WHEAT VARIETY GRADING BY SCORE ANALYSIS APPLICATION OCENJIVANJE KVALITETA SORTE PŠENICE PRIMENOM SCORE ANALIZE

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ABSTRACT

New 48 wheat varieties, harvested in 2016 are classified in four wheat quality groups (improvers, bread varieties, basic varieties, poor quality varieties), based on minimum level of crude protein content, sedimentation value, flour extraction, yield of bread volume and bread crumb quality. 22.9 % of analyzed varieties met all the prescribed parameter values for grading into defined quality groups. The objective of the presented study was to evaluate the quality of the different wheat varieties by integrating physicochemical, rheological and bread characteristics of wheat. Following 13 parameters: test weight, 1000 kernel weight, vitreousness, flour extraction, crude protein content, sedimentation value, wet gluten content, falling number, absorption, farinograph number of quality, extensograph area, yield of bread volume and bread crumb quality were subjected to score analysis. Outcomes may help in better differentiation the quality of wheat varieties. Score analysis has been estimated as a helpful mathematical tool for wheat grading.

Key words: wheat, variety, quality grading

REZIME

Pšenica (*Triticum aestivum* spp. *vulgare*) je jedna od najznačajnijih ratarskih kultura na svetu kojom je zasejano oko ¼ obradive površine. Ova kultura se koristi u prehrambenoj, hemijskoj i farmaceutskoj industriji kao i u industriji proizvodnje hrane za životinje. Osnovna namena pšenice je proizvodnja hleba, pri čemu je pšenični hleb osnovna hrana za oko 70% ljudi. U Srbiji se oko 90% pšenice koristi za proizvodnju hleba i peciva, pa se kvalitet sorti pšenice prevashodno određuje na osnovu kvaliteta hleba. U ovom radu je prikazano 48 novih sorti pšenice roda 2016, koje su svrstane u četiri grupe kvaliteta (sorte poboljšivači, hlebne sorte, osnovne sorte i sorte van klase), na osnovu minimalnih vrednosti sadržaja proteina, sedimentacione vrednosti, prinosa brašna, prinosa zapremine i kvaliteta sredine. Rezultati pokazuju da je samo 22.9% analiziranih sorti pšenice zadovoljilo sve kriterijume kvaliteta za razvrstavanje u tehnološke grupe. Cilj prezentovanog rada je bio da se različite sorte pšenice vrednuju na osnovu fizičkih, hemijsko-tehnoloških, reoloških i pecivnih osobina hleba. U ovom radu 13 pokazatelja kvaliteta pšenice (hektolitarska masa, masa 1000 zrna, staklavost), brašna (proteini, vlažan gluten, izbrašnjavanje, broj padanja, moć upijanja vode, farinografski kvalitetni broj i energija) i hleba (prinos zapremine i kvalitet sredine), su rangirane po kvalitetu primenom score analize kako bi se pouzdanije diferencirale sorte prema kvalitetu. Score analiza se pokazala kao veoma pogodan alat za pouzdanije vrednovanje kvaliteta sorti pšenice.

Ključnereči: sorta, pšenica, kvalitet, klasifikacija.

INTRODUCTION

Wheat (*Triticum aestivum* spp. *vulgare*) is produced, consumed and traded in the world, planted at round ¼ agricultural areas. It is utilised mainly as human food, less animal feed, but also in various industries, such as: chemical, pharmaceutical. The main application of wheat is bread production, which is a dietary staple for approximately 70 % of world population. In Serbia, around 90 % of wheat is used for bread and pastry production, therefore the quality of wheat varieties is evaluated based on bread quality. The suitability for bread making of particular wheat variety is determined mainly by its genetic make-up. A wheat variety is more suitable for bread making when the ability of its proteins to form the dimensional networks of gluten during kneading is greater (Callejo *et al.*, 2015). The two main factors governing wheat quality are variety and growth environment. Within the limits of environment, quality is influenced by characteristics that can be altered by breeding and is further modified during harvesting, drying, transportation and storage (Anjum *et al.*, 2008). Comprehensive knowledge exists on the variability of gluten proteins, their inheritance and influence on gluten

function properties, in contrast, the impacts of environmental factors and their interactions with genotype affecting gluten quality are still only scarcely understood (Aghagholzadeh, 2017). The task of wheat breeders is to develop new wheat varieties which, beside possessing an improved yield potential and disease resistance, have improved bread making quality. Studies have documented that environmental variations in gluten quality can be large and thus a great challenge for the milling and baking industry. The great share of varieties attributed with low quality at the market makes difficulties in milling and baking industry (Živančev *et al.*, 2016, Fištes *et al.*, 2017).

