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# PHYSICAL AND MECHANICAL PROPERTIES AND QUALITY INDICATOR OF WHEAT

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**ABSTRACT**

The study was conducted during 2011–2015 in the Department of technology of storage and grain processing of Uman National University of Horticulture and on the production complex farm "Prolisok +" in Graniv village, Haysyn ditrict, Vinnytsia region.The aim of the research is to study the physical and mechanical properties and quality of wheat grain depending on weather conditions and properties of the variety.Studies of eligibility of certain varieties of grain for use in the processing industry is new.Wheat grain of Podolyanka, Trizo, Lazurna and Midas varieties has marked peculiarities of type and variety, meets the requirements in terms of external geometric parameters, volume, area of the outer surface, sphericity, specific and volume weight, volume of surface layers of grains and mass fraction of endosperm starch, indicating its suitability for processing. There was a tendency of changes in the geometric characteristics of the grain of the varieties studied under the influence of weather conditions of the year of study. Significant difference in physical indicators of grains of different growing years was recorded in the wheat grain of Trizo variety in terms of length, width, volume, area of the outer surface, specific surface area and volume of surface layers of the grains; Midas – volume, external surface area, specific surface; Lazurna – sphericity. Technological properties of wheat grain are high enough

## 1. Introduction

### 1.1. Setting of the problem

Indicators of properties of grain can be divided into two groups: properties peculiar to grain of the crop, as well as properties that vary within the same crop. The technical process of grain processing should be improved towards obtaining maximum endosperm, increasing product yield of highest grades and improving their quality (Kazakov et al., 2005; Merko, 2001; Savchuk et al., 2005).

Studies of eligibility of certain varieties of grain for use in the processing industry is new. In addition, there are no recommendations for triticale grain production for the moment. Eligibility of grain for industry is characterized by its quality as a raw material for recycling.

### 1.2. Analysis of recent studies and publications

Wheat is the most important food crop. It contains all necessary elements of food: proteins, carbohydrates, fats, vitamins, enzymes and minerals. There is good reason that wheat is the staple food in 43 countries with a population of over 1 billion people (Likhochvor, 2004; Nettevich et al. 1990; Osokina et al., 2016).

For grain, as a raw material for processing, its biometric characteristics, size and

uniformity of grain mass have the main technological importance (Osokina et al., 2016).

The shape and linear grain size influence the choice of sieves or separators as well as the characteristics of shelling machines. In addition, the geometric characteristics of the grain determines its density when forming the layer and peculiarities of moving grain while transportation. Different from the average, values of grain shape affect the porosity, the angle of repose and the angle of friction. The larger geometric size of grain is, the greater the angle of slope is, which has a positive effect on gravity feed of grains during transportation by gravity pipes. Because of the complexity of the processes, many cereal and flour mills are characterized by a significant extent of processing grain products, which reaches a few kilometres of machines and different mechanisms for average powered plants (Gortinskyi et al., 1989; Osokina et al., 2016; Ostapchuk et al., 2005; Zverev, 2007).

That is why the study of physical and mechanical properties of grain has not only theoretical but also practical meaning. Given that these properties vary considerably depending on weather conditions, growing technologies and features of varieties, it requires thorough study. In addition, physical and mechanical characteristics of triticale grain have not been studied enough and thus it determines the relevance of the study.

## 2. Materials and methods

**2.1. The aim of the research** is to study the physical and mechanical properties and quality of wheat grain depending on weather conditions and properties of the variety.

### 2.2. Research Methodology

Wheat grain of Podolyanka, Trizo and Lazurna varieties were grown on the experimental field of educational research and production department of Uman National University of Horticulture, while wheat of Midas variety was grown in the experimental field of the farm "Prolisok +" in Graniv village, Haysyn district of Vinnitsa region.

The study was conducted during 2011–2015 in the Department of Technology of storage and grain processing of Uman National University of Horticulture and on the production complex farm "Prolisok +" in Graniv village, Haysyn ditrict, Vinnytsia region.

Linear dimensions were measured for the grain of wheat by the method described by G.A. Egorov (Egorov, 2000).

