METHODS TO DETERMINE THE WHEAT KERNEL HARDNESS

Theses book

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1. INTRODUCTION

Cereals are essential mass sustaining products, covering significiant fraction of Earth's nutrition necessities. Besides human nourishment, cereal crops are used for forage and industrials needs as well. Cereals can be easily produced, can be grown anywhere, exertion facilities are large, and grain kernel can be siloed easily. It is typican for them that, their protein content is average or high, and provide high energy.

The most important corn in the ear is the wheat. It gives almost half of the produced amount of grain. It is grown in each of our nineteen counties. Best quality crop is produced in Békés-, Szolnok-,Hajdú-,Bács-,Pest counties and in Mezőföld and Kisalföld.

In the world's grain- , crops, grown and used for commercial purposes, are sorted in numerous classes. In case of durum and aestivum kernel, it contains the vernal and autumnal, the red and white just as soft and hard corns and all their combinations. In the last 20 years, the importance of endosperm classification (soft and hard wheat kernel) has grown bigger.

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.

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.

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 corn's 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.

A further goal was to specify the link between the different flour quality properties and mechanical properties made of different wheat crop sample sets and the quality of the flour and the Hardness Index.

Our task was to work out a proposal according to a given wheat crop sample set's mechanical properties distribution function, for the value category classification, meaning Hardness Index and the soft, transitional or hard categories.

3. MATERIALS AND METHODS

In the course of our experiments, we examined 34 different wheat samples. Out of these samples 14 sets can be classified as soft and 20 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.

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

3.1. Determining the kernel hardness by Lloyd 1000R Testing Machines

The instrument 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.

3.2. Determining the kernel hardness by Perten SKCS 4100 equipment

During the measurement, the instrument 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.

3.3. 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.

3.4. Odometric measurements

The measuring method used is quasi static, during which the sets squeeze ability is measured. Before the odometric measurements, we tried various forms of sample preparation for the purpose of ensuring repeatability. For the measure we chose soft and hard samples. The measurement was carried out at the Hungarian Institute of Agricultural Engineering in Gödöllő on an Instron 5581, because experiments, done on sets, need much greater power than measuring a single kernel. This instrument can produce 50 kN.

Among our experiments there were the determination of the humidity content, laboratory production of flour, gluten test, capability of water absorption of the given wheat samples and alveograph paste examination. For the evaluation we used STATISTICA for Windows 6. (StatSoft Inc. USA) and Excell table manager program.

4. RESULTS

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.

We tested three different sample sets, adjusted on different levels of moisture. Sample mark "A" was called "air-dry" (10.59% moisture content), "B" sample had 13.52%, while sample set mark "C" was set on 12.71% moisture content.

From the Hardness Index and the quasi static procedure we found that, with sample set mark "A",in case of "air-dry" set (moisture content 10,59%), the vertical experiments were more useful, in kernel hardness assortment, than experimenting in a horizontal position. We found that, the hardness index of the kernel with the average moisture of 10.6%, in vertical compression procedure, with the breaking work, has tight, and with the breaking force, has acceptable correlation.

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 and the breaking work (Figure 1.). Hardness Index has a close relationship with deformation modulus measured on horizontal compression procedure, and an acceptable relationship with breaking force.