It takes a lot from creating the new variety of wheat to the final product comprising: selection, recognition, testing in macro trials, classification into the technological groups, production, purchase, storage and finely processing (Šarić *et al.*, 1995/96).

Long lasting system of wheat classification in Serbia (also in Yugoslavia) is based on distribution of varieties in three technological groups (improving varieties, bread varieties and basic varieties) based on six parameters: protein content, zelleny sedimentation value, flour extraction, yield of bread, yield of bread volume and score for crumb quality. Experience showed

that yield of bread is considered to be a facultative one and doesn't limit the technological group. Table 1 point at the limiting values of six parameters (Šarić et al. 1995/96, 1998). It is worth emphasizing that there are two values for yield of volume and score for bread crumb quality bread which allow different grading of the same wheat variety.

The objective of the presented study was to evaluate the quality of the different wheat varieties by integrating physicochemical, rheological and bread characteristics of wheat. Following 13 parameters: test weight, 1000 kernel mass, vitreousness, flour extraction, crude protein content, sedimentation value, wet gluten content, falling number, absorption, farinograph number of quality, extensograph area, yield of bread volume and score for bread crumb quality were subjected to score analysis. Outcomes may help in more objective and better differentiation the quality of wheat varieties. Score analysis has been estimated as a helpful mathematical tool for wheat grading.

Table 1. Minimum limiting values for parameters of wheat quality which determine technological groups

Wheat technological groups	Parameters of wheat quality					
	Protein content (% d.m.)	Zeleny sedimentation n value	Flour extraction (%)	Yield of bread (g/100g)	Yield of bread volume (ml/100g)	Score for bread crumb quality
Improving varieties	13.0	38	68	139	550/500	5.5/5.0
Bread varieties	11.5	30	65	137	450	4.0
Basic varieties	10.5	18	60	136	400	2.0
Varieties out of lower limiting values	<10.5	<18	<60	<136	<400	<2.0

MATERIAL AND METHODS

Different 48 new wheat varieties which are going to be recognized were used in this study. Experiments were carried out on field trials according to regulated production technology. Each wheat variety, used in this study, was grown at two research stations in Bačka region. Samples of 5kg grains were properly stored in store room until analyzed.

Methods

Grain samples were evaluated for milling and baking quality. Presented data are mean values for a new variety grown at two locations.

Physical properties

Weight of 1000 kernels, test weight or hectoliter weight and vitreousness were recorded according to Regulations about methods... (1988). Wheat sample was free of foreign material and broken kernels.

Physicochemical properties:

Protein content (macro Kjeldahl procedure), wet gluten (using glutomatic instrument Perten) and Zeleny sedimentation value were determined according to Regulations about methods... (1988). The falling number values of flour samples (14 % moisture basis) were determined by AACC method 56/81B (1983) using falling number apparatus (Perten, model 1100).

Rheological properties

Farinograph and extensograph analyses were recorded using Brabender instruments according to procedures consistent with The Regulations about methods... (1988).

Wheat milling

The tempered wheat grains, free of foreign material and broken kernels, were milled in Quadrumate Senior Mill to obtain

straight grade flour (break flour + reduction flour), (Kaluderski, Filipović, 1998).

Bread making procedure

Bread was baked in the accredited laboratory of the Institute of food Technology Novi Sad in Novi Sad according to the internal procedure for evaluating wheat varieties (Kaluderski, Filipović, 1998).

Yield of bread and yield of bread volume are calculated using following formulas:

$$\text{Yield of bread} \left(\frac{\text{g}}{100 \text{ g of flour}} \right) = \frac{(\text{Average weight of bread}) \cdot (\text{Yield of dough})}{\text{Weight of dough}} \quad (1)$$

$$\text{Yield of bread volume} \left(\frac{\text{ml}}{100 \text{ g of flour}} \right) = \frac{(\text{Average volume of bread}) \cdot (\text{Yield of dough})}{\text{Weight of dough}} \quad (2)$$

Sensory analysis of bread crumb was conducted to determine score for bread crumb quality using panel members previously trained on bread characteristics. The best and the worst quality are scored as 7.0 and 0.0, respectively (Kaluderski, Filipović, 1998).

Statistics

Score analysis uses min-max normalisation of wheat quality parameters transforming them from their original unit system in new dimensionless system where further mathematical calculations with different types of quality parameters are applicable (Jayalakshmi and Santhakumaran, 2011). Maximum value of normalised score

presents optimum value of all combined analysed parameters, indicating on optimum total quality. Three score calculation is proposed: Score₄, Score₁₃ and Score₄₊₉:

$$\text{Score}_{4i} = \frac{\sum_{k=1}^4 \frac{(x_{ki} - x_{k \min})}{(x_{k \max} - x_{k \min})}}{4}; \quad k = 1-4, i = 1-48 \quad (3)$$

where x_{ki} is: Protein content, Zeleny sedimentation value, Yield of bread volume (500ml), Bread crumb quality (5.0);

$$\text{Score}_{13i} = \frac{\sum_{n=1}^{13} \frac{(y_{ni} - y_{n \min})}{(y_{n \max} - y_{n \min})}}{13}; \quad n = 1-13, i = 1-48 \quad (4)$$

where y_{ni} is: Test weight, 1000 kernel weight, Vitreousness, Protein content, Zeleny sedimentation value, Wet gluten content, Flour extraction, Falling number, Farinograph water absorption, Farinograph number of quality, Extensograph area, Yield of bread volume (500ml), Bread crumb quality (5.0);

$$\text{Score}_{4+9i} = 0.8 \cdot \left(\frac{\sum_{m=1}^4 \frac{(z_{mi} - z_{m \min})}{(z_{m \max} - z_{m \min})}}{4} \right) + 0.2 \cdot \left(\frac{\sum_{l=1}^9 \frac{(q_{li} - q_{l \min})}{(q_{l \max} - q_{l \min})}}{9} \right) \quad (5)$$

$m = 1-4, l = 1-9, i = 1-48$

where z_m is: Protein content, Zeleny sedimentation value, Yield of bread volume, Bread crumb quality; and q_l is: Test weight, 1000 kernel mass, Vitreousness, Wet gluten content, Flour extraction, Falling number, Farinograph water absorption, Farinograph number of quality, Extensograph area.

For all three Scores calculations:

$\max[\text{Score}_i] \rightarrow \text{optimum}$

RESULTS AND DISCUSSION

Data for one year testing of a new wheat variety at recognition, grown at only two sites, are not enough reliable. Therefore real judgement of the technological quality, particularly safe grading into the technological groups of quality is of particular interest. In the usual procedure each grain sample is subjected to 17 different tests resulting in 29 outcoming parameters defining milling and baking quality of wheat variety, but wheat grading is done based on five parameters, listed in Table 1. For this study 13 characteristic parameters which define milling and baking wheat characteristics are taken into consideration. The results of 48 wheat varieties quality parameters are shown in supplementary material. Data in Table 2, point at wide range of selected parameters for wheat varieties. Concerning minimum limiting values listed in Table 1, minimum values for protein content and yield of volume are lower than the limiting values for basic varieties while minimum flour extraction is very high, it is reaching the upper limit for bread quality group. Grading wheat variety solely based on one year testing in physico-chemical, rheological and functional characteristics is a great responsibility due to variations in genetic, seasonal and environmental factors (Kundu et al., 2017). Concerning five parameters listed in Table 1, among 48 new varieties (data enclosed in supplementary) only 22.9 % of samples met all limiting values and that safely could be classified in an adequate technological group, Table 3. It is worth emphasizing that in this group only one sample belongs to the technological group of improving varieties and majority to the basic group. There arise question how to determine to which technological group of quality belong samples that are partly meeting limiting values. In this study nearly half (45.8 %) of tested samples had 4 quality parameters within limiting values and one with higher or lower value, 27.1 % of samples have three parameters within limiting values and other two with higher or lower values and finally 4.2 % of samples have three parameters within group limits, one parameter with higher and the other with lower limiting values, Table 3. Flour extraction was always either within limiting values for the group or higher. It was particularly characteristic for the varieties classified in the group out of lower limiting values. According to Aghagholizadeh et al. (2017) gluten proteins are mainly responsible for dough handling and loaf volume for bread quality. Characterization of wheat varieties for end product utilization is also experienced by Panghal et al. (2017). Consistent with above mentioned statements those 77.1 % of varieties are graded assuming that either protein content or scores for bread crumb quality (choosing higher value) are responsible for grouping. The result that is presented in Table 4 summarizes two above mentioned ways of wheat grading. The main disadvