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HARDNESS OF GRAIN

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When the moisture content of wheat and maize increases, the value of the hardness of the layers decreases. Humidity characterizes the amount of nutrients in the grain, as well as its suitability for storage and processing.

Key words: regime, grain, hardness, moisture, structure, kinetics.

Introduction. The efficiency of using processing equipment, as is known, is related to physical and mechanical indicators of grain, one of which is hardness and humidity. Chemically bound water of grain is a part of proteins, carbohydrates, fats and other compounds. It can be distinguished only by violating the structure of these substances. Molecules of physico-chemically bound water lose the properties of the solvent and are associated with hydrophilic substances. Such water can be removed from the grain by drying. Free water is in the capillaries of the grain and can easily be dried. This moisture affects the physiological, biochemical and microbiological processes in the grain. It is established that an increase in the moisture content of wheat grains in the arithmetic progression causes a decrease in the hardness of all layers in accordance with the law of geometric progression.

Problem. The change in the hardness of wheat grain layers should be prevented after drying of the membranes. The regularity of the process of moisture transfer to the outer layers of the shells is characterized by a high intensity of saturation with moisture, which decreases with increasing depth of the layer, which significantly affects the process of its processing.

Analysis of recent research and publications. The harvested crop of grain crops with the help of combine harvesters and other modern harvesting machines always requires a certain primary treatment. When organizing and conducting post-harvest treatments it is necessary to know the specific biological and technological properties of the components of the processed grain mass. In practice, very often the fresh moisture of the removed grain requires the use of one of three technological processing schemes:

- at a grain moisture content of 17%, it is sufficient to apply primary and secondary cleaning;
- with grain moisture within 17 ... 20%, preliminary cleaning, drying, primary and repeated cleaning are applied;
- at grain moisture above 20%, pre-cleaning, not once drying, primary and repeated cleaning are necessary.

Repeated cleaning of the grain is used when it is necessary to bring the supernuminal material into seminal conditions.

Post-harvest processing of grain is performed so that the grain mass sees the requirements of the standard in terms of the number of full seeds in the visible sample of the main crop, other plants (including weeds), humidity, the percentage of crushed and injured grains, etc. The grain of any culture is a living organism that possesses the properties of living objects: breathing, development, aging and so on. The parts of the grain are film, shells (fruit and seed), aleuron layer, embryo, endosperm. Different parts of the grain are differently sensitive to thermal conditions. Grains of cereals refer to colloidal capillary-porous bodies, some parts of which (shells, embryos) have a different structure, different physical and chemical characteristics. What constitutes the bulk of the cereal starch, as well as the fiber, is the substance of the crystal structure. Protein substances have an amorphous structure. Grain, in contrast to ideally solid bodies, is characterized by spatial anisotropy, that is, their mechanical properties in different directions are not the same. Finally, the cereal grains belong to organic bodies and are characterized by a complex configuration. These features of grain structure significantly affect the mechanical properties and its behavior in the process of deformation and grinding. Depending on the nature and size applied to the grain of external forces, its linear dimensions and shape change, that is, deformation occurs in the grain. They can be elastic (reversible) and plastic (irreversible). If the external forces do not exceed a certain limit, the displacement of the particles from the equilibrium positions and the resulting deformations will be reversible. In the case of elastic deformation after removal of external forces, the grain, under the action of interatomic interaction forces, returns to its original state. Plastic deformations appear at loads exceeding the elastic limit. Plastic deformation is accompanied by a "flow" of the substance without disturbing its integrity. Plastic deformations, unlike others, are deformations of a large scale and develop at a very small rate. The development of elastic, and then plastic deformations in the grain under the influence of external forces ends with destruction. occurs when there is a voltage in it, exceeding a certain limit, called the ultimate strength, or a critical voltage. In the mechanics of fracture, the special role of cracks, which exist in any body, in particular in grain, is proved. At the tips of the cracks, stress concentration occurs, causing the grain to break down at a lower voltage. In fracture theory, it is necessary that there are some critical stresses σ * for a given crack length m, above which it grows:

$$\sigma_* = \sqrt{\frac{2E\lambda}{\pi\ell}}, \qquad (1)$$

where E- is the modulus of elasticity of the material;

λ- is the specific destruction work per unit increment of the product surface (material constant).

