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PRIMARY WHEAT (*Triticum aestivum*) SEED TEXTURE

GLAVNE OSOBINE SEMENA PŠENICE (*Triticum aestivum*)

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ABSTRACT

The results of some physical properties three domestic wheat cultivars are presented in this paper. Three axial dimensions of the seed length, width and thickness were measured only at equilibrium moisture content. The length of Simonida kernel is 5.2-5.7 mm, Dragana 5.1-6.0 mm and NS 40S is 5.0-5.9 mm. The other two dimensions are similar within the varieties: the width is 2.3-2.8 mm, 2.0-3.0 mm and 2.2-3.0 mm for Simonida, Dragana and NS 40S respectively. The thickness for Simonida seed is 1.9-2.4 mm, Dragana has 1.9-2.7 mm and NS 40S kernel dimension is 2.0-3.4 mm. Those surveying indicate that the shape of kernels is rather prolong elliptical then spheroid. This conclusion confirms the sphericity of the grains, so this value for Simonida cultivar is 0.57 as well as for Dragana, while NS 40S seed shpericity is 0.6. The bulk densities are 791.34 kg/m^3, 788.51 kg/m^3 and 731.77 kg/m^3 for Simonida, Dragana and NS 40S. The porosity of Simonida kernels is 28.28%, for Dragana 31.46% and for NS 40S is 31.59%. The results of slow compressive test demonstrate that Simonida and Dragana are hard wheat. The highest value of mean rapture force of 244.4 N was observed for Simonida variety at the 13.6% of moisture content. Cultivar Dragana value of mean rapture force was 241.4 N at 13.3% of moisture content and cultivar NS 40S had mean rapture force of 106.8 N at 14.1% grain moisture content.

Key words*: wheat, physical properties, compression test.*

REZIME

Rezultati istraživanja nekih fizičkih osobina domaćih domaćih selekcija semena pšenice su prikazani u radu. Tri aksijalne dimenzije semena dužina, širina i debljina su rađeni samo pri jednoj vlažnosti mase zrna i to ravnotežnoj vrednosti. Dužina semena Simonide su 5.1-6.0 mm, Dragane 5.1-6.0 mm, a NS 40S su 5.0-5.9 mm. Ostale dve dimenzije su dosta slične za sve tri sorte: širina je od 2.3-2.8 mm, 2.0-3.0 mm i 2,2-3.0 mm za Simonidu, Draganu i NS 40S respektivno. Debljina semena Simonide je od 1.9-2.4 mm, za Draganu 1.9-2.7 mm i sa sortu NS 40S je 2.0-3.4 mm. Ova merenja ukazuju na oblik semena koji je kod svig triju sorti više izduženo elipsoidan nego sferoidan. Ovaj zaključak su potvrdila merenja sferičnosti zrna koja su relativno niskih vrednosti i iznose za Simonidu i Draganu 0.57, dok je kod sorte NS 40S sferičnost 0.6. Nasipne gustine su 791.34 kg/m^3, 788.51 kg/m^3 and 731.77 kg/m^3 za Simonidu, Draganu i NS 40S. Srednja vrednost poroznosti mase semena Simonide je 28.28%, Dragane 31.46% i zy NA 40S je 31.59%. Kada je u pitanju čvrstoća pojedinačnog semena, rezultati kompresionog testa su potvrdili da su Simonida i Dragana tvrde pšenice. Najveća srednja vrednost sile razaranja je bila kod sorte Simonida i iznosila je 244.4 N pri vlažnosti zrna od 13.6%. Sorta Dragana je imala srednju vrednost ove sile od 241.4 N pri vlažnosti od 13.3%, dok je sorta NS 40S imala srednju vrednost sile od 106.8 N pri vlažnosti semena od 14.1%.