Grains volume (V) and an external surface area (F) were calculated by the formulas:

$$V = k \bullet a \bullet b \bullet \ell, \ mm^3 \qquad (1)$$

where – a, b, ℓ are width, thickness and length of grain;

k – research coefficient (for wheat grain k=0,52).

$$F = 1{,}12 \times a^2 + 3{,}76 \times b^2 + 0{,}88 \times \ell^2, \ mm^2 \qquad (2)$$

Peculiarity of grain form is evaluated by its sphericity, which is the ratio of external surface area equivalent grain bullet ($F_{sh}$) for up to actual grain area (F):

$$\Psi = \frac{F_{sh}}{F}, \qquad (3)$$

Thus: $F_{sh} = 4 \times \pi \times r^2$; $r = 0{,}62 \times \sqrt[3]{V}$

Specific surface of grain was set by the ratio of the area of the outer surface (F) to the volume of grains (V):

$$F/V \qquad (4)$$

The volume of surface layers ($V_{s.l.}$) of grain was determined by the formula:

$$V_{s.l.} = F \times G, \ mm^3 \qquad (5)$$

where G – the thickness of tissue (for wheat grain 0,065 mkm).

Mass fraction of starchy endosperm was calculated by the formula:

$$m_e = \frac{V-V_{s.l.}}{V} \times 100 - m_z, \% \quad (6)$$

where $m_z$ is mass of a bud (for wheat grain $m_z = 2,5\%$).

Specific gravity (density) of grain was determined by the formula:

$$\rho = m/V, \quad (7)$$

where m – mass of grain, $g/cm^3$.

(Egorov, 2000; Gortinskyi et al., 1989; Kazakov et al., 2005; Osokina et al., 2016; Ostapchuk et al., 2005; Zverev, 2007).

To determine the quality of the grain standard methods were used: sampling [GOST 13586.3–83; GOST 24104–88]; determination of the color and smell [GOST 10967–75]; contamination [GOST 13586.6–93; GOST 13586.4–83]; debris [GOST 30483–97]; humidity [GOST 13586.5–93]; nature (bulk density) [GOST 10840–64]; 1000 grain weight [GOST 10842–89]; glasslike structure [GOST 10987–76].

## 3. Results and discussions

The geometric characteristics of the grain determine its density when forming layer (porosity) and features of the moving grain during transportation. Because of the complexity of the processes cereal and flour mills are characterized by a significant extent of processing grain products, which reaches a few kilometres of machines and various mechanisms (pneumatic pipes, elevators, conveyors, etc.) for average powered plants (Gortinskyi et al., 1989; Osokina et al., 2016; Ostapchuk et al., 2005; Zverev, 2007).

10 average-sized grains of wheat were selected and their size was measured. According to the conducted measurements, indicators of geometric characteristics of the grain vary rather greatly.

To characterize the geometric features of grain, it is not enough only to specify linear dimensions. The value of volume, area, sphericity, specific surface of grains, specific and bulk density that play an important role in moisturizing, heating and cooling of the grain were determined by the average value of linear dimensions of wheat of varieties studied, as well as the volume of surface layers of the grains and mass fraction of endosperm starch which characterize a possible yield of grain and flour from such grain (table 1).

The obtained values of physical and mechanical indicators of wheat and triticale (table 1) are within the limits given in the sources of literature (Likhochvor, 2004; Nettevich et al. 1990; Osokina et al., 2016; Savchuk et al., 2005). However, the grains of wheat of Podolyanka, Midas, Trizo and Lazurna varieties have the thickness up to 7 % larger, and the length and width, respectively, 4–11 and 2–10 % lower than average. Grains of soft winter variety of Lazurna have the largest linear dimensions, grains of spring soft wheat of Trizo variety grown in 2014 have the smallest dimensions.

These characteristics affected the volume and area of the outer surface of the grain, values of which are lower than the average values according to the sources of literature 4–8 $mm^3$ respectively and 4–12 $mm^2$ for wheat of Podolyanka, Trizo, Midas varieties, whereas for the grains of Lazurna varieties they are 0,8 and 0.3 % larger respectively. Value of sphericity of grains wheat – 0,58–0,63.

Specific surface of grains was determined by the ratio F/V. This indicator is extremely important in grain drying because it is responsible for the intensity of the heat exchange and moisture diffusion in the grain. The value of this indicator for wheat is 2,15–2,61 and exceed the average literature data for corresponding crops except wheat of Lazurna variety of 2014 (table 1).