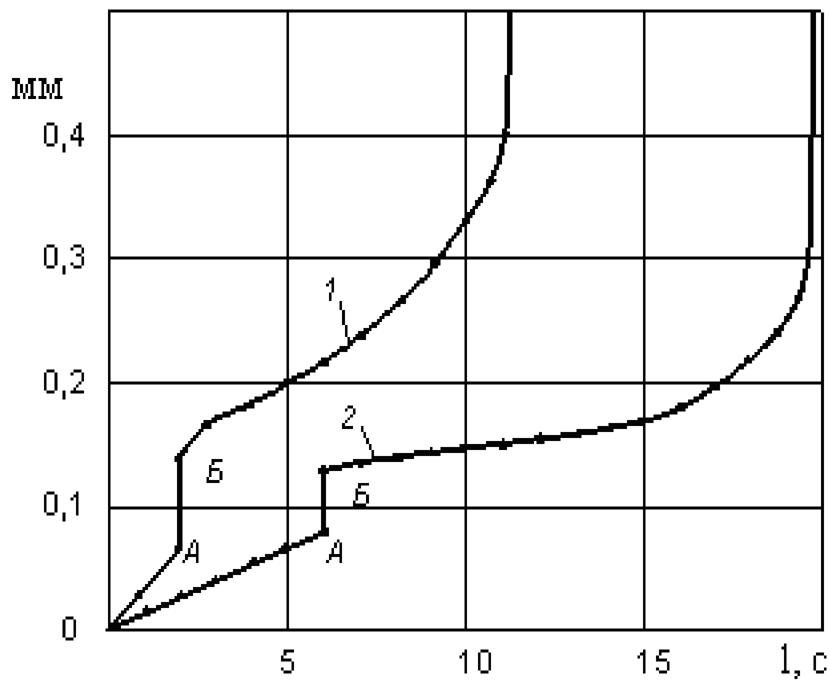

Fig. 1. Curves of wheat grain deformation in time at a loading speed: 1-437 g / s; 2-223 g / s (according to IA Naumov).

Figure 1 shows, as an example, the curves characterizing the process of wheat destruction at a moisture content of W = 12.5% and a loading speed of 437 and 223 g / s. From the curves it can be seen that the first phase of deformation (section OA), at which the strain value is directly proportional to time and load. The elastic step is followed by an abrupt increase in deformation (section AB) due to brittle fracture of the shells and upper layers of the endosperm. The third stage is characterized by a gradual increase in plastic deformation, which sharply increases before destruction. With a slow loading, grains exhibit a greater degree of plasticity: the strength of such grain is lower, and the deformation is higher. It is also significant that the influence of the loading speed on the change in the mechanical characteristics of the grain is more pronounced on the wet grain than on the dry grain. Analysis of the hardness data of the surface of whole grain of wheat made it possible to establish that its local value depends on the moisture indices Wob, the vitreousness of C and the part of measurement ξ. Dependence of the microhardness of Non-fruit shells of wheat grain Ukrainka, ordinary soft. Odesskaya 16, Odesskaya 26 Novomichurinka of different vitreousness, respectively, 46, 42, 70, 96, 93% with kn values equal to 156, 162, 246, 324, 330, is determined by the empirical expression

$$H_o^{п} = k_n \exp(-0{,}05\ W_{ОБ}), \qquad (2)$$

where: kn = 3Cu + 12ξ is a coefficient that takes into account the total grain glass data, with an average value of ξ = 3.

It is established that an increase in the moisture content of the grain of the investigated wheat in the arithmetic progression causes a decrease in the hardness of all the layers in accordance with the law of geometric progression. The hardest is the aleuron layer, and the smallest - the seed coat. It was proved that when the humidity rises from 10 to 50%, a relative decrease in the microhardness of the aleuron layer in 6 ... 10 times was observed for fruit and seed shells, the decrease was approximately the same and was 0.3 ... 0.5 of their values in the air- dry state [1].

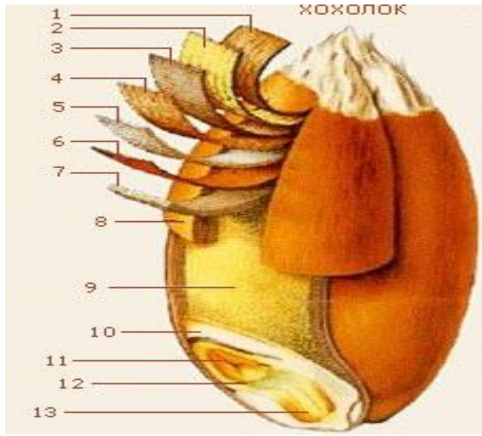

Fig. 2. Structure of the grain. Longitudinal section of wheat grain: 1,2,3 - fruit shells; 4,5,6-seminal membranes; 7-aleuron layer; 8 - layers of cells of the fruit shell of wheat from the surface; 9 - endosperm; 10 - the shield; 11 - the kidney; 12 - the axial part of the embryo;13 - spine.

The grain of wheat and rye consists of several anatomical parts - shells, endosperm and embryo and others, which are characterized by different physiological functions and therefore have different structure and chemical composition (Fig. 2). With increasing vitreousness of the grain, an increase in the hardness of the anatomical parts is observed. Studies have established a different hardness of previously separated shells from their outer and inner sides. For low vitreous wheat microhardness from the outside is less than from the inner, in highly vitreous - the outer part of the shells has an increased hardness [2]. The value of the hardness of the endosperm is not directly dependent on the grain size of the corn, characterized by a mass of 1000 grains, and the shells Ho - in the reverse. At the same time, for corn grain H0 = (1.5..7.5) He, and for wheat, on the contrary, a He = (1,1 ... 2,5) Ho. This dependence is determined for wheat samples of different varieties and regions at W = 9 ... 12% and total vitrification of 40 ... 100%. The ratio between the hardness values of shells and endosperm in grains of wheat and corn is significantly different. The high hardness of shells of corn grain makes it possible to create increased dynamic stresses in the working zone of the shelling machines in comparison with wheat grain. Estimating the strength of single grains with the magnitude of the destructive stress, it was established that for barley it averages 7.03 ± 1.02 MPa in static tests against 12.73 ± 0.4 MPa obtained in a dynamic mode. On the basis of these data, S.V.

Melnikov concluded that "the property of most materials is to increase their strength with an increase in the rate of subsidence proper and grain." Of the crops, barley is the most durable, which, being the main fodder crop, can be considered a benchmark for comparative evaluation. The ratio of grain strength indicators of different crops can be judged from the following data. Melnikova (barley grain strength is taken as 100%):

- barley - 100%;
- wheat - 91%;
- rye - 83%;
- peas - 65%;

Wet grain contains less nutrients and is unstable during storage. Humidification activates physicochemical and physiological processes (breathing, germination, cleavage of high molecular weight biopolymers, activation of enzymes, swelling), all this makes it difficult to store and process it. On the surface of moist grain microorganisms begin to develop rapidly, and the number of insects, ticks and other pests increases in the grain mass. The totality of the listed processes in the grain leads to a deterioration in its quality and to its spoilage during storage. The physical properties of moist grain change. It swells considerably, the surface becomes smooth. Friability and nature of grain decreases. Also, the elasticity of the shells increases and the resistance to compression decreases. As a result, during processing, energy costs for grain crushing increase, output and product quality decrease. In some cases, the processing of grain becomes impossible. The most important way to improve the quality of grain during storage and processing, drying, is performed with a mandatory consideration of the state of the grain in terms of humidity. The moisture content of the grain is determined in the sample together with the impurities, since their moisture content differs from the moisture content of the grain. Moisture in the grain is in the form of: chemically bound water (bound water), physico-chemically bound water, and free water. For uniformity of the water content assessment, dry, medium dry, wet and raw grain are distinguished. For example, in dry wheat, rye, barley, dry grain has a moisture content of up to 14%, a grain of medium dryness - from 14.1% to 15.5%, a wet grain - from 15.6% to 17%, raw - from 17.1% and more. In the seeds of oil plants, the humidity is even lower, and in seeds of some legumes, on the contrary, more. Dry sunflower seeds contain no more than 7%, and beans - not more than 15% moisture. The grain is well stored "in a dry" state. In this case, there is practically no free moisture, all water is associated with hydrophilic colloids of grain. The moisture limit at which free water appears in the grain depends on the chemical composition, culture, and its anatomical structure. Lower moisture values in oilseeds are associated with a high fat content, does not contain water, and therefore it concentrates in large quantities in the hydrophilic part of the grain, which leads to activation of biochemical processes. Usually this is due to the value of the critical humidity, which usually lies in the zone of "average dryness" of the grain. When the critical moisture reaches the grain, vital processes in the grain (respiration, germination, etc.) begin to grow and actively develop microorganisms.

Purpose of the study. Determination of the dependence of the average hardness of the endosperm and the moisture content of the shells**.**

Results of the research. Because the humidity of the shells was determined by the relative index (drying time), the hardness measurement was carried out at the drying time of the shells, exceeding the time required to establish equilibrium moisture [3]. For this purpose, a control calibration determination of the hardness of shells of wheat grain Odessa 16 was performed, it was to be dried for 60 min with an interval of 3 min. The obtained results made it possible to establish that the change in hardness of the peripheral layers of wheat grains ceases after drying of the fertile shells within 15 minutes, the seed coatings - 21 minutes, the aleuron layer - 33 minutes. These data confirm the conclusions that after the specified periods of time, the equilibrium moisture is reached in the separated shells and a further increase in the drying time does not change the constant humidity, and consequently does not affect their mechanical properties. The data given, characterizing the different desorption of the structures of the coverslips of wheat grain, indirectly confirm the conclusion that the aging time for the removal of fruit shells can be rationally selected within 15 minutes. Lesser duration of dampening Recommended after moistening, indicates a different intensification of sorption and desorption processes. It is established that when indenter is pressed in, the different orientation of the endosperm cracks leads to a scatter of the hardness data and, consequently, the strength data of the material being measured. The effect of the weakening surfaces, the dependence of the average hardness of the endosperm can be described by an empirical expression

$$H_e = H_{зм} + k\,q\,V_з\,, \qquad (2)$$

where: $N_{зм}$ is the averaged hardness of fine grain;

k and q are coefficients whose numerical values are due to botanical features of the grain.

The resistance of parts of the grain, in the stage of elastic deformation at their natural humidity, is directly dependent on the microhardness. Measurements of the microhardness of moistened grains have confirmed the conclusion that with an increase in humidity from 18% or more, the microhardness of the endosperm and shells is consistently reduced. With a moisture content of 23 ... 26%, the hardness of corn grain of different varieties was practically the same, since with the increase in humidity there is a swelling process and a significant weakening of the bond between the shells and the core occurs. At high humidity, fuzzy blurred prints are formed, which distort the results of measurements. When the grain is moistened by 1.5..2.0% and deferred within 16 hours But decreases by about 10..30%, not - by 15 ... 40%.

Experimental studies have established that the strength of the endosperm of corn grain σe is roughly determined by the expression

$$H_o = 2{,}5\,\sigma_e\,, \qquad (3)$$

Experimental studies of the hardness of grain and anatomical parts showed that with increasing moisture in all studied varieties of wheat and corn, a decrease in the hardness of all peripheral layers is observed when measuring it from both the external and internal sides. Regardless of the varietal characteristics of wheat grain, the cells of the aleuron layer possess the greatest hardness, and the smallest - the seminal shells; shells of dry grain corn have a hardness in comparison with endosperm in 1,5 ... 7,5 times more, and this difference is more essential for cultivars of dentine corn. With an increase in the moisture content of wheat grain from 10 to 50% [3], the greatest relative decrease in hardness in 6 .. 10 times is found in the aleuron layer. Under these conditions, the relative decrease in the hardness of the fruit and seminal membranes is approximately the same and amounted to 0.3 to 0.5 of its hardness in the air-dry state. Using the data on the kinetics of the diffusion migration of moisture by wheat grain structures, graphical dependences of the moisture variation of the two upper layers of the fruit shell on the duration of moisture transfer at various intervals of its variation have been developed and constructed. To analyze the general regularities of the process of moisture transfer, the first step was to calculate the time interval t = 0 ... 70 s. As follows from Fig. 3, the outer layer of the shells is characterized by a high intensity of saturation with moisture, which decreases with increasing depth of the layer. Taking into account the high dynamism of the process of "capture" of moisture by the fruit shells, calculations were carried out for reduced time intervals and graphical dependences were constructed for t = 0.1 ... 1.0, Δt = 0.15, and t = 0.001 ... 0, 1 s with Δt = 0.0165 s. From the obtained dependences it follows that within 0.05 s, the outer layer of the shells (ρ = 0.76 mm) reaches a humidity close to the limiting one, and in the internal (ρ = 0.71 mm) humidification process is in the initial stage.

