DIFFERENT METHOD TO DETERMINE THE KERNEL HARDNESS OF HUNGARIAN WINTER WHEAT VARIETIES

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REZUMAT. Textura nucleului de grâu diferențiază soiurile în clase de grâu dur şi moale. Duritatea nucleului este un factor genetic (de control al proteinei ”friabilin”). Friabilin se găsește în concentraţie mare în soiuri de cereale moi şi in concentraţie scăzută în soiuri de cereale tari (Békési, 2001). Duritatea nucleului de grâu determină calitatea, randamentul făinii, dimensiunile particulelor de făină, absorbţia de apă şi alte caracteristici de calitate a cerealelor. Scopul cercetării a fost de a determina duritatea nucleului. Am folosit maşina de testare Lloyd 1000 R, sistemul Perten pentru analiza semințelor (SKCS) dispozitiv 4100, moara de laborator Perten 3303 şi vitezometrull. Au fost analizate soiurile ungare de grâu utilizate pe scară largă. S-au utilizat de 23 soiuri diferite de grâu de toamnă. Ca rezultat, am găsit corelaţii între rezultate.

Cuvinte cheie: duritatea nucleului de grâu, modul de deformare, comportamentul făinii.

ABSTRACT. Wheat kernel texture differentiates cultivars of hard and soft wheat classes. The kernel hardness is a genetic factor (control by friabilin protein). The friabilin presents in high concentration in soft grain varieties and low concentration in hard grain varieties (Békési, 2001). Wheat kernel hardness determines quality, flour yield, flour particle-size, water absorption and other quality characteristics of cereals. The aim of our research was to determine the kernel hardness. We used Lloyd 1000 R Testing Machines, the Perten Single Kernel Characterization System (SKCS) 4100 device, Perten 3303 laboratory mill, and odometer. Registered and widely used Hungarian wheat varieties were applied in the study. It was 23 different winter wheat varieties. As a result, we found correlation among the results.

Keywords: wheat kernel hardness, deformation modulus, flour behaviour

1. INTRODUCTION

In the past 20 – 25 years , the interest in connection with commercial assortment, has grown considerably. Among from the previously mentioned emerges the significance of endosperm classification, rating according to the inner structure of the kernel. At wheat rating, postulating the inner structure of the kernel, it is extremely important that kernel hardness is the dependant of many properties in connection with the grain's technological quality. The system of endosperm classification of wheat means essential advantage for all participants of the wheat varieties, from the grower, through the dealer to the user (Békés 2001).

The good mill and baker quality wheat belong to the hard grain type. As well as the mill industry and the baker industry (making of bread) prefer this type. The hard endosperm composition is in close relationship with the large flour yield (from amongst the better is the greater ratio of the more valuable fraction), with the flour's greater water consumption, the volume of the bread, the bread's quality parameters (inner, height etc.) and the protein content.

For the determination and measuring of the endosperm structure, kernel hardness indicators were made, which measures the power needed to snap a seed. With this method, they determine a ration: Hardness Index (HI), which is one of the bases of mill crop's acceptance qualification.

The kernel hardness has great effect on the baking properties of the resulting flour. Flour, which is made from hard wheat generally have a medium to high protein content and stronger gluten than flour, which is made from soft wheat. The friabilin protein complex determines the kernel hardness. Generally, when the amount of the friabilin is high, the kernel hardness is soft and when the amount of the friabilin is low the kernel hardness is hard. Hardness in wheat is largely controlled by genetic factors but it can be affected by the environment (Gyimes, 2004). The transgenic expression of wild type Pina sequence in the Pina null genotype gave soft grain with the characteristics of soft wheat including increased starch bound friabilin. Hardness is suggested to influence the adhesion forces between starch granules and protein matrix whereas vitreousness would rather be related to the endosperm microstructure (Greffeuille, et. al., 2006).

Kernel hardness reliant assortment, and the quality acceptance is essential for the companies, and this is why the identification of hardness that can be automate able if is so necessary.

Our experiments were carried out between 2004 and 2007, at the Faculty of Food Engineering at the University of Szeged and later at it's successor the Faculty of Engineering. In our experiments we measured the physical properties of wheat (Triticum aestivum) reology, with various methods.

2. OBJECTIVES

The primary objective was to find a measuring method for the kernel mechanical properties; especially deformation modulus, breaking force and work, measuring by compressional procedure, and to establish a link at corn sample sets between the mechanical properties, produced by the developed procedure, and the kernels Hardness Index.

Furthermore an aim was to determine the nexus between the specific grinding energy demands, during the fracture of grains with the help of a disc grinder, and between the Hardness Index.

3. MATERIALS AND METHODS

In the course of our experiments, we examined 11 different wheat samples. Out of these samples 4 sets can be classified as soft and 7 as hard grain structured. This numeral difference is due to that one of the aims of weed sublimation, is to sublimate hard wheat, and because of this, softer sets become insignificant.