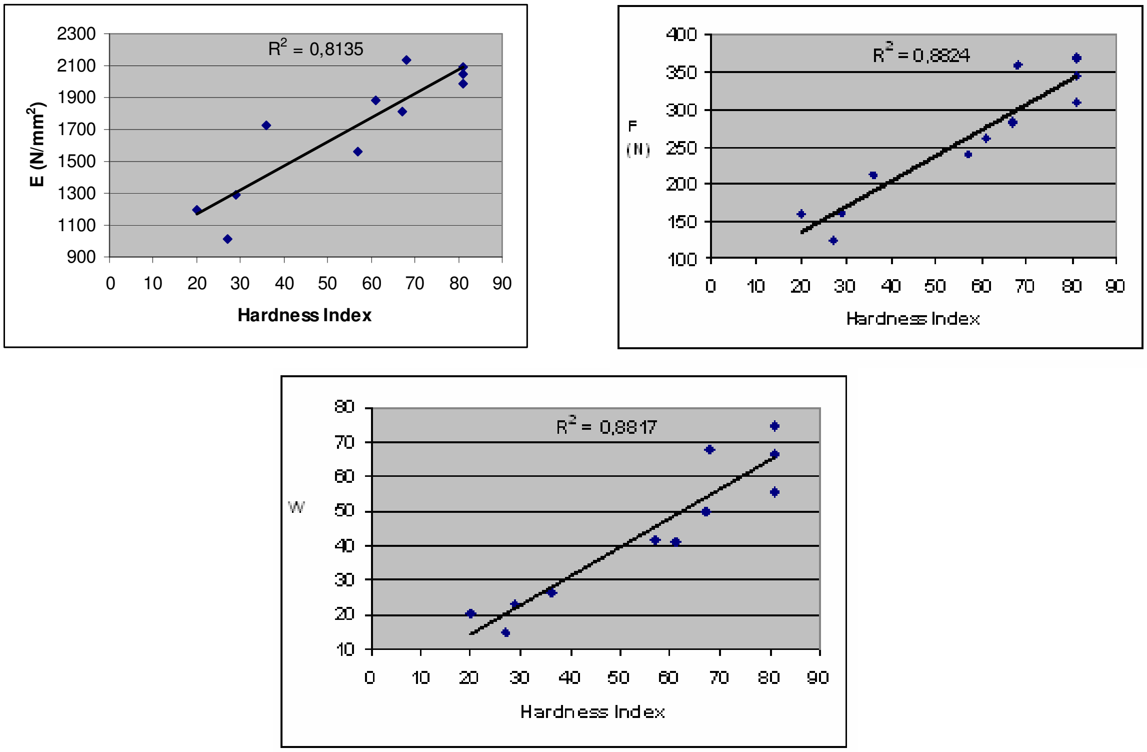

Figure 1. Connection between the deformation modulus (E) and the Hardness Index, breaking force (F) and the Hardness Index, breaking work (W) and the Hardness Index (set "B", vertical position, moisture content: 13.52%)

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 2.). A very close correlation is present between the Hardness Index and kernel hardness, defined by NIR meter at 10.59% moisture content.

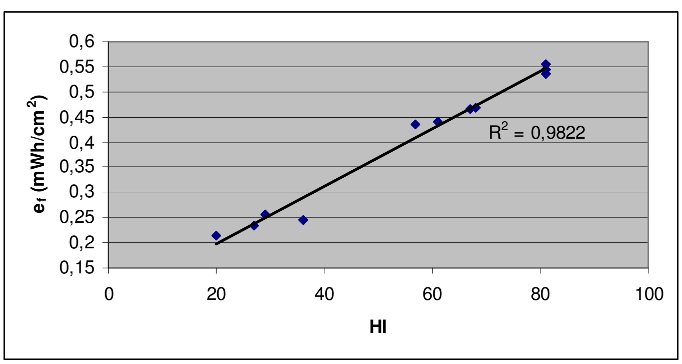

Figure 2. Connection between specific grinding energy demand (e_f) and the Hardness Index (set "B", moisture content: 13.52%)

The connection between the nutritional parameters and kernel hardness (Hardness Index and mechanical properties), was investigated in sample set “B”. At sample set “B” (moisture content 13.52%) showed a very close correlation with the Hardness Index, measured by SKCS 4100, the water absorbance capacity of the flour (Figure 3.), made out of the crops, and got an acceptable correlation with the flours wet gluten content, and the alveographic deformation work as well.

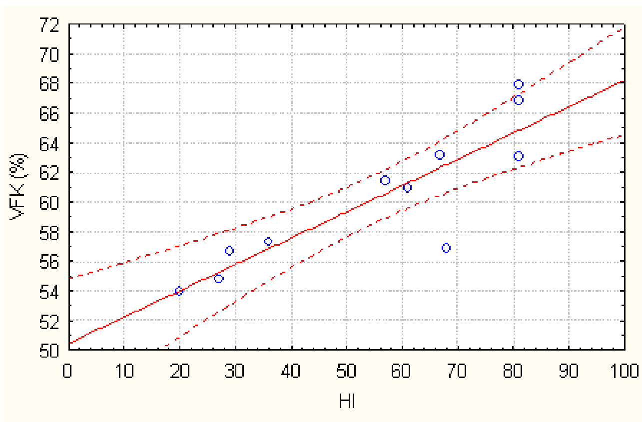

Figure 3. Connection between the water absorbance capacity and Hardness Index (set „B”, moisture content: 13.52%

We defined a close correlation between the deformation modulus measured by compression procedure in vertical position, and the wet gluten content of the flour, made of crops. There is also an acceptable correlation of the breaking force, in case of compression procedure in vertical position, and the water absorbance capacity of the flour, made of the crops, and wet gluten content, and there is also an acceptable correlation of the breaking work, and the water absorbance capacity of the flour, made of the crops, and wet gluten content.

