# Abstract

Wheat, similarly to rice and maize, is a staple food consumed by humans and livestock around the world. An analysis of the characteristics of grain is required to design and implement technological and processing operations in the milling industry. The available literature provides information on the physical properties of wheat grain, usually limited to individual varieties. The aim of this study was to perform a comprehensive analysis of the basic chemical, physical and structural properties of grain, including their correlations, in a large group of wheat varieties.

The experimental material comprised kernels of 23 wheat varieties differing in average hardness. The content of crude protein, total ash and friabilin in grain, and the relative moisture content and vitreousness of kernels were determined. The basic geometric parameters (length, width and thickness) and mass of kernels, as well as the values of deforming force and deformation were measured. Geometry- and mass-based indicators, strain energy and the coefficient of elasticity were calculated. Grain hardness index *HI*, the geometric mean diameter and mass of kernels, and their relative moisture content were also measured. The friabilin content of grain was determined by p*olyacrylamide gel* electrophoresis, followed by computer image analysis. The micostructure of wheat kernels of selected varieties characterized by similar crude protein content was visualized by electron microscopy. The results of measurements and calculations were analyzed statistically using Statistica 12.5 software at a significance level of $\alpha = 0.05$.

The average values of the analyzed properties of wheat kernels were determined in the following ranges: crude protein content – from 10.14 to 16.22%, total ash content – from 1.55 to 2.02%, vitreousness – from 0.0 to 89.4%, relative moisture content – from 10.84 to 11.83%, hardness index *HI* – from 8.71 to 145.57, mean diameter – from 1.75 to 4.16 mm, thickness – from 2.46 to 3.19 mm, width – from 2.74 to 3.72 mm, length – from 5.42 to 8.04 mm, mass – from 29.97 to 54.87 mg, arithmetic mean diameter – from 3.54 to 4.82 mm, geometric mean diameter from 3.32 to 4.35 mm, aspect ratio – from 40.55 to 59.06%, sphericity index – from 53.35 to 66.80%,

cross-sectional area – from 5.33 to 9.36 $mm^2$, volume – from 19.35 to 43.46 $mm^3$, density – from 1.24 to 1.42 $g \cdot cm^{-3}$, deforming force – from 75.48 to 156.01 N, displacement – from 0.46 to 0.66 mm, deformation – from 15.72 to 22.01%, strain energy – from 11.92 to 30.58 mJ, unit strain energy – from 0.33 to 0.60 J $g^{-1}$, and the coefficient of elasticity – from 6.21 to 9.34 mJ.

Wheat kernels are characterized by different mechanical properties because in most of the analyzed varieties, they represent all five hardness classes (*HI)*. Kernels subjected to deforming force in the range of 29.43 to 271.46 N undergo damage and deformation in the range of 9.43 to 31.83%. Among geometric parameters, length exerts the greatest effect on the mechanical properties of kernels. A clear relationship between the friabilin content of grain and hardness index *HI* was not observed, and no significant correlations were found between this parameter and the remaining mechanical properties. However, an increase in the average thickness of grain was accompanied by a decrease in friabilin content. Among chemical properties, only vitreousness had a significant influence on the mechanical properties of kernels. An analysis of microscopic images revealed that the mechanical properties of wheat kernels are affected by their microstructure. Kernels with high technological hardness have a relatively thick seed coat and aleurone layer, and starch granules are tightly bound to the endosperm protein matrix, making them hard to discern. In kernels of soft wheat varieties, the seed coat and aleurone layer are thinner, and starch granules are loosely packed in the protein matrix.

A number of regressive relationships between pairs of the analyzed properties of wheat kernels were determined. A high coefficient of correlation between hardness index *HI* and kernel length could be a starting point for developing a rapid and non-destructive method for evaluating the technological hardness of wheat grain.