PHYSICO-MECHANICAL INVESTIGATIONS ON DIFFERENT WINTER WHEAT VARIETIES

Balázs P. Szabó
University of Szeged, Faculty of Engineering

SUMMARY

In Hungary the wheat flour is the basic food product. The flour consumption is reducing in the last years and changes the claim the compound of the flour. The consumption of the fine flour is increase, so the baking industries have to use fine flour. Grain texture (hardness) in wheat (*Triticum aestivum* L.) is a major determinant of end-usage.
Wheat kernel hardness determines quality, flour yield, flour particle-size, water absorption and other quality characteristics of cereals. The hardness is determined by the degree of adhesion between various components of the starchy endosperm cells of the mature wheat grain, notably between starch granules and matrix (gluten) proteins but also between proteins and cell walls.
The aim of my research was to determine the kernel hardness with new static methods. To the static methods I used the Lloyd 1000 R Testing Machines and the Instron 5581. I determined the kernel hardness with the well-known and recognized method also. It was the Perten Single Kernel Characterization System (SKCS) 4100 device, NIR technic and the Perten 3303 lab mill. They are the dynamic methods. Registered and widely used Hungarian wheat varieties were applied in the study. It was 23 different winter wheat varieties (13 of HRWW and 10 of SRWW). The samples were labelled with code number. My aim was to compare these methods.

1. INTRODUCTION

There are three parts which make up the wheat kernel: the endosperm, the bran, and the germ. The endosperm is the largest part of the kernel and takes up eighty-three percent of the kernel's mass. The wheat bran is the outer coat of the kernel and, therefore, is a very good source of fiber. It comprises about 14.5 percent of the kernel's mass. The wheat germ is the sprouting section or embryo of the wheat. It makes up about 2.5 percent of the total kernel mass.
Wheat genetics is more complicated than that of most other domesticated species. Some wheat species are diploid, with two sets of chromosomes, but many are stable polyploids, with four sets of chromosomes (tetraploid) or six (hexaploid). (Hancock, James, 2004)
Greenwell and Schofield (1986) extracted proteins associated with the surfaces of starch granules from hard and soft wheat cultivars using sodium dodecyl sulphate (SDS). They named this protein friabilin.
Kernel texture is very strongly heritable in wheat. In other words hard wheat will always be hard, and soft wheat will always be soft, no matter where or when it is grown. If a series of wheat varieties of different hardness are grown in different locations and/or different seasons they will retain their order of hardness with minor changes. The friabilin protein determines the kernel hardness.

A recent French study allowed distinguishing between consequences of hardness and vitreousness. Hardness is suggested to influence the adhesion forces between starch granules and protein matrix whereas vitreousness would rather be related to the endosperm microstructure (Grefeuille et al, 2006).

2. MATERIALS AND METHODS

The aim of this research was the investigation of winter wheat varieties. I investigated the kernel hardness in wheat varieties widely used in the Hungarian agriculture.

Materials

23 entries (registered wheat varieties) of bread with diverse technological qualities were used in this study (13 of HRWW and 10 of SRWW). The entries produced in the year of 2005 and 2006 in Szeged, Hungary and were evaluated for various quality characteristics.
Clean grain samples were used to identify the hardness index (HI) by SKCS-4100 instrument (Perten Inc.) and the NIR hardness. Grain samples then were grinded by Perten 3303 for establishing the grinding energy using a 1-phase output indicator interface.

Methods

The Perten SKCS 4100 instrument is one of the well know machines, which examine the kernel hardness. This device measures kernel texture by crushing the kernels one at a time, recording the force required to crush the kernel, and reporting the average force for crushing 300 kernels, in terms of a hardness index (HI). (Szabó, 2006)
The most practicable reference methods include the Particle Size Index (PSI) methods, using Perten 3303 mill. The Lab Mill 3303 is a disc type mill for grinding of grains, peas, maize, soybeans and other products with low fat content. This involves grinding a sample, and sieving a weighed amount (usually 10g) through a standard screen for a standard time. (Gyimes, et. all., 2002) The percentage of throughs is recorded as the PSI. I determined the grinding energy with this machine.
I determined the maximum breaking force, the break work, the Young's modulus with the LLOYD 1000 R Material Testing Machines and Instron 5581. I examined the grain in standing and prone position. To the standing position II scraped the grain, the surface on the side of the beard and the germ and this machine presses the kernels with the compressor head of Lloyd 1000 R testing machine of 1000 N force, and by reading the force – displacement curve. From this graph I read the breaking force, the incline and the break work. This method is a new invention. I measured the samples of 2005 with the Lloyd machines and the samples of 2006 with the Instron.

3. RESULTS

The four parameters of the static tests were: the incline, the maximum breaking force and the break work and the Young's modulus. (Table 1, Table 2)

Table 1.