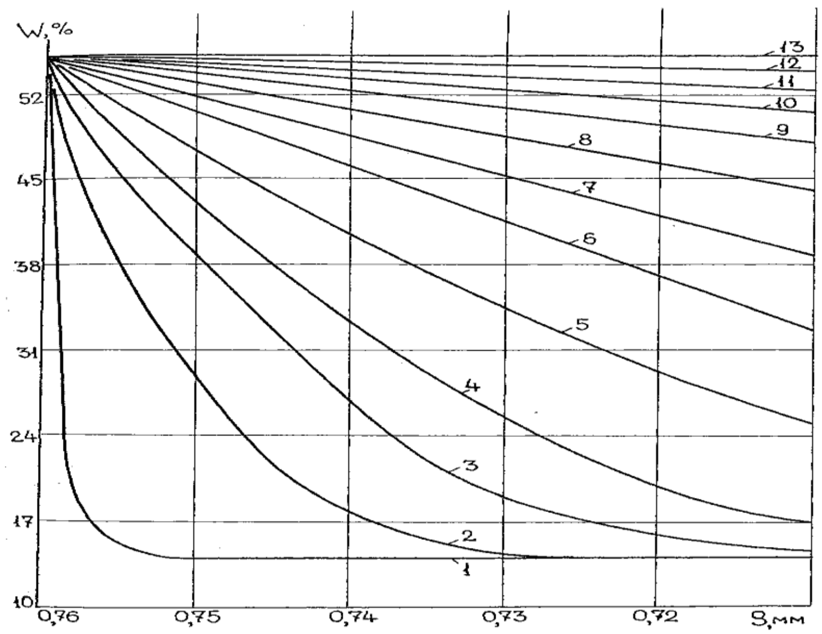

Fig. 3. Change of humidity of environments on their thickness.

The intensity of moisture absorption by the outer layers in the interval from 0.1 decreases and the internal layer rises, and only after this period it begins to decrease for all layers. The outer layer of 15c, reaches moisture saturation, and the inner has a moisture content of 4% less, but after 55 ... 70s, the humidity of all layers reaches the limiting equilibrium. From the analysis of graphical dependencies (Fig. 3) it follows that for t ≥ 0.55 the humidity of the shells varies directly in proportion to their radius, and for t <0.55 the dependence is characterized by second-order curves and for each layer with increasing t the intensity of moisture absorption decreases. Laboratory studies found that the humidity of the shells as a result of peeling in advance moistened by 8% and aged for 5 minutes. grain was 54.4 ... 57.2%, which is consistent with the data. In this connection, it can be stated that the obtained dependence of the diffusion migration of moisture adequately describes the process under investigation.

Conclusions. Using this approach, one can take into account the moisture content of not only the fruit shell, but also the other structural constituents of the grain of different cultures, which is necessary to select the optimal regimes for their ringing. It is established that the hardness of the endosperm is directly dependent on the volume of the grains and their moisture content.

REFERENCES

1.Hynzburh MS Technology of cereals production. - M .: Kolos, 1981.
2.Dudarev Y.R. Kynetics of water cconductivity of corn shell. - W. Agricultural Institute, Odessa, 1988.
3.Dudarev Y.R. Diffusion of moisture in grain shells in primary moisture phase. – Tez dokl. (English). VIII International Congress of grain and bread. - Lausanne, Switzerland, 1988.

ТВЕРДОСТЬ ЗЕРНА

Дударев И.И.

Ключевые слова: режим, зерно,твердость, влажность, структура, кинетика.

Резюме

При повышении влажности зерна пшеницы и кукурузы наблюдается уменьшение значения твердости слоев. Влажность характеризует количество полезных веществ в зерне, а также его пригодность к хранению и переработке.

HARDNESS OF GRAIN

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Key words: mode, grain, hardness, moisture, structure, kinetics.

Summary

With increasing moisture content of wheat and corn, a decrease in the hardness of the layers is observed. Humidity characterizes the amount of nutrients in the grain, as well as its suitability for storage and processing.