**Table 1.** Physical and mechanical properties of wheat grain

| Variety | Year | Size, mm | | | Grains volume, $V$, mm$^3$ | Sphericity, $\varphi$ | External surface area, $F$, mm$^2$ | Specific surface of grain, F/V | Volume of surface layers, $V_{s.l.}$, mm$^3$ | Mass fraction of starchy endosperm, $m_e$, % | Specific gravity (density), ρ, г/см$^3$ | Bulk density, kg/dm$^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | length, $\ell$ | width, $a$ | thickness, $b$ | | | | | | | | |
| Podolyanka | 2011 | 6.6 | 3.7 | 3.1 | 38.8 | 0.62 | 89.4 | 2.30 | 5.81 | 82.5 | 1.33 | 0,78 |
| | 2012 | 6.8 | 3.8 | 3.1 | 40.8 | 0.62 | 93.0 | 2.28 | 6.05 | 82.7 | 1.34 | 0,78 |
| | average | 6.7 | 3.7 | 3.1 | 39.8 | 0.62 | 91.2 | 2.29 | 5.93 | 82.6 | 1.33 | 0,78 |
| Trizo | 2013 | 6.5 | 3.6 | 3.1 | 37.7 | 0.62 | 87.8 | 2.33 | 5.71 | 82.4 | 1.38 | 0,76 |
| | 2014 | 6.1 | 3.4 | 2.9 | 30.9 | 0.61 | 76.4 | 2.47 | 4.97 | 81.4 | 1.38 | 0,76 |
| | 2015 | 6.4 | 3.7 | 3.0 | 36.9 | 0.63 | 85.2 | 2.31 | 5.54 | 82.5 | 1.40 | 0,76 |
| | average | 6.3 | 3.6 | 3.0 | 35.2 | 0.62 | 83.1 | 2.36 | 5.41 | 82.1 | 1.39 | 0,76 |
| Midas | 2014 | 6.2 | 3.9 | 3.1 | 32.9 | 0.54 | 86.0 | 2.61 | 5.59 | 80.5 | 1.34 | 0,77 |
| | 2015 | 6.3 | 3.9 | 3.2 | 40.9 | 0.63 | 90.5 | 2.21 | 5.88 | 83.1 | 1.35 | 0,77 |
| | average | 6.2 | 3.9 | 3.1 | 36.9 | 0.58 | 88.2 | 2.39 | 5.74 | 81.8 | 1.34 | 0,77 |
| Lazurna | 2013 | 6.7 | 3.9 | 3.2 | 43.4 | 0.58 | 94.6 | 2.18 | 6.15 | 83.3 | 1.35 | 0,79 |
| | 2014 | 6.7 | 4.0 | 3.2 | 44.6 | 0.63 | 95.9 | 2.15 | 6.23 | 83.5 | 1.35 | 0,79 |
| | average | 6.7 | 3.9 | 3.2 | 44.0 | 0.61 | 95.2 | 2.16 | 6.19 | 83.4 | 1.35 | 0,79 |
| According to literature sources* | | 4,8–8,0 | 1.6–4.0 | 1.5–3.3 | 12.0–54.9 | 0.36–0.68 | 58–115 | - | 3.77–7.48 | 77.0–85.0 | 1.33–153 | 0.73–0.84 |
| | | 7,0 | 4.0 | 3.0 | 43.7 | 0.63 | 94.9 | 2.17 | 6.17 | 83.4 | - | - |
| *LSD 5%* | | *0,32* | *0.19* | *0.16* | *3.20* | *0.03* | *4.50* | *0.12* | *0.30* | *4.11* | *0.07* | *0.04* |

Note. * – according to (Likhochvor, 2004; Nettevich et al. 1990; Osokina et al., 2016; Savchuk et al., 2005): above the line – the border; below the line – average.

It is obvious that with decreasing grain size decreases ratio value of volume and area of the outer surface; therefore, small grains should have a higher content of shells and smaller content of the endosperm.

Furthermore, cereals and flour are obtained by means of endosperm and coat, aleurone layer and embryo should be sent in by-products and waste. It is therefore important to have information about the content in the grain endosperm of the parties and the amount of surface layers of the grains to make a prediction about the possible yield of the product.

The largest mass fraction of starchy endosperm is defined in the grain of winter wheat of Lazurna variety – 83,4 %, and in the grain of other varieties studied it is 1,7–3,4 % less.

The volume of surface layers of grains of wheat during the years of study varied within 4,97–6,23 mm$^3$ (table 1). Among the varieties studied, grains of Lazurna variety had the highest figure and Trizo variety had the lowest figure (13 % less).

The highest value of bulk density was determined in the grain of wheat of Lazurna variety – 0,79 kg/dm$^2$.

Specific gravity (density) of the grain as a whole describes chemical composition, structure, fullness, hardness, strength, maturity of the grain and has a great impact on productive properties. Starch and minerals have the highest specific mass, therefore with the increase of their share density of grains increases, and, conversely, increased protein and lipid lower the density of grain. The value

of this index (table 1) for wheat is 1,33–1,40 g/cm$^3$, with the advantage of Trizo variety.

The quality of the finished product depends on the quality of raw materials. Study of grain quality showed that the samples have smell and taste typical for crops.

Technological properties of grain are a combination of features and indicators of its quality which characterize the state of grain in processing and production processes and affect the yield and quality of the product.