The results of the Young's modulus , break work and other account traits of the wheat samples (2005)

Code	E (N/mm^2)	Max breaking force (N)	Incline (^{0})	Break work (N*mm)	E (N/mm^2)	Incline (^{0})	Max breaking force (N)	Break work (N*mm)
311	578,41	246,822	49,0735	53,851	96,919	29,77	112,43	19,61
320	661,812	288,58	54,18	64,588	99,03	31,24	107,58	18,265
321	712,78	294,284	54,77	60,428	108,2	33,77	120,64	18,69
322	679,149	285,76	52,601	63,12	102,23	33,14	117,41	18,396
325	596,905	268,0168	50,228	66,99	102,99	29,81	98,89	14,94
331	568,08	246,2	49	64,862	108,08	30,94	103,85	20,346
307	914,579	394,695	57,828	101,09	121,75	36,388	126,93	11,99
374	751,98	369,968	55,365	91,887	123,9	37,53	118,72	13,69
376	698,734	407,863	55,96	100,787	115,25	35,21	114,98	12,55
378	841,56	408,38	56,75	106,78	133,23	35,57	135,05	18,85
379	787,211	421,77	54,887	105,542	114,29	32,188	111,71	12,48
389	653,84	313,14	50,927	76,66	142,71	36,43	120,71	12,66

Standing position — Prone position

Table 2.

The results of the Young's modulus , break work and other account traits of the wheat samples. (2006)

Code	E (N/mm^2)	Max breaking force (N)	Incline (^{0})	Break work (N*mm)	E (N/mm^2)	Incline (^{0})	Max breaking force (N)	Break work (N*mm)
II.	1010,99	123,81	31,85	14,98	83,76	25,83	73,47	9,52
III.	1726,72	211,21	46,17	26,6	96,81	28,34	91,79	12,6
VI.	1193,7	160,22	36,52	20,55	80,15	25,22	81,61	11,63
IX.	1287,68	162,14	34,54	23,25	87,84	26,56	91,7	18,76
IV.	1884,78	260,82	46,77	41,265	103,86	34,04	103,31	10,78
VII.	1563,73	239,46	41,82	41,57	107,75	31,83	107,12	11,67
VIII.	1810,62	282,35	46,13	50,001	111,43	31,92	109,19	12,99
X.	2049,02	367,45	51,82	74,82	129,2	39,15	140,76	12,65
XI.	2087,371	343,89	50,204	66,457	128,51	37,41	125,05	11,4
XII.	1985,99	309,26	50,67	55,85	108,69	31,92	103,65	14,17
XIII.	2133,84	358,27	52,48	68,01	132,39	35,31	154,78	22,73

Standing position — Prone position

The SKCS 4100 compartmentalize the results in two groups. Under 50, the entries belong to Soft Wheat-, while entries above values 50 considered as Hard Wheat category. I measured the entries of 2005 with the NIR machines also. I measured the entries of 2006 with a Perten mill and determine the grinding energy.

In 2005 there are six hard winter wheat varieties (71-91) and six soft winter wheat varieties (24-46). The averages are 38 in soft and 79 in hard winter wheat varieties. In 2006 there are four soft winter wheat varieties (20-36) and seven hard winter wheat varieties (57-81). The averages are 28 in soft and 70 in hard winter wheat varieties. I used twin correlation to determine the connection, the significant level was 5 %.
The correlation between the SKCS hardness index and the NIR hardness is 0,954.
The correlation between the SKCS hardness index and the grinding energy is 0,991.

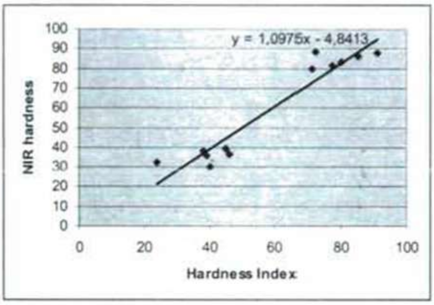

Figure 1. SKCS 4100 hardness index and NIR hardness connection

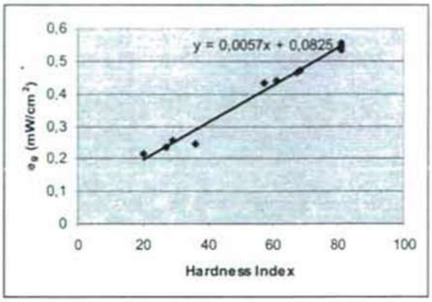

Figure 2. SKCS 4100 hardness index and Perten mill e_g connection

I use twin correlation to determine the relationship among the results. The correlation between the dynamic method (SKCS 4100) and the static tests (Lloyd 1000 R, Instron 5581):

In 2005, the correlations:

- Young's modulus (standing) – Max. breaking force (standing), r=0,838
- Young's modulus (standing) – SKCS 4100 (HI), r=0,720
- Max. breaking force (standing) - SKCS 4100 (HI), r=0,830
- Break work (standing) - SKCS 4100 (HI), r=0,889
- Young's modulus (prone) - SKCS 4100 (HI), r=0,786
- Young's modulus (prone) - Max. breaking force (prone), r=0,659
- Break work (prone) - SKCS 4100 (HI), r=0,722

In 2006, the correlations:

- Young's modulus (standing) – Max. breaking force (standing), r=0,958
- Young's modulus (standing) – SKCS 4100 (HI), r=0,901
- Max. breaking force (standing) - SKCS 4100 (HI), r=0,939
- Break work (standing) - SKCS 4100 (HI), r=0,938
- Young's modulus (prone) - SKCS 4100 (HI), r=0,896
- Young's modulus (prone) - Max. breaking force (prone), r=0,952
- Max. breaking force (prone) - SKCS 4100 (HI), r=0,770

There is a correlation between the dynamics method and the static test.

The Instron has stronger correlation with the dynamic method (SKCS 4100) than the Lloyd test. The static tests help to measure the grain hardness and it can sort the winter wheat in two groups (soft, hard). With this method we have more information about the variety.

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