Ključne reči*: pšenica, fizičke osobine, kompresioni test.*

INTRODUCTION

Wheat (*Triticum aestivum*) is the basic cereal crop in Serbia, in other countries on Balkan Peninsula too. According to the data of Statistical Office of the Republic of Serbia (www.webrzs.staserb. sr.gov.yu), the wheat was cultivated on 485,745 ha in the year 2008. The gross production was 2,095,403 tons. The seeds of wheat varieties for such a production are also domestic results; this is one of the most important objectives of farm crops breeders. The study of wheat seed texture has been conducted for many years, those researches are of interest even at now days because new varieties (with different properties) of this crop are produced constantly.

The knowledge about wheat seed physical properties is essential for adequate design the equipments for processing, drying and storing of grains (Babić, Lj. & Babić, M, 2000a). Kernel size distribution is important for cleaning, grading and separation. Bulk and true density, surface area and porosity determine the capacity of dryer, storage and transportation means, as well as the resistance to airflow during aeration (Mohsenin, 1980, Babić, M. & Babić, Ljiljana, 2000). Bulk density and porosity also affect the horizontal and vertical loads in the silos during storage, angle of repose is important in design handling system and their accessories. The study results of not only wheat kernels, but other farm crops physical properties are published by many authors (Unal, H., Isik, E., Isli, N, & Tekin, Y, 2008; Davis, R. M. & El-Okene, A. M, 2009; Taser , F. O., Altuntas, E. & Ozgoz, E, 2005; Kaleemullah, S. & Gunasekar, J. J, 2002; Saiedirad, M. N., Tabatabaeefar, A., Mirsalehi, M., Badii, F., & Varnamkhasti, M. G, 2008; Dursun, E & Dursun, I, 2005; Konak, M., Carman, K. & Aydin, C. 2002; Coskum, M. B., Jalcin, I. & Ozarslan, C., 2006; Karababa, E., 2006; Ozturk, T. & Esen, B., 2008; Kibar, H. & Ozoturk, T., 2008; Isik, E., & Izli, N. 2007).

Wheat grain hardness is very important physical properties in kernel quality assessing. Milling industry often used this factor to classify as hard or soft varieties. Hard wheat produces flour with damage angular starch desirable for bread making. The particles of starch are larger which flow easily and easy to handle. Soft varieties give flour with smaller irregularly shaped particles of starch which are not flow easily and block the sieves in the mill. On the other hand, some researchers used classification on hard and soft wheat according to genetic differences. But researchers Stenvert, N.L & Kingswood, K, (1977) proved that it is possible to have genetically soft wheat which is physically hard and hard wheat can be soft by changing environmental and drying conditions. This confusion in definition may be solved by quantitative definition of hardness as physical properties. This approach defines hardness as mechanical properties (Dobraszczyk, B.J., Whitworth M. B., Vincent J. V. & Khan A.A, 2002) which are useful for objective compressions between different wheat varieties under different environmental conditions. Therefore, the hardness is mechanical properties of individual wheat kernel which is defined as the resistance to deformation or crushing.

The objectives of this study are to support with new information about primary three brand new wheat varieties physical properties of domestic selection. The first part is focused on kernel dimensions, geometric mean diameter, kernel surface area, bulk and true density, porosity, sphericity, thousand kernels weight, moisture content and static coefficient of friction. In the second part of the study, the relation between seed moisture content and hardness, actually compression will be presented and discussed.

MATERIAL AND METHOD

Wheat samples

Three Serbian cultivars of wheat seed are studied; two varieties Simonida and Dragana are hard wheat, while variety NS 40S is soft wheat. All three varieties were selected by Institute of field and vegetable crops in Novi Sad, which is a part of University of Novi Sad. Those genotypes were grown at the same location and under the same agroecological conditions. The spike of Simonida cultivar is white and smooth, medium compact and the grain is red (Mladenov, N., Hristov, N., Malešević, M., Mladenović, G. & Kovačević, N, 2007), the quality subgroup is A-2. Dragana has also white spike, awns absent, moderately dense (Hristov, N. & Mladenov, N, 2006) and belongs to quality subgroup A-1. Cultivar NS 40S is in acceptation by Commission for Varietals Approval. The samples were collected manually in the summer of 2009, from experimental field which is about 8 km north of Novi Sad. The seeds were manually cleaned in order to remove all foreign matters, broken and immature seeds. All samples were divided in two parts; one was used for the physical properties testing within original moisture content, the other part of each varieties were divided in three groups and were tempered by water adding to adjust different higher moisture contents. Those seeds were kept in the sealed plastic bags and stored in the refrigerator at 4^0C for further use.

