PHYSICAL AND MECHANICAL PROPERTIES AND QUALITY INDICATOR OF BARLEY

Abstract. The study has been 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 the village of Graniv, Haysyn district, Vinnytsia region. The aim of the research is to study the physical and mechanical properties and quality of barley grain depending on weather conditions and properties of the variety. Studies of eligibility of certain varieties of barley grain for the use in the processing industry is new. Barley grain of Zvershennya, Komandor and Svagor 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 barley grain of Zvershennya variety in terms of external surface area, specific surface and volume of surface layers; Komandor – thickness, volume and specific surface; Svagor – volume. Large linear dimensions are found in the barley grain of Svagor variety.

Keywords: grain, barley, variety, physical and mechanical properties, quality.
Винницької області. Цель исследования — изучение физико-механических и качественных свойств зерна ячменя в зависимости от условий погоды и особенностей сорта. Исследование пригодности зерна ячменя определенных сортов для использования в перерабатывающей промышленности является новым.

Зерно ячменя сортов Свершение, Командор и Свагор имеет выраженные особенности рода и сорта, соответствует требованиям по внешним геометрическим показателям, объемом, площадью внешней поверхности, сферичностью, удельной и объемной массой, объему поверхностных слоев зерновки и массовой долей крахмальной части эндосперма, что свидетельствует о его пригодности для переработки.

Наблюдалась тенденция изменения геометрических характеристик зерна ячменя сортов, что изучали под влиянием погодных условий года исследования. Существенная разницу по физическим показателям зерна разных лет выражения зафиксировано в зерне ячменя сорта Свершение по величине площади внешней поверхности, удельной поверхности и объема поверхностных слоев зерновки; Командор – толщины, объема, удельной поверхности; Свагор – объема.

Большие линейные размеры определены в зерне ячменя сорта Свагор.

Ключевые слова: зерно, ячмень, сорт, физико-механические показатели, качество.

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 [1–5].

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.

Analysis of recent studies and publications. Barley – one of the oldest cultures. In Ukraine barley grown four to five thousand years BC. Barley is widely used by man for food, feed and industrial purposes [6, 7].

For grain, as a raw material for processing, its biometric characteristics and uniformity of grain mass have the main technological importance [1, 6].

The shape and linear grain size influence the choice of sieves or separators as well as the characteristics of shellling 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 [6, 8–10].

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.

The aim of the research is to study the physical and mechanical properties and quality of barley grain depending on weather conditions and properties of the variety. Research Methodology. Barley grain of Zvershennya and Komandor varieties were grown on the experimental field of educational research and production department of Uman National University of Horticulture, while barley of Svagor variety was grown in the experimental field of the farm «Prolisok++» in Graniv village, Haysyn district of Vinnytsia 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 district, Vinnytsia region.

Linear dimensions were measured for the grain of barley by the method described by G. A. Egorov [4].

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

\[ V = \frac{k \cdot a \cdot b \cdot l}{6}, \quad \text{mm}^3 \quad (1) \]

where \( a, b, l \) are width, thickness and length of grain. \( k \) – research coefficient (for barley \( k=0,58 \)).

\[ F = 1,12 \times a^2 + 3,76 \times b \times l + 0,88 \times l^2, \quad \text{mm}^2 \quad (2) \]

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

\[ \Phi = \frac{F_{\text{sh}}}{F}, \quad (3) \]

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

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

\[ F/V = \quad (4) \]

The volume of surface layers (V⊥) of grain was determined by the formula:

\[ V_\perp = F \times G, \quad \text{mm}^3 \quad (5) \]

where \( G \) – the thickness of tissue (for barley \( 0,085 \) mkm).

Mass fraction of starchy endosperm was calculated by the formula:

\[ m_\text{z} = \frac{V_\perp}{V} \times 100 - m_z, \quad \% \quad (6) \]

where \( m_z \) – mass of a bud (for barley \( 2,5\% \)).

