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RELATIONSHIP BETWEEN THE TECHNOLOGICAL AND AGROPHYSICAL CHARACTERISTICS ON SZEGED WINTER WHEAT VARIETIES

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SUMMARY

This paper outlines a new method of determining wheat kernel hardness. The investigation is based on the fact that the grinding resistance measured by the granulometric characteristics registered during grinding is different for each wheat variety, and is the primary physical feature of a given kernel structure.

The method uses a hammermill of a simple, practical structure to grind wheat, which is followed by screen analysis. Grinding resistance (kWh/ cm^2) can be calculated from the energetic data (tested during the grinding process) the resulting new grinding surface values. Of all known kernel hardness investigation methods this new is the only one, which considers not just crumbling force but the fineness of grits (average grits size, specific surface increase) as well.

To compare results 21 Hungarian aestivum varieties were tested the kernel hardness was determined with Perten`s device SKCS 4100 and with the new grinding method. The results coming from Perten`s device and those from the Hungarian method showed similar kernel hardness classes.

Both methods for measuring kernel hardness show medium strong, significant correlation with the valorigraph flour test values and the alveograph reological test values.

1. INTRODUCTION

The quantitative and qualitative parameters of ground flour can usually be safely predicted from the inner structural characteristics of the wheat grain. A hard endosperm structure is closely connected with flour yield, a bigger water absorbing capacity, bread volume and other important quality indices (Bedő et al. 1998, Láng et. al. 1999, Vida-Bedő 1999). According to Meppelink (1974) determining kernel hardness can be correct with almost all kinds of grinding machines (hammer-mill, drift-mill, disk-mill, stone-mill) provided the conditions of grinding are of fixed parameters. The operation of both the Moloquant device (Szániel 1986, Kertész 1987) and Brabender's durograph (Miller et al. 1981) is based on the principle of impact grinding but neither is much used.

The device of the Perten company (SKCS 4100 type) brought a breakthrough in the elimination of the difficulties during the investigation of kernel and item hardness. This device is capable of determining the so-called hardness-index coming from the roll-grinding of 300 grains in a single measuring cycle (Martin et al.1993, Steele and Martin 1991, Psotka 1997, Martin and Steele 1997). It is mainly used in the American milling industry and trade since the hardness-index based on its combined measuring principle has a close relationship with milling and dough quality parameters (Satumbaga et al. 1995). It is also suitable for predicting the hardness of different wheat varieties e.g. in the period of wheat breeding (Gaines et al. 1996). The principle of measuring (grinding-force vs. deformation) can only be used to form a ratio (index) which fails to consider one of the most important characteristics of grinding - i.e. the average size (mm) of grist and its specific surface (cm2/g).

Our investigations have so far covered the grinding of different graines by means of a simple hammer mill and also the determining of kernel hardness of different wheat varieties based on grinding energetics (Véha and Gyimes 1996).

By the physical concept of kernel hardness we mean the so called grinding resistance (Véha et al. 1998), that is the determination of the amount of grinding energy required for producing 1 cm2 of new grinding surface from different wheat varieties (Bölöni-Bellus 1998). Thus the unit of measurement of kernel hardness determined by us is mWh/cm2, which value presents a significant difference from the wheat varieties investigated before (Bölöni et al. 1997, Véha and Gyimes 1998, Véha and Gyimes 1999).

2. THE AIM OF INVESTIGATIONS

Our research into selected wheat varieties with significant differences in inner contents and physical characteristics had the following objectives:

- ➔ Granulometric and energetic analysis of wheat varieties with similar moisture content and of different vitreousity grades - ground on a simple grinding machine.
- ➔ Determining the specific superficial grinding energy consumption values (mWh/cm^2) of grits.
- ➔ Comparing our grinding resistance values (mWh/cm^2) with the hardness index (Hi:%) values (determined by Perten's instrument SKCS 4100) and seeking their relations with the other measurable parameters of wheat quality (flour, dough and rheological parameters).

