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PHYSICAL AND MECHANICAL PROPERTIES AND QUALITY INDICATOR OF TRITICALE GRAIN

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The study was conducted during 2011–2015 in the Department of technology of storage and grain processing of Uman National University of Horticulture. The aim of the research is to study the physical and mechanical properties and quality of triticale 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. 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.

Triticale grain of Khlibodar kharkiv and Avatar 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 triticale grain of Khlibodar kharkiv variety in terms of volume; Avatar – volume and specific surface. Technological properties of triticale grain are high enough.

Key words: corn, triticale, variety, physical and mechanical properties, quality.

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 [1–4].

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Analysis of recent studies and publications. Triticale is relatively new winter or spring grass plant artificially created by crossing wheat with rye, and thus many morphological and biological properties of triticale are intermediate between wheat and rye. Triticale is less demanding to growing conditions than wheat which makes it particularly valuable for households with low resource provision [5, 6].

For grain, as a raw material for processing, its biometric characteristics, size and uniformity of grain mass have the main technological importance [1, 4].

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 [4, 7, 8].

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 triticale grain depending on weather conditions and properties of the variety.

Методика дослідження. Triticale grain of Khlibodar kharkiv and Avatar varieties were grown on the experimental field of educational research and production department of Uman National University of Horticulture.

The study was conducted during 2011–2015 in the Department of Technology of storage and grain processing of Uman National University of Horticulture.

Linear dimensions were measured for the grain of triticale by the method described by G.A. Egorov [3].

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

$$V = k \cdot a \cdot b \cdot \ell, \text{ мм}^3 \quad (1)$$

where – a, b, ℓ are width, thickness and length of grain; k – research coefficient (for triticale grain k=0,52).

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

Peculiarity of grain form is evaluated by its sphericity, which is the ratio of external surface area equivalent grain bullet ($F_ш$) for up to actual grain area (F): $\Psi = \frac{F_ш}{F}$, (3)

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

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 (4)

The volume of surface layers of grain was determined by the formula: $V_{п.ш.} = F \times G$, mm^3 (5)

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

Mass fraction of starchy endosperm was calculated by the formula:

$$m_э = \frac{V - V_{п.ш.}}{V} \times 100 - m_з, \%$$ (6)

where $m_з$ – mass of a bud (for triticale grain $m_з$ = 2,5%).

Specific gravity (density) of grain was determined by the formula: $\rho = m/V$, (7)

where m is mass of grain, g/cm^3 [2–4, 7, 8].

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 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 [4, 7, 8].

10 average-sized grains of triticale 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, triticale 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).

Table 1

Physical and mechanical properties and quality indicator of triticale

Varieties	Year	Size, mm			Grains volume, V, mm^3	Sphericity, φ	External surface area, $F_э$, mm^2	Specific surface of grain, F/V	Volume of surface layers, $V_{п.ш.}$, mm^3	Mass fraction of starchy endosperm, $m_э$, %	Specific gravity (density), ρ, г/см^3	Bulk density, kg/dm^2
		length, l	width, a	thickness, b								
Khlibodar kharkiv	2011	7,6	3,2	2,9	36,1	0,57	93,5	2,59	6,08	80,7	1,27	0,66
	2012	7,8	3,3	2,9	38,1	0,55	97,3	2,55	6,32	80,9	1,30	0,69
	average	7,7	3,2	2,9	37,1	0,56	95,4	2,57	6,20	80,8	1,29	0,68
Avatar	2013	7,9	3,2	3,0	39,4	0,56	100,2	2,54	6,51	81,0	1,27	0,72
	2014	7,7	3,2	3,0	37,0	0,55	98,3	2,66	6,39	80,2	1,27	0,72
	2015	7,8	3,2	3,0	38,9	0,56	98,8	2,54	6,42	81,0	1,28	0,73
	average	7,8	3,2	3,0	38,2	0,55	99,3	2,60	6,44	80,7	1,27	0,72
According to literature sources*		5,0–10,0	1,4–3,6	1,2–3,5	4,4–65,5	-	72,0–148,5	-	4,68–9,65	74,0–81,0	-	0,70–0,75
		8,4	3,5	2,6	39,7	0,56	101,2	2,55	6,58	80,0		-
LSD 5%		*0,39*	*0,16*	*0,15*	*1,89*	*0,03*	*4,88*	*0,09*	*0,32*	*2,04*	*0,06*	*0,04*

*Note. * – according to [4–6]: above the line – the border; below the line – average.*

The obtained values of physical and mechanical indicators of triticale (table 1) знаходяться are within the limits given in the sources of literature [4–6].

Grains of triticale of Khlibodar kharkiv and Avatar varieties have an elongated ellipse shape, their length and width, on average during the years of research are 7–8 % lower than corresponding average values and thickness is 11–15 % larger than average data of sources of literature.

Values of volume and area of the outer surface of triticale grain yielded the average data of sources of literature respectively 2–3 mm^3 and 2–6 mm^2. Value of sphericity of grains triticale – 0,55–0,57.

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 triticale is 2,54–2,66 and exceed the average literature data for corresponding crops except triticale variety of Avatar variety of 2013 and 2015. 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 mass fraction of endosperm of triticale grain was 80–81 %, a margin of 2013 and 2015.

Triticale grains of Avatar variety had 4 % less volume compared to the surface layers of the grains of Khlibodar kharkiv variety (table 1).