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

\[ p = \frac{m_\text{z}}{V}, \quad (7) \]

where \( m \) is mass of grain, g/cm³. [3, 4, 6, 8–10].

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].

Research results. 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 plants 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 [8–10].

10 average-sized grains of barley 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 barley of varieties studied, as well as the volume of surface layers of the grains and mass fraction of endosperm starch which characterizes a possible yield of cereals output 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 [2, 5, 6, 7]. The grains of barley variety of Zvershenny averages linear dimensions almost coincided with the corresponding average values of literature sources. However, the grains of barley of Komandor, the average for the years of research, the width and thickness of the grains is 0.1 mm larger, and the length is 0.3 mm less than the corresponding mean values from literature sources slight advantage grown in 2014.

In turn, the grains of variety of Svagor the length, width, thickness were respectively 9.6, 3.4, 3.0 mm, an increase of 10–26% of the corresponding mean values of sources and literature at 13–23% and 8–30% average data the grains of barley of Commander and Zvershenny varieties respectively.

For grains of barley of Svagor variety value and volume of external surface area accounted for 49.9 mm3 and 129.1 mm2 respectively, more average values of literature sources respectively 1.9 and 1.4 times.

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 barley is ~ 2.56–4.20 and exceed the average literature data for corresponding crops except barley of Komandor and Svagor varieties

Table 1 present comparative characteristic of technological properties of barley grain, of the varieties studied.

Determined that the value of barley grain humidity 6–10% less than the allowable upper limit. Total waste impurities content in the grain barley varieties Achievements matches the permissible limit, and barley varieties Commander and less Svahor admission rules 35 and 25% respectively. In turn, admixture grain barley varieties accomplishments, and Commander Svahor, average years of research, is 2.5, 3.3 and 2.8%, part of the permissible limits. Content compliance standards of quality grain impurities evidence of a thorough cleaning.

Weight of 1000 grains of barley varieties Commander was 32.6–37.6 g (with preferred grain in 2014), while class