The samples were provided by the Cereal Research NPC, Szeged, in Hungary, and included the following varieties: GK Garaboly, GK Békés, GK Kalász, GK Verecke,GK Holló, GK Ati, GK Petur, GK Nap, GK Élet, GK Csongrád, GK Hattyú.

For this examination we used many known, previously used measuring techniques, and the quasi statical measuring method, developed by us.

Determining the kernel hardness by Lloyd 1000R Testing Machines

The instrument (Figure 1.) measures the pressure power on the kernel, due to the way that the pressure head has taken. The machine records data during the measurement, and draws the load – extension curve (with mm on the X axis and Newton on the Y axis).
According to data we can instantly see the measure of power, which the kernel can not withstand and it snaps. Due to the 0 N and max. N values of the diagram and the path related to them, the max. power to snap a kernel can be determined, further called as snapping power and the snapping labour related to it, which is given by the field under the curve. From the power, path curve, the deformation modulus can be determined. The experiment was carried out on horizontally and vertically set crops as well.

Fig. 1. *Lloyd 1000R Testing Machines*

Determining the kernel hardness by Perten SKCS 4100 equipment

During the measurement, the instrument (Figure 2.) measures the weight, size, moisture content and the hardness of the kernels. After determining 300 kernels unique properties it counts the average of the data gathered and counts standard deviation value and also, there is an opportunity to illustrate the measured results in column charts. The program provides an opportunity to see the last results after the following measurement. The measured results and their histograms can be printed if wished. The Hardness Index, produced by the machine as final results, is a physically non determined ratio, so in extremes cases the outcome can be zero or negative value.

Fig. 2. *Perten Single Kernel Characterization System (SKCS) 4100 device*

Valuation of grinding and performance

For the valuation of cutting and performance, we used a Perten 3303 laboratory mill. We poured the sample into the mill's pharynx, than we started the discs and by pulling the bolt, we started the mincing. The measurement lasted for a minute, under which we recorded it's cycle time, the mincing mass stream and the electric energy. We measured the power consumption (W) and the energy use (Ws), needed for the mincing on a monophase Power Monitor PRO power meter instrument, and the mincing time with a stopwatch. We measured the weight of the grist, produced in the mincing, with an electric scale, and we carried out the sieve analysis. For the grist's sieve analysis we used a laboratory sieve row and a shaking machine. With the help of the specific milling labour (e_d – kWh/t) and the formed grists specific increase in surface area (Δa_d – cm^2/g), specific grinding energy demand (e_f – kWh/cm^2) can be calculated.

Table 1. *Selected technology parameters of the entries in the study ("B" sample, 13.52% moisture content)*

Code	Wheat moisture cont. (%)	Flour yield (%)	Water Absorption Capacity (%)	Wet gluten (%)	Alveograph (P) (mm)	Alveograph (L) (mm)	P/L	Alveograph (W) (x10^{-4} J)
B1	13,27	71,88	54,80	21,58	43,15	60,50	0,715	95,05
B2	13,86	71,79	57,30	27,48	60,75	77,00	0,790	179,85
B3	14,01	74,01	54,00	16,85	45,75	50,75	0,905	99,40
B4	14,00	68,33	56,60	25,30	55,90	68,75	0,815	128,85
B5	13,90	72,89	60,90	28,13	77,00	89,00	0,875	250,20
B6	13,85	71,28	61,40	22,88	105,01	42,75	2,460	187,35
B7	13,58	70,16	63,20	33,68	87,80	70,00	1,355	214,75
B8	13,37	70,96	67,90	31,70	93,15	59,50	1,565	176,80
B9	13,15	67,94	66,80	35,60	94,30	66,50	1,430	226,85
B10	12,82	70,46	63,00	29,68	102,55	53,00	1,960	225,20
B11	12,92	69,66	56,90	31,08	55,40	66,50	0,835	156,35

4. RESULTS

We tested different sample sets, adjusted on different levels of moisture. Now we would like to show the samples which have 13.52% moisture content.

We developed a method, with which we can directly determine the breaking force and the breaking work, needed for snapping a kernel, and a parameter that gives information about the kernel flexibility (deformation modulus). To determine these values, we developed a measuring method, with which a single kernel can be measured. For this task we considered the measuring equipment Lloyd 1000 R to be appropriate, which is a precision stock measurer. We compared the results with outcomes from other kernel hardness measuring techniques.

Table 2. *The results of the deformation modulus, break work and other account traits of the wheat samples ("B" sample, 13.52% moisture content)*

Code	Deformation modulus (N/mm^2)	Max breaking force (N)	Break work (N*mm)	SKCS 4100 (HI)	Perten mill Grinding energy (mWh/cm^2)
B1	1010,99	123,81	14,98	27	0,235
B2	1726,72	211,21	26,60	36	0,245
B3	1193,70	160,22	20,55	20	0,215
B4	1287,68	162,14	23,25	29	0,255
B5	1884,78	260,82	41,26	61	0,440
B6	1563,73	239,46	41,57	57	0,435
B7	1810,62	282,35	50,00	67	0,465
B8	2049,02	367,45	74,82	81	0,555
B9	2087,37	343,89	66,45	81	0,545
B10	1985,99	309,26	55,85	81	0,535
B11	2133,84	358,27	68,01	68	0,470

5. DISCUSSION

In case of sample set "B" (13.52% moisture content) Hardness Index has a close relationship with the deformation modulus of compression procedure in vertical procedure, with breaking force (Figure 3.) and the breaking work (Figure 4.).