The highest value of bulk density was determined in the grain of triticale of Avatar variety – 0,72 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 for triticale is 1,27–1,30 g/cm^3, with the advantage of Avatar variet.

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 triticale grain of the varieties studied.

Table 2

Characteristics and quality standards of triticale

Indicator	Permissible limits (DSTU 4762:2007) [9]	The actual quality grade							*LSD 5%*
		Khlibodar kharkiv			Avatar				
		2011 p.	2012 p.	average	2013 p.	2014 p.	2015 p.	average	
Moisture, %	not more 14,5	11,7	11,5	11,6	12,7	13,0	13,0	12,8	*0,64*
Waste impurities, %:	not more 2,0	1,6	1,2	1,4	1,3	1,3	1,4	1,3	*0,07*
- mineral admixture	not more 0,3	-							
Grain impurities, %	not more 7,0	5,9	4,6	5,3	6,1	6,2	4,3	5,5	*0,27*
Contamination by pests, units of live specimens	not allowed in addition to mite infestation level 1	not found							
Nature, g/l	630…750	663	690	676	720	722	726	722,7	*34,96*
Weight of 1000 grains, g	10–50*	45,8	49,5	47,7	50,0	47,0	49,8	48,9	*2,42*
Vitrescence, %	-	24,0	28,0	26,0	24,0	24,0	24,6	24,2	*1,21*

*Note. * – according to literature sources [1, 4–6].*

Research results of studies of technological grain quality indicators (table 2) showed that triticale varieties studied meet the quality standards. Thus, moisture of triticale grains is 1,7–2,9 % subtolerance. In turn, the waste impurities content is less than allowable for triticale grain of Khlibodar kharkiv and Avatar by 0,7 and 0,6 % respectively. Content compliance of waste impurities with grain quality standards demonstrates its thorough cleaning. Grain impurities in the triticale grain of indicated varieties is 5,5 and 5,3 % on average which is less than the allowable values by 1,5 and 1,7% respectively (table 2).

Weight of 1000 grains of triticale of Avatar variety was 48,9 g on average during the years of the research which is more than in grains of Khlibodar kharkiv variety by 1,2 g. Grain-unit of triticale grain was 663–726 g/l. 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 with vitrescence of triticale grain is 24–28 %.

Conclusion. 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 triticale grain of Khlibodar kharkiv variety in terms of volume; Avatar – volume and specific surface.

Triticale grain of Khlibodar kharkiv and Avatar 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 triticale grain are high enough. Grain moisture, content of waste and grain impuritiess are within acceptable standards.

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ФІЗИКО-МЕХАНІЧНІ ТА ЯКІСНІ ПОКАЗНИКИ ЗЕРНА ТРИТИКАЛЕ

К. В. Костецька

Дослідження проведено впродовж 2011–2015 рр. на кафедрі технології зберігання і переробки зерна Уманського НУС. Мета дослідження – вивчення фізико-механічних та якісних властивостей зерна пшениці та тритикале залежно від погодніх умов і особливостей сорту.

Дослідження придатності зерна певних сортів для використання в переробній промисловості є новим. Крім того, на сьогоднішній день, відсутні рекомендації щодо виготовлення продуктів із зерна тритикале.

Зерно пшениці сортів Подолянка, Trizo, Лазурна та Midas, тритикале сортів Хліборад харківський і Аватар, має виражені особливості роду та сорту, відповідає вимогам за зовнішніми геометричними показниками, об'ємом, площею зовнішньої поверхні, сферичністю, питомою і об'ємною масою, об'ємом поверхневих шарів зернівки та масовою часткою крохмальної частини ендосперму, що свідчить про його придатність для переробки.

Спостерігалась тенденція зміни геометричних характеристик зерна тритикале сортів, що вивчали під впливом погодних умов року дослідження. Істотну різницю за фізичними показниками зерна різних років вирощування зафіксовано в зерні тритикале сорту Хліборад харківський за величиною об'єму; Аватар – об'єму та питомої поверхні. Технологічні властивості зерна тритикале достатньо високі.

Ключові слова: зерно, тритикале, сорт, фізико-механічні властивості, якість.

ФИЗИКО-МЕХАНИЧЕСКИЕ И КАЧЕСТВЕННЫЕ ПОКАЗАТЕЛИ ЗЕРНА ТРИТИКАЛЕ

К. В. Костецкая

Исследование проведено в течение 2011–2015 гг. на кафедре технологии хранения и переработки зерна Уманского НУС. Цель исследования – изучение физико-механических и качественных свойств зерна тритикале в зависимости от условий погоды и особенностей сорта.

Исследование пригодности зерна определенных сортов для использования в перерабатывающей промышленности является новым. Кроме того, на сегодняшний день отсутствуют рекомендации по изготовлению продуктов из зерна тритикале.

Зерно тритикале сортов Хлебодар харьковский и Аватара имеет выраженные особенности рода и сорта, соответствует требованиям по внешним геометрическими показателями, объемом, площадью внешней поверхности, сферичностью, удельной и объемной массой, объемом поверхностных слоев зерна и массовой долей крахмальной части эндосперма, что свидетельствует о его пригодности для переработки.

Существенную разницу по физическим показателям зерна разных лет выращивания зафиксировано в зерне тритикале сорта Хлебодар харьковский по величине объема; Аватар – объема и удельной поверхности.

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

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