3. MATERIALS, EQUIPMENTS AND METHODS

We conducted investigations into 21 wheat varieties cultivated in Hungary. Some of their main characteristics are to be seen in Table 1. To calculate kernel hardness from the energetic data tested during the grinding process, we determined the amount of energy (mWh) needed to produce 1 cm2 of new grinding surface.

Kernel hardness was determined by means of a semi-plant hammermill (type KD 161S) and an expedient watthourmeter (CONRAD type) attached to it. To calculate the specific surface (cm2/g) of the grist the value of average grain size (μm) as determined through sieve analysis was used. To determine Perten's kernel hardness index (Hi: %) we used a

SKCS 4100 type device, which gave not only the mean hardness index, but the mean grain size, the grain mass and the moisture content as well.

Table 1. Main physical and hardness parameters of the tested wheat varieties

Varieties / year	Moisture content	1000 kernel weight	True density	Average size	Perten hardness Hi	Grinding resistance ef
	(%)	(g)	(g/cm3)	(mm)	(%)	(mWh/cm2)
GK-Duna 1996	8.6	40.20	1.37	3.37	71.20	44.90
GK-Csűrös 1997	11.7	47.20	1.31	3.38	53.50	41.10
Jubilejnaja-50 1996	11.5	48.70	1.34	3.40	52.12	37.30
GK-Öthalom 1995	11.4	44.60	1.35	3.38	64.66	30.00
GK-Öthalom 1997	11.3	43.90	1.27	3.37	49.34	28.70
GK-Kata 1995	11.4	44.60	1.31	3.40	9.92	26.50
GK-Kata 1997	10.5	41.00	1.27	3.39	6.49	24.30
MV-15 1994	11.7	37.60	1.37	3.16	75.99	76.00
MV-16 1994	12.3	39.40	1.36	3.18	75.01	62.70
MV-17 1995	12.9	41.80	1.35	3.55	34.47	46.20
MV-21 1995	12.1	37.90	1.30	3.25	76.11	63.70
MV-22 1997	12.2	32.70	1.36	3.11	48.93	52.20
MV-23 1997	12.1	40.00	1.34	3.44	14.87	41.70
MV Fatima 1998	11.9	45.00	1.31	3.52	65.68	74.20
MV Magvas 1998	11.8	40.00	1.33	3.30	73.69	50.50
MV Summa 1998	12.3	37.00	1.43	3.35	19.72	57.10
MV Pálma 1998	12.3	38.00	1.40	3.36	72.11	98.70
GK-Csűrös 1998	11.7	41.90	1.36	3.33	35.90	44.10
GK-Duna 1998	11.7	35.10	1.31	2.95	62.50	60.20
GK-Kata 1998	11.9	35.80	1.30	3.22	14.65	34.20
GK-Öthalom 1998	11.9	40.20	1.31	3.21	58.20	61.90
Average	11.7	40.60	1.34	3.32	49.29	50.30
SD 5%	0.86	4.06	0.04	0.14	23.99	18.68
c.v (%)	7.33	9.99	2.99	4.23	48.68	37.15
No. of samples	21	21	21	21	21	21