We recommend further experiments on measuring kernels in horizontal position with the quasi static compression procedure and on matching the results with the Hardness Index, from measurement by meter SKCS 4100. It is presumable that experiments, done on different wheat species in huge numbers of sample sets, can be efficient.

We recommend estimating hardness categories, from the mechanical properties, got from compression procedure on vertically placed kernels, firstly from breaking work, based on distribution function (Figure 4.).

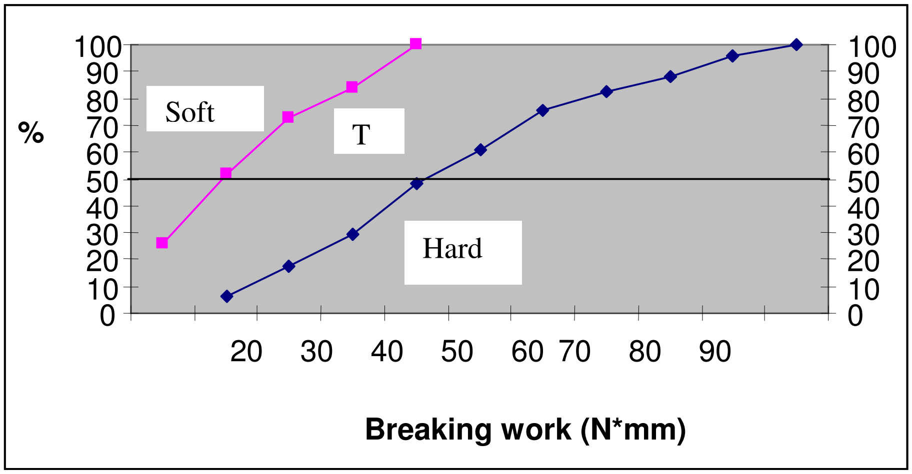

Figure 4. Distribution curve of breaking work (set „B”, moisture content: 13.52%, vertical position, T– transitional)

We further recommend defining the kernel’s hardness categories, based on the specific grinding energy demand development, measured by disc mill. This is a perspective measuring method, which is simple and fast because the measuring time is one minute. We can safely determine the hardness by finding the specific grinding energy demand. By measuring friction power, the accuracy of determining kernel hardness, can be further enchanced.

5. NEW SCIENTIFIC RESULTS

1. I 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.

2. 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 34 different- 14 soft and 20 hard- wheat varieties.

2.1. 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.

2.2. 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).

2.3. A strong correlation was found in the case of samples that had 10.6 % moisture content in average between the Harness Index and the breaking work measured (in the vertical state) by the compression method (R^2 = 0,791), and a good correlation between the Hardness Index and the breaking force (R^2 = 0,690).

3. 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).

4. 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.

5. Correlation was found between the mechanical characteristics measured by Lloyd 1000R equipment and the properties of the wheat flours prepared from 11 different varieties of wheat (4 soft and 7 hard).

5.1. The correlation of breaking force with the water absorbance capacity was good (R^2 = 0,599) when determining by the compression method (in the wheat's vertical state).

5.2. The correlation of breaking work with the water absorbance capacity was good (R^2 = 0,632) when determining by the compression method (in the wheat´s vertical state).

6. Correlation was found between Hardness Index determined by SKCS 4100 equipment and the examined flour parameters of the group of 11 different wheat varieties (4 soft and 7 hard) with an average moisture content of 13.5 %.

6.1. A strong correlation was found between the Hardness Index and the water absorbance capacity of the wheat flours (R^2 = 0,768), and a good correlation between the Hardness Index and the alveograph deformation work (R^2 = 0,598).

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