MEASURING THE WHEAT KERNEL HARDNESS

Balázs P. Szabó, Antal Véha, Ernő Gyimes
University of Szeged, Faculty of Engineering

SUMMARY

The wheat kernel hardness determines quality, flour recovery, flour grain size, water absorption, etc. 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. Hard textured grains require more grinding energy than soft textured grains to reduce endosperm into flour, and during this milling process a larger number of starch granules become physically damaged. We have to know that the kernel hardness is soft or hard, because it determines the milling process, so we have to measure it. (Békési, 2001) In our investigation we used three methods to measuring kernel hardness. There were two dynamic methods the Perten Single Kernel Characterization System (SKCS) 4100 device and the Perten 3303 mill and there was a static test, it was the Lloyd 1000 R Material Testing Machines. Our aim was to compare these methods.

1. INTRODUCTION

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. 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. We can sort in these two groups the kernel hardness. Hardness in wheat is largely controlled by genetic factors but it can be affected by the environment and factors such as moisture, lipid, and pentosan content. Friabilin, a marker protein for grain softness, consists of two proteins, puroindoline a and b. The lipid binding proteins puroindolines a (PINA) and b (PINB) have been identified as responsible in determining differences between hard and soft textured wheat. (Gyimes, 2004)
Kernel texture influences power consumption during milling. Hard wheat requires more power to grind the wheat than does soft wheat, and power consumption can increase by as much as 30 % when milling hard, relative to soft wheat.

2. OBJECTIVES

The aim of the kernel hardness determines. In our investigation we have used the Perten SKCS 4100, the Perten 3303 mill and Lloyd 1000 R. We used Hungarian as samples. There were four soft grain varieties and seven hard grain varieties, which were labelled with code number.

3. MEASUREMENT 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, recording the force required to crush the kernel. This machine reports the average force for crushing 300 kernels, in terms of a hardness index (HI). The SKCS-4100 can complete a test in about 3 minutes, and simultaneously reports mean and standard deviation data for diameter, kernel weight, and moisture content, and the HI. (Szabó, 2006)

We used Perten 3303 mill to determine the Particle Size Index (PSI). This involves grinding a sample, and sieving a weighed amount through a standard screen for a standard time. The percentage of throughs is recorded as the PSI. We determine the specific grind energy pretence (ef). All measurements were repeated 3 times. We can determine the maximum breaking force, the break work, the Young's modulus with the LLOYD 1000 R Material Testing Machines. We examine the grain in standing and prone position. We scraped the grain, the surface on the side of the beard and the germ to measure the grain in standing position. We measure 30 grains of each sample. This machine presses the kernels with the compressor head of Lloyd 1000 R testing machine of 1000 N force. This method is a new invention.

4. RESULTS

Result of Lloyd 1000 R machines (table 1.)

Table 1.: Results of Lloyd

Samples		Incline (°)	Max. breaking force (N)	E (N/mm2)	Break work (N*mm)	Incline (°)	Max. breaking force (N)	E (N/mm2)	Break work (N*mm)
II.	S	31,85	123,81	1010,99	14,98	25,83	73,47	83,76	9,52
III.	O	46,17	211,21	1726,72	26,6	28,34	91,79	96,81	12,6
VI.	F	36,52	160,22	1193,7	20,55	25,22	81,61	80,15	11,63
IX.	T	34,54	162,14	1287,68	23,25	26,56	91,7	87,84	18,76
IV.		46,77	260,82	1884,78	41,26	34,04	103,31	103,86	10,78
VII.	H	41,82	239,46	1563,73	41,57	31,83	107,12	107,75	11,67
VIII.	A	46,13	282,35	1810,62	50	31,92	109,19	111,43	12,99
X.	R	51,82	367,45	2049,02	74,82	39,15	140,76	129,2	12,65
XI.	D	50,2	343,89	2087,37	66,45	37,41	125,05	128,51	11,4
XII.		50,67	309,26	1985,99	55,85	31,92	103,65	108,69	14,17
XIII.		52,48	358,27	2133,84	68,01	35,31	154,78	132,39	22,73
		STANDING POSITION				PRONE POSITION			

As a result, the Lloyd 1000 R machine can sort the winter wheat in two groups (soft, hard).

Results of Perten SKCS 4100 and Perten 3303 mill (table 2.)