Table 2 present comparative characteristic of technological properties of wheat grain of the varieties studied.

Research results of studies of technological grain quality indicators (table 2) showed that wheat varieties studied meet the quality standards. Thus, moisture of wheat grains is 0,4–1,2 % subtolerance.

The total content of impurities is 0,8 % lower than minimum standards for the second-class grain of Trizo variety and Podolyanka, Lazurna is 0,7 % lower and the first-class grain of Midas variety is 0,4 % lower than minimum standards. Grain impurities in the wheat grain is 3,0 and 3,1 % on average which is 2,0 and 1,9 % less than minimum standards for the first-class wheat (table 2).

**Table 2.** Characteristics and quality standards of wheat

| Indicator | Permissible limits (DSTU 3768:2010)* | The actual quality grade | | | | | | | | | | | | | *LSD 5%* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Podolyanka | | | Trizo | | | | Midas | | | Lazurna | | | |
| | | year | | | | | | | | | | | | | |
| | | 2011 | 2012 | average | 2013 | 2014 | 2015 | average | 2014 | 2015 | average | 2013 | 2014 | average | |
| Moisture. % | not more 14.0 | 12.9 | 12.5 | 12.7 | 12.9 | 12.6 | 13.0 | 12.8 | 12.8 | 13.2 | 13.0 | 13.7 | 13.5 | 13.6 | *0.65* |
| Waste impurities. %: | not more 1.0/2.0 | 1.2 | 1.2 | 1.2 | 1.6 | 1.5 | 0.6 | 1.2 | 0.6 | 0.6 | 0.6 | 1.8 | 0.9 | 1.3 | *0.05* |
| - mineral admixture | not more 0.3 | - | | | | | | | | | | | | | - |
| Grain impurities. % | not more 5.0/8.0 | 3.7 | 2.2 | 3.0 | 3.1 | 2.8 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.1 | 3.1 | 3.1 | *0.15* |
| Contamination by pests. units of live specimens | not allowed in addition to mite infestation level 1 | not found | | | | | | | | | | | | | - |
| Nature. g/l | no less 760/740 | 780 | 780 | 780 | 765 | 760 | 764 | 763 | 770 | 775 | 773 | 790 | 790 | 790 | *38.80* |
| Weight of 1000 grains. g | 35–75** | 51.6 | 54.3 | 52.9 | 52.0 | 42.6 | 51.2 | 48.6 | 44.1 | 55.2 | 49.6 | 58.6 | 60.2 | 59.4 | *2.64* |
| Vitrescence. % | no less 50/40 | 32.0 | 37.0 | 34.5 | 42.0 | 42.0 | 44.0 | 42.7 | 44.0 | 50.0 | 47.0 | 45.0 | 45.0 | 45.0 | *2.11* |

Note. * – before the line – 1 class; after the line – 2 class; ** – according to literature sources (Likhochvor. 2004; Nettevich et al. 1990; Osokina et al.. 2016; Savchuk et al.. 2005).

Weight of 1000 grains of wheat of Lazurna variety was 59,4 g, which is more than in grains of Trizo, Midas and Podolyanka varieties by 18, 16 and 11 % respectively. The greatest value of nature is defined in the grain of wheat of Lazurna variety – 790 g/l, and in grain of other varieties studied – by 3–4 % less.

In the specimens studied no pests were found.With the increase of vitrescence of grain there is a higher protein content and better technological properties. Yield of cereals and flour from with high vitrescence is larger. Samples of the grain investigated had floury endosperm. Vitrescence of wheat grain – 32–50 %.

## 4. Conclusions

Thus, comparing the geometric parameters of wheat it was found that grain of Midas variety has the most rounded shape and grain of Lazurna variety has prevailing linear dimensions. It should be used while preparation of grain for processing as well as the selection of sieves, machines and speed of rotation of their working bodies.

There was a tendency of changes in the geometric characteristics of the grain of the varieties studied under the influence of weather conditions of the year of study. Significant difference in physical indicators of grains of different growing years was recorded in the wheat grain of Trizo variety in terms of length, width, volume, area of the outer surface, specific surface area and volume of surface layers of the grains; Midas – volume, external surface area, specific surface; Lazurna – sphericity.

Large linear dimensions are found in the wheat grain of Lazurna variety.

Wheat grain of Podolyanka, Trizo, Lazurna and Midas varieties has marked peculiarities of type and variety, meets the requirements in terms of external geometric parameters, volume, area of the outer surface, sphericity, specific and volume weight, volume of surface layers of grains and mass fraction of endosperm starch, indicating its suitability for processing.

Technological properties of wheat grain are high enough. Grain moisture, content of waste and grain impuritiess are within acceptable standards.

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