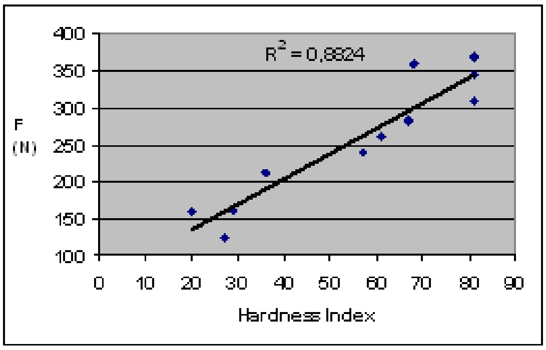

Fig. 3. *Connection between the breaking force (F) and the Hardness Index (set "B", vertical position, moisture content: 13.52%)*

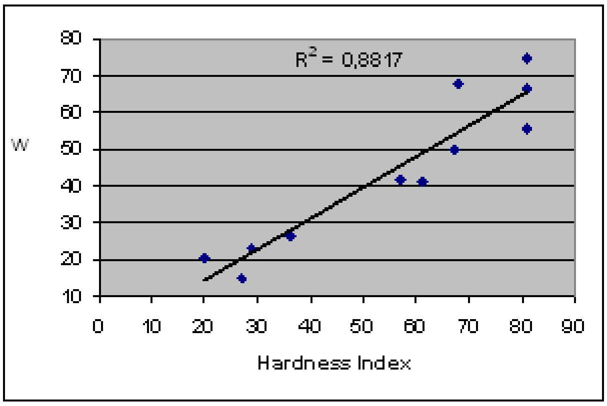

Fig. 4. *Connection between the breaking work (W) and the Hardness Index (set "B", vertical position, moisture content: 13.52%)*

In case of sample set "B" with the average moisture content of 13.5%, the Hardness Index of the set of wheat, defined by meter SKCS 4100, and the specific grinding energy demand, we can find a very close correlation (Figure 5.).

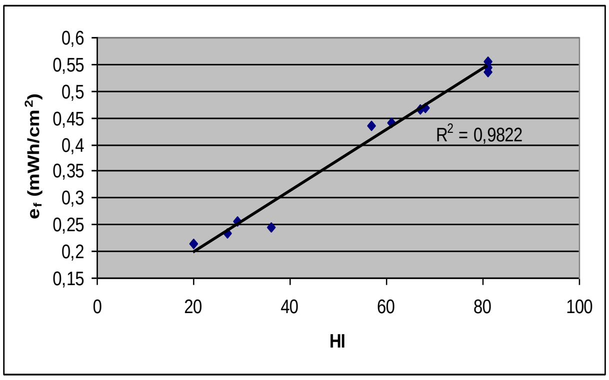

Fig. 5. *Connection between specific grinding energy demand (e_f) and the Hardness Index (set "B", moisture content: 13.52%)*

6. CONCLUSIONS

We worked out a measuring method, for measuring the mechanical properties of wheat species, by quasi static compression procedure. According to this method, after burnishing both ends of the wheat kernel, we measure the geometric properties and than put the kernels between the sheet of the precision pressing disks and the plane in vertical position. During the measurement, we record the load - extension curve, out of which the mechanic properties can be counted.

There has been a correlation between the Hardness Index measured by SKCS 4100 equipment and some of the mechanical characteristics of the wheat measured by Lloyd 1000R equipment when investigating a group of 11 different- 4 soft and 7 hard- wheat varieties.

A strong correlation was found between the Harness Index and the deformation modulus (R^2 = 0,813), between the Hardness Index and breaking force (R^2 = 0,882), and also a strong correlation between the Hardness Index and the breaking work (R^2 = 0,881) in the case of samples that have 13 % moisture content in average.

A strong correlation was found in the case of samples that have 13.5 % moisture content in average between the harness index and the deformation modulus measured (in vertical state) by the compression method (R^2 = 0,804), and a good correlation between the Hardness Index and the breaking force (R^2 = 0,593).

A very strong correlation was found in the case of 11 different (4 soft and 7 hard)varieties with a 13.5 % moisture content in average between the Hardness Index measured by SKCS 4100 type equipment and the specific grinding energy demand measured by Perten 3303 disc type mill (R^2 = 0,982).

The Hardness Index aquired from the cumulative distribution function measured (in the vertical state) by the compression method was adequate to describe the hardness class of 11 different (4 soft and 7 hard) varieties with an average moisture content of 13.5 %. It was found that the hardness categories determined by the breaking work were the closest to the hardness categories measured by the SKCS 4100 equipment.

The static tests help to measure the grain hardness and it can sort the winter wheat in two groups (soft, hard).

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