5 we show the main physical indices of the analyzed rye varieties. The hectolitre mass is a physical indicator with direct influences on the flour extraction, which can be obtained from a cereal lot. The linear coefficients that correlate the hectolitre mass and the flour extraction (Table 6) have been bigger than the ones found by Mangels and Sanderson +0.762 and Sheney +0.744 [4] for wheat.

Table 5. *Average physical indices of the analyzed rye varieties*

Physical indices	Rye		
	Mean ± SD	Confidence Level	CV
Hectoliter mass, kg/hL	75.3 ± 0.71	1.5	0.943
Absolute mass of 1,000 grains, g	28.6 ± 1.13	2.5	3.951
Volume of 1,000 grains, cm^3	28.8 ± 1.5	0.3	5.208
Specific apparent mass, g/cm^3	1.133 ± 0.026	0.06	2.295
Glassiness, %	27 ± 7.63	15	28.26

Table 6. *Correlation obtained between physical / technological indices*

Physical / technological indices	Coefficients of the correlation equation $y = a + b \cdot x$	Determination coefficients, r^2	Standard error
Extraction (y) / hectoliter mass (x)			
Rye varieties	a = - 168.710 / b = 2.931	0.8285	1.1662
Extraction (y) / absolute mass of 1,000 grains (x)			
Rye varieties	a = 7.552 / b = 1.549	0.5781	1.8293
Extraction (y) / volume of 1,000 grains (x)			
Rye varieties	a = 11.944 / b = 1.388	0.8206	1.1930
Extraction (y) / specific apparent mass (x)			
Rye varieties	a = 126.510 / b = - 65.903	0.5679	1.8513
Extraction (y) / mean dimension of grains (x)			
Rye varieties	a = 9.202 / b = 9.557	0.4484	2.0919
Extraction (y) / glassiness (x)			
Rye varieties	a = 55.357 / b = - 0.107	0,3798	2,2181
Rye autumn varieties	a = 49.357 / b = 0.132	0.6316	1.0957

Its flour extraction and ash contents are directly influenced by the size of grains, due to the large surface of layers in the case of small grains. The 1,000 kernel weight is considered to express indirectly the size of grains. From the analysis of the results, we can remark the decrease of flour extraction through the milling of the average smaller grains. The correlation that we obtained between the flour extraction and volume of

1,000 kernel has been higher than the ones between the flour extraction and the 1,000 kernel weight. We appreciate that the volume of 1,000 kernel indicates more precisely the size of grains than 1,000 kernel weight. The correlation between the flour extraction and the glassiness improves when only autumn varieties are analyzed which can be explained by the fact that in the case of Impuls variety, the resistance of the endosperm determined by the glassiness of grains, impose a more intense action to the roller notches or the necessity of using a longer break roller line. In this case, the factors related to the Buhler milling aggregate and the technical scheme seem more important.

CONCLUSIONS

The results obtained indicate Orizont variety as having the best behavior in the process of milling.
The values obtained for the milling indices calculated on the basis of the experimental results are inferior to those mentioned in the literature for the wheat. The experimental results pointed out the contribution of the physical properties of rye to the intrinsic value of milling.

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