Physical properties

Moisture content of each wheat seed varieties were measured according to Regulations about agricultural crops quality. The samples were prepared for three repetitions and were oven dried at 103^0C for 72 hours, when they removed for weight control. This procedure was repeated until the changed of mass was less than 0.01 g. Finally, the samples were removed into desiccators and allowed to cool at room temperature. The samples weight was recorded by digital balance with resolution ±0.001 g (Kern, PLJ360-314). The mean moisture content values in percentages of wet basis and standard deviations were calculated. The specimens who were sealed in polyethylene bags in order to reach higher moisture contents were treated similarly. Before each test, the necessary quantity of seeds were taken out of refrigerator and kept on ambient temperature to worm.

Three principal dimensions of the seed; length (L), width (W) and thickness (T), were measured by micrometer (measurement accuracy 0.01 mm). The specimen for this surveying contained 90 randomly selected kernels. The mean values, variance, SC and CV were determined. Those data were used for kernel size distribution establishing. The geometric mean diameter (Dg), sphericity (Φ) and the surface area of single kernel (S) were calculated from three principal dimensions according to following relationship (Mohsenin, N.N, 1980; Al-Mahasneh & Rababah, 2007; Babic Ljiljana & Babic M. 2000b; Babić, Ljiljana & Babić, M. 2001):

$$Dg = (LWT)^{1/3} \tag{1}$$

$$\Phi = (\frac{LWT^{\,1/3}}{L}) \tag{2}$$

$$S = \pi Dg^2 \tag{3}$$

The thousand kernel weights in grams were done by the help of electromechanical counter (Numigral, NUM 3, Tripette et Renaud) and digital balance (KERN, PLJ360-314). The mean value of single kernel, as well as variance, standard deviation (SD) and coefficient of variation (CV) were calculated to ascertain the uniformity in measurement of 1000 seeds weight.

The true density (ρ_t) of the seeds was surveying using liquid displacement method. The test was done in three replications; therefore the mean values, standard deviations (SD) and coefficient of variations (CV) of three wheat cultivars were calculated. Measurement of bulk density (ρ_b) (Republic of Serbia directive 47/1987) started with the surveying the kernel's mass by the digital balance and pouring those seeds in the graduated measuring cylinder, so the total volume was observed. The procedure was replicated three times; therefore the bulk density is determined according to equation (Babić, Ljiljana , 2000):

$$\rho = \frac{m}{V} \tag{4}$$

The porosity was measured, but also calculated according to previous measurements as relationship between bulk - - ρ_b and true – ρ_t density (Mohsenin, 1980) as follows:

$$p = (1 - \frac{\rho_b}{\rho_t})x100 \tag{5}$$

The static coefficient of friction was measured for one structural material only, it was galvanised metal sheet. An adjustable tilting surface with graduate scale (Gupta & Das, 1997) was used for these tests. An inclined surface was lifted up by the help of screw device until the seeds started to slide down. At this point an angle of tilt was recorded - α (^{0}). The tests for all three wheat varieties were repeated five times and the mean values of the result were taken as the representative values. The friction coefficient – μ (-) was calculated as tangent of measured tilt angle:

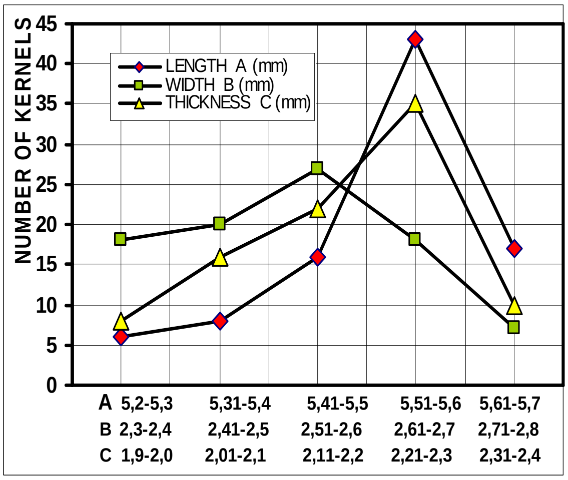
$$\mu = tg\alpha \tag{6}$$

The slow loading compression test is performed with all wheat varieties. Thirty replicate tests are done for each variety. Four different moisture content of each variety was tested. Testing equipment consists of loading cell and PC with manufacturer's software (Food Technology Corporation, TMS-PRO Texture measurement system) trigger load is from 0.5 to 450N. The constant deformation rate before contact with specimen is 60 mm/min, while during compression is 30 mm/min. The range of load applied by measuring head is from 0 to 500 N. Every individual seed is placed on the lower plate of the machine, in such an orientation that the crease is in the contact with bottom plate. The result of each test is presented as curve and as a table data with force (N), the loading head displacement (mm) and time (s). From the force and head displacement curve, the following parameters are observed: force at rapture point (F), head displacement at the same point (h). The individual work corresponding to rapture point (J) was calculated.

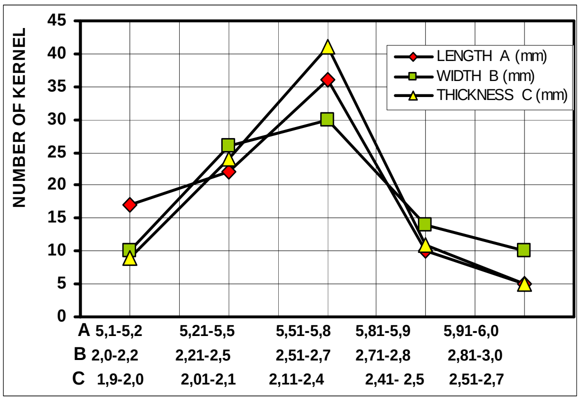
RESULTS AND DISCUSSION

The wheat seeds three dimensions, length – L, width –W and thickness –T of Dragana, Simonida and NS 40S varieties are presented in Fig. 1.

The distribution of 90 wheat kernels surveying results of length, width and thickness is normal distribution. The statement is confirmed by Pirson's $\chi 2$ test for all three dimensions which is quite usual for such a measurement of bio materials. The test also certifies the surveying correction procedure and the validity of samples. All axial dimensions have peaks around mean values which agree with earlier results by Akaaimo & Raji (2006) and Konak, Carman & Aydin (2002). This is an indication that the axial dimensions are relatively uniform and that information is valuable for cleaning and separation equipments design. Variety Simonida has the smallest dispersion in kernel dimensions; compare to other two varieties the thickness value is low. Length dispersion of Dragana is very expressive, as well as with NS 40S genotype.



a)



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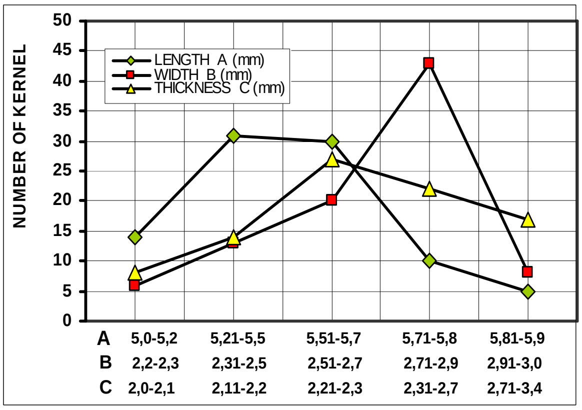

c)