Table 2. Values of rheological and kernel hardness tests

Varieties / year	Valorigraph		Glutomatic		Falling Number	Alveograph				Grinding resist.	SKCS 4100
	WAC	VV	GI	DG	FN	P	L	P/L	W	ef	Hi
	%			%	s	mm	mm		10-4 J	mWh/cm2	%
GK-Öthalom '95	55.8	90.1	92.1	1.13	438	88.3	68.1	1.29	228.1	30.03	64.66
GK-Öthalom '97	55.4	71	98.35	0.86	220	64.4	79.2	0.81	197.0	28.7	49.34
GK-Kata '95	53.4	61	33.25	0.86	303	46.9	75	0.62	97.1	26.53	9.92
GK-Kata '97	56.6	15	45.5	0.81	89.5	19.0	95	0.2	43.1	24.26	6.49
GK-Duna '96	62.4	73.4	85.4	0.94	435	90.0	70	1.29	228.4	44.87	71.2
GK-Csűrös '97	60.2	38	31.3	0.88	275	52.4	60.3	0.87	92.9	41.07	53.5
Jubilejnaja50 '96	60.6	100	97.2	1.07	427	90.9	87	1.05	326.2	37.28	52.12
GK Csűrös'98	61.5	n/a	53.8	0.88	224	51.8	95	0.54	118.5	44.08	35.9
GK Duna'98	59	n/a	67	0.85	326	47.2	68	0.69	128.4	60.19	62.5
GK Kata '98	54.4	n/a	82.45	0.75	196	34.2	76.5	0.45	91.6	34.22	14.65
GK Öthalom'98	61.8	n/a	86.64	0.99	218	63.3	143	0.44	288.8	61.9	58.2
MV-15 '94	56	n/a	42.43	0.73	364	77.8	34	2.29	94.8	75.97	75.99
MV-16 '94	60	n/a	50.27	0.85	430	136.8	32.5	4.21	173.4	62.72	75.01
MV-17 '95	53	n/a	46.82	0.75	380	64.9	43	1.51	98.6	46.15	34.47
MV-21 '95	56	n/a	14.15	0.81	439	84.6	35	2.42	107.3	63.74	76.11
MV-22 '97	55	n/a	7.6	0.76	412	73.7	35.9	2.05	91.1	52.15	48.93
MV-23 '97	58	n/a	62.71	0.96	176	83.16	71.9	1.15	217.8	41.71	14.87
Magvas '98	59.4	83.9	96.3	n/a	441	n/a	n/a	n/a	n/a	50.5	73.69
Fatima '98	57.9	79.8	76.5	n/a	179	n/a	n/a	n/a	n/a	74.2	65.68
Summa '98	51.3	58	42.5	n/a	331	n/a	n/a	n/a	n/a	57.1	19.72
Pálma '98	59.1	58.8	42.5	n/a	293	n/a	n/a	n/a	n/a	98.7	72.11

Table 3. Main statistical parameters and correlation coefficients between kernel hardness and inner characteristics

Statistical parameters	Valorigraph		Glutomatic		Falling Number	Alveograph				Grinding resist.	SKCS 4100
	WAC	VV	GI	DG	FN	P	L	P/L	W	ef	Hi
	%			%	s	mm	mm		10-4J	mWh/cm2	%
r (ef)	0.194	0.103	-0.251	-0.293	0.166	0.43	-0.35	0.592**	-0.003	1	0.607**
r (H i)	0.481*	0.593*	0.135	0.161	0.590*	0.66**	-0.38	0.595**	0.319	0.607**	1
Average	57.47	66.27	59.75	0.88	314.12	68.8	68.79	1.29	154.29	50.29	49.29
Standard dev.	3.12	24.19	27.58	0.11	108.33	27.10	28.42	1.00	80.21	18.69	23.99
c.v. (%)	5.43	36.50	46.16	12.88	34.49	39.41	41.31	77.46	51.99	37.16	48.68
No. of samples	21	11	21	17	21	17	17	17	17	21	21

Remarks:

p=0,1% p=1 % p=5 %

FG=10: p=0,1 % r=0,82; p=1% r=0,70; p=5 % r=0,57

FG=16: p=0,1 % r=0,70; p=1% r=0,58; p=5 % r=0,46

FG=20: p=0,1 % r=0,65; p=1 % r=0,53; p=5 % r=0,42

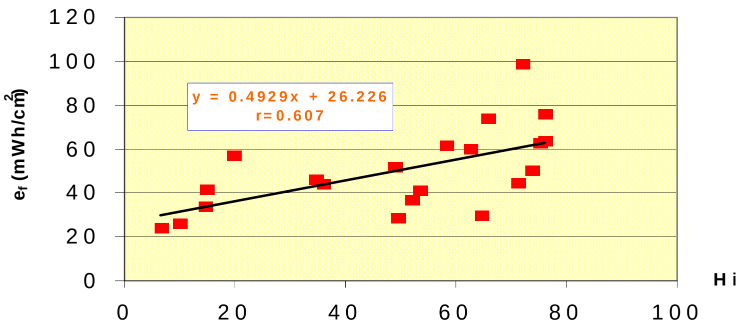

Figure 1. Correlation between the grinding resistance (e_f) the Perten Hardness index (HI)