<table>
<thead>
<tr>
<th>Variety</th>
<th>Year</th>
<th>Size, mm</th>
<th>Length, ℓ</th>
<th>Width, a</th>
<th>Thickness, b</th>
<th>Grains volume, V mm³</th>
<th>Sphericity, φ</th>
<th>External surface area, F, mm²</th>
<th>Specific surface of grains, F/V</th>
<th>Volume layers of starchy endosperm, Vₐ, mm³</th>
<th>Mass fraction of starch of endosperm, mₛ, %</th>
<th>Specific gravity (density), ρ, g/cm³</th>
<th>Bulk density, ρ₌, kg/dm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zvershenny</td>
<td>2011</td>
<td>8.9</td>
<td>2.6</td>
<td>2.1</td>
<td>24.3</td>
<td>0.43</td>
<td>93.8</td>
<td>3.86</td>
<td>7.97</td>
<td>64.7</td>
<td>1.29</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>8.8</td>
<td>2.6</td>
<td>2.1</td>
<td>24.1</td>
<td>0.44</td>
<td>101.1</td>
<td>4.20</td>
<td>8.59</td>
<td>61.8</td>
<td>1.28</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td></td>
<td>average</td>
<td>8.8</td>
<td>2.6</td>
<td>2.1</td>
<td>24.2</td>
<td>0.43</td>
<td>97.5</td>
<td>4.03</td>
<td>8.28</td>
<td>63.3</td>
<td>1.28</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>Komandor</td>
<td>2014</td>
<td>8.4</td>
<td>2.6</td>
<td>2.3</td>
<td>25.1</td>
<td>0.46</td>
<td>89.6</td>
<td>3.57</td>
<td>7.62</td>
<td>67.2</td>
<td>1.30</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>8.4</td>
<td>2.6</td>
<td>2.4</td>
<td>28.2</td>
<td>0.48</td>
<td>92.5</td>
<td>3.28</td>
<td>7.86</td>
<td>69.6</td>
<td>1.31</td>
<td>0.64</td>
<td></td>
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<tr>
<td></td>
<td>average</td>
<td>8.4</td>
<td>2.7</td>
<td>2.4</td>
<td>27.6</td>
<td>0.47</td>
<td>91.0</td>
<td>3.30</td>
<td>7.74</td>
<td>69.3</td>
<td>1.30</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>Svagor</td>
<td>2014</td>
<td>9.7</td>
<td>3.5</td>
<td>3.0</td>
<td>50.9</td>
<td>0.52</td>
<td>130.3</td>
<td>2.56</td>
<td>11.08</td>
<td>75.7</td>
<td>1.10</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>9.6</td>
<td>3.4</td>
<td>3.0</td>
<td>49.0</td>
<td>0.50</td>
<td>127.9</td>
<td>2.62</td>
<td>10.87</td>
<td>75.3</td>
<td>1.12</td>
<td>0.65</td>
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</tr>
<tr>
<td></td>
<td>average</td>
<td>9.6</td>
<td>3.4</td>
<td>3.0</td>
<td>49.9</td>
<td>0.51</td>
<td>129.1</td>
<td>2.59</td>
<td>10.98</td>
<td>75.5</td>
<td>1.11</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>According to literature sources*</td>
<td>7.0–10.0</td>
<td>2.0–3.0</td>
<td>1.7–3.0</td>
<td>12.0–45.0</td>
<td>-</td>
<td>58.5–131.9</td>
<td>-</td>
<td>4.97–11.21</td>
<td>62–69</td>
<td>1.13–0.54</td>
<td>1.28–0.70</td>
<td></td>
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</tr>
<tr>
<td>LSD 5%</td>
<td>0.45</td>
<td>0.15</td>
<td>0.13</td>
<td>1.70</td>
<td>0.03</td>
<td>5.30</td>
<td>0.16</td>
<td>0.45</td>
<td>3.81</td>
<td>0.06</td>
<td>0.03</td>
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<td></td>
</tr>
</tbody>
</table>
Table 2

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Zvershennya</td>
<td>Komandor</td>
</tr>
<tr>
<td>Moisture, %</td>
<td>not more 14,5</td>
<td>13,4</td>
</tr>
<tr>
<td>Waste impurities, %:</td>
<td>not more 2,0</td>
<td>2,0</td>
</tr>
<tr>
<td>- mineral admixture</td>
<td>not more 0,3</td>
<td>-</td>
</tr>
<tr>
<td>Grain impurities, %</td>
<td>not more 7,0</td>
<td>2,8</td>
</tr>
<tr>
<td>Contamination by pests, units of live specimens</td>
<td>not found</td>
<td>not found</td>
</tr>
<tr>
<td>Nature, g/l</td>
<td>no less 600</td>
<td>615</td>
</tr>
<tr>
<td>Weight of 1000 grains, g</td>
<td>20–55*</td>
<td>31,3</td>
</tr>
</tbody>
</table>

Note. * – according to literature sources [5–7].

achievements – 30,8–31,3 g (with preferred grain in 2011), in its all for variety Svahor this figure corresponded to 54,8 g (30–40% and 43–44% more than corn varieties Commander and Achievements respectively). Nature is indicated barley varieties was 606–645 g/l.

Barley does not apply to crops hulled because determination of films for the culture is not mandatory standards and is not standardized. However, we found that pilchastist barley is 10,9–12,2%, which corresponds to the source literature (10–13%) [6, 7].

In the specimens studied no pests were found.

Conclusion. Thus, comparing the geometric parameters of barley it was found that grain of Zvershennya variety has the most elongated shape and grain of Svagor 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 barley grain of Zvershennya variety in terms of external surface area, specific surface and volume of surface layers; Komandor – thickness, volume and specific surface; Svagor – volume.

Large linear dimensions are found in the barley grain of Svagor variety.

Barley grain of Zvershennya, Komandor and Svagor 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.

References

Література