Fig 1. Distribution curves of three seed dimensions for domestic wheat varieties: a. Simonida – moisture content 15.8%; b. Dragana – moisture content 15.8%; 3. NS 40S – moisture content 16.4%

The mean values of three dimensions with standard deviations and geometric mean diameter is presented in Table 1. The mean length value of Simonida is corresponding to results of Al-Mahasneh and Rababah (2007) for the moisture content of 9.3%, while other two dimensions are significantly smaller. The similar observation is when compare with the results of Tabatabaeefar, A. (2003), only one variety has the mean length like Simonida, but other two dimensions are significant larger. The measured value of Simonida thickness of 2.12 mm with a SD 0.09 and a CV of 0.01 mm is especially small comparing with the same dimension of other two cultivars. The thickness mean values for Dragana and Simonida are similar. The measured values of bulk density are smaller when compare with the results of Syrian hard wheat, reported by El-Khayat G. et al., (2006), or Iranian wheat presented by Tabatabaeefar, A. (2003), but the mean true density for all varieties are similar to the results of Tabatabaeefar, A. (2003), measurements.

Table 1. Some physical properties of domestic wheat varieties seeds

Physical property	Simonida	Dragana	NS 40S
Length (mm)	6,46	5,37	5,38
Width (mm)	2,56	2,47	2,62
Thickness (mm)	2,12	2,18	2,43
Geom. mean diameter (mm)	3,09	3,06	3,24
Bulk density (kg/m^3)	791,34	788,51	731,77
True density (kg/m^3)	1103,51	1150,52	1075,56
Weight of 1000 kernels (g)	46,16	45,86	40,01
Porosity (-)	0,2828	0,3146	0,3196
Sphericity (-)	0,57	0,57	0,60
Coeff. of friction (-)	0,3583	0,3494	0,3554

The second third dimension of all three cultivars is relatively small; width is between 2.47 and 2.62 mm while thickness is from 2.12 to 2.43 mm. This indicates that the shape of cultivars is rather prolong elliptical then spheroid. This statement confirms the results of sphericity calculation, values are smaller then 0.6; specially when compare to Tabatabaeefar A. (2003) observation where the values are between 0.62 till 0.65. The mean values of 1000 kernels mass are from 40.01 g to 46,16 g at the moisture content around 8,5%, which are larger values compare to the 23.2 g to 29.7 g reported by Tabatabaeefar A. (2003). Static coefficient of friction upon metal sheet corresponding to the measurements of Tabatabaeefar A. (2003) for wheat cultivar which are cultivate in Iran.

The slow loading compression tests results for three wheat varieties is shown in Table 2. Three different moisture contents were performed, therefore the maximum rapture force, as well as minimum and mean value of force with standard deviation was obtained. Maximum value of head displacement, minimum and mean value was recorder too.

Table 2. Rapture force and head displacement maximum, minimum and mean values with standard deviation for wheat varieties during slow load compression tests

Dragana variety	Moisture content (%)		
	37,5%	13,3%	8,5%
Max force (N)	205,6	342,7	311,2
Min force (N)	81,5	94,9	141,6
Force Mean value (N)	139,1	241,4	196,4
SD	3,6945	6,1877	4,1701
Max displacement (mm)	2,2	3,1	8,5
Min displacement (mm)	0,7	1,2	1,6
Mean value (mm)	1,33	2,32	2,11
SD	0,4398	0.5128	0,2558
Simonida variety	Moisture content (%)		
	26,8%	13,6%	8,2%
Max force (N)	253,4	375,8	243,8
Min force (N)	136,1	178,1	134,3
Force Mean value (N)	172,9	244,4	192,2
SD	3,2588	5,0341	3,1041
Max displacement (mm)	2,1	2,9	2,7
Min displacement (mm)	1,5	1,9	1,7
Mean value (mm)	1,89	2,27	2,13
SD	0,1787	0,3136	0,2621
NS 40S variety	Moisture content (%)		
	43,3%	14,1%	8,5%
Max force (N)	271,9	207,3	209,0
Min force (N)	74,7	53,4	96,1
Force Mean value (N)	164,9	106,8	149,3
SD	5,0751	4,7681	2,6987
Max displacement (mm)	2,5	3,7	2,3
Min displacement (mm)	1,5	1,3	1,3
Mean value (mm)	1,92	2,67	1,83
SD	0,2314	0,6742	0,3803