To determine hardness index (Hi: %) with a Perten device we used 300 grains per sample and repeated the process three times.

The complex evaluation of wheat quality was completed through flour and dough tests (MSZ 6369), the falling number, the alveograph (ICC 121) and the Glutomatic gluten index tests were also used.

4. RESULTS

The values of kernel hardness are shown in Table 1, and the results of flour and gluten tests are summarized in Table 2. If the measuring process is objective, both methods are suitable for classifying wheat varieties according to their kernel hardness, so this value will be available both when improving the variety by breeding and in the purchasing process (Fig. 1.) Let us see how the hardness vaules and the rheological parameters of the wheat varieties tested by us correlate. (Table 3.) In the bottom lines the correlation coefficients [r (ef); r(Hi)] are shown. These represent how strong the relationship between kernel hardness and the qualitative parameters is.

The results of our testing methods, which are in accordance with the ICC standard, also accepted in our country, correlate with kernel hardness. The Perten Hardness index shows a medium strong correlation with the valiograph water absorbing capacity (WAC: 0.481) and with the value VV: 0.593, with the falling number of the amylolitic status /enzyme activity/ of the flour /FN: 0.590/ on the 5% probability level. There is a stronger correlation between alveograph P-value (maximum pressure) /P: 0.66/ and the configuration value (P/L: 0.592 – 0.595). The fact that the gluten index and the dry gluten content have a weak statistical correlation with the kernel hardness values /GI, DG: 0.135 – 0.161/ is an interesting new scientific result in my opinion.

Finally, the basic similarity of the American (Perten) and the Hungarian methods is proven by the r=0.607 medium strong correlation between them (on p=1% probability level). Since these investigations included varieties with different physical and qualitative parameters, which were harvested in different years, the correlation coefficient r=0.8 –0.9 for each variety group deteriorated (The Szeged and Martonvásár varieties were tested separately.)

5. CONCLUSIONS

- The grinding resistance values (e_f) are suitable for determining the kernel hardness with.
- The hardness index (Hi) of the Perten device (SKCS 4100) and the grinding resistance values (e_f) are significant on 1% probability level and show a medium strong correlation (r=0,607 see Fig 3.).
- The results of both methods for measuring kernel hardness (Hungarian-Perten) are comparable, and suitable for classifying the wheat varieties with.
- The values of hardness index (Hi) show medium strong and significant correlation with the valorigraph water absorption, and valorigraph index (value), with the falling number and with the alveograph P, P/L values (r=0,481…0,656).
- The values of grinding resistance (ef) are medium strongly, significantly related to the alveograph P, P/L values (r=0,433…0,592).
- None of the kernel hardness (e_f, Hi) values show any relationship between the gluten index and the dry gluten content.
- The endospermium structure of the wheat seems to have a medium strong effect on the rheological qualities of the dough, which means that the quality of the flour and the dough can be estimated fairly reliably, and this can be done through various complicated laboratory-testing procedures.
- Grinding resistance (e_f: mWh/cm^2) as the value of kernel hardness unites all the physico-mechanical and physico-chemical effects of the grain grinding process. None of the methods I have been familiar with so far has ever taken the decrease in grits size (i.e. the specific surface increase) into account after the grinding process although the strength of adhesion of the endospermium protein-starch matrix is made more perceptible and measurable by the change of the surface increase rate, which underlies the classification of wheat varieties based on their kernel hardness.

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