Table 2.: Results of SKCS 4100 and Perten 3303 mill

Samples	Perten SKCS 4100 (HI %)	Perten 3303 mill (ef mW/cm2)
II.	27	0,235
III.	36	0,245
VI.	20	0,215
IX.	29	0,255
IV.	61	0,44
VII.	57	0,435
VIII.	67	0,465
X.	81	0,555
XI.	81	0,545
XII.	81	0,535
XIII.	68	0,47

The SKCS 4100 compartmentalize the results in two groups. Fewer than 50 is soft grain (the hardness index was between 27-36). Above 50 is hard grain (the hardness index was between 57-81).

We use twin correlation to determine the relationship among the results.

Table 3.: Correlation

	STANDING POSITION				PRONE POSITION					
	E(N/mm2)	Max. breaking force (N)	Incline (°)	Break work (N*mm)	E (N/mm2)	Max. breaking force (N)	Incline (°)	Break work (N*mm)	Perten SKCS 4100 (HI %)	Perten mill (ef mW/cm2)
E(N/mm2)	1									
Max. breaking force (N)	0,95854	1								
Incline (°)	0,986854	0,950112	1							
Break work (N*mm)	0,910383	0,989451	0,897569	1						
E (N/mm2)	0,907823	0,967568	0,88389	0,970414	1					
Max. breaking force (N)	0,839495	0,917664	0,818964	0,924984	0,952068	1				
Incline (°)	0,889848	0,94325	0,860949	0,948541	0,947762	0,876744	1			
Break work (N*mm)	0,536952	0,553214	0,554145	0,523271	0,565879	0,712373	0,343597	1		
Perten SKCS 4100 (HI %)	0,901936	0,939342	0,880715	0,938984	0,896914	0,770205	0,914325	0,346533	1	
Perten mill (ef mW/cm2)	0,863426	0,925425	0,837205	0,937342	0,886562	0,773122	0,917374	0,322905	0,991076	1

The correlation between hardness index and the static test was significant (r=0,7-0,9), for example: hardness index – breaking force (standing) r=0,939 (figure 1); hardness index – break work (standing) r=0,938 (figure 2.); hardness index – Young' s modulus (prone) r=0,896. There is a correlation between the two positions (standing, prone) of wheat, Young's modulus (standing) - Young's modulus (prone) r=0,907, maximum force (standing) – maximum force (prone) r=0,917. So there is a correlation between the dynamics methods and the static test. This static test is sensible, and gives more data to us, so it is a good method to determine the kernel hardness.

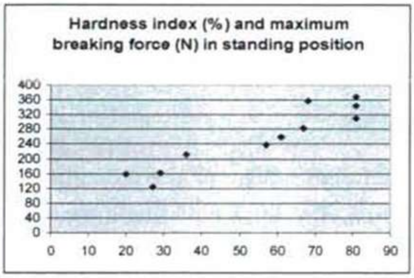

Figure 1.: HI and max. breaking force connection

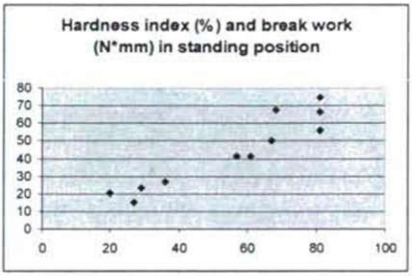

Figure 2.: HI and break work connection

BIBLIOGRAPHY

1. Békési, F (2001): A búza endospermium szerkezetének szerepe néhány minőségi búzát termelő országban. (in szerk Bedő, Z.: A jó minőségű, keményszemű búza nemesítése és termesztése, p. 25-34)
2. Gyimes, E. (2004): Összefüggés-vizsgálatok búzafajták szemtermésének agrofizikai tulajdonságai között, Doktori (PhD) értekezés Mosonmagyaróvár
3. Gyimes, E. – Neményi, M. – Véha, A (2002): Reológia és szemkeménység összefüggése őszi búzáknál In: Ötven éves az Acta Agronomica Hungarica Martonvásár, p. 117-124
4. Láng, L. – Juhász, A. – Rakszegi, M. – Bedő, Z. (2001): A búza keménységmérés ismételhetősége búzában, Növénytermelés 50, 497-503
5. Sitkei, Gy. (1981): Mezőgazdasági anyagok mechanikája, Akadémiai Kiadó, Budapest p. 11-461
6. Szabó P. Balázs (2006): A búza szemkeménységének a meghatározása a Lloyd 1000 R állományvizsgáló segítségével, VII. Nemzetközi Élelmiszertudományi Konferencia, Szeged