It is observed that cultivar Dragana has a highest value of mean rapture force 241.4 N at 13.3% moisture content, the mean value of force of 196.4 N is observed at seed moisture of 8.5%, while the lowest value of rapture force (139.1 N) is at 37.1% moisture content. The similar results are reached for Simonida cultivar. The highest value of rapture force is 244.4 N at 13.6% of moisture content, then of lower moisture content of 8.2% the rapture force is 192.2 N, and on higher seed moisture value of 26.8% the rapture force is 172.9 N. Variety NS 40S is soft wheat, therefore the values of forces are different. The lowest rapture force of 106.8 N is at 14.1% of moisture content, when the moisture content of seed is 8.5% the mean rapture force is 149.3 N, on the highest moisture content of 43.3% this force is 164.9. Fig 2 describes the measurement values of rapture forces and head displacement for three cultivars under similar seed moisture content level. Those results do not agree with Dziki, D. (2008) research, his compressive curves showed a lack of break-downs point when the kernel moisture content was 16% and higher.

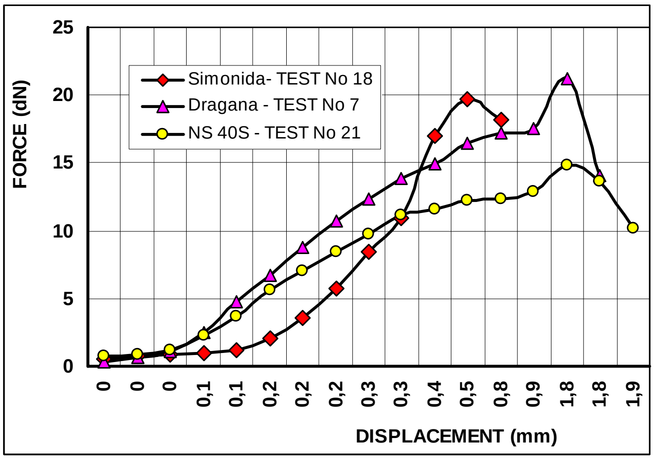

Fig. 2. The rapture force of wheat varieties at moisture content of 8.5% (Dragana and NS 40S) and 8.2% (Simonida)

CONCLUSIONS

The study of some physical properties of grain was focused on wheat seeds which were the results of domestic breeding program. Three widely spread seeds of wheat varieties Simonida, Dargana and NS 40S were tested. Cultivas Simonida and |Dragana are hard, while cultivar NS 40S is soft wheat. The surveying of axial dimensions confirme the seeds shape are more prolong elliptical then spheroid. Consequently the mean value of seeds sphericity are low; 0.57 for Simonida and Dragana cultivars and 0.60 within NS 40S. The seeds shape also indicates good packaging in the pale and lower mean values of porosity. The mean values of bulk density are in the range of 731.77 kg/m^3 to 791.34 kg/m^3, true densities are from 1075.56 kg/m^3 (cultivar NS 40S) till 1103.51 kg/m^3 within Simonida variety. The slow compression test confirms that hard varieties Simonida and Dragana have higher mean values of individual kernel rapture force (244.4 N and 241.4 N respectively), this mean value for soft cultivar NS 40S is 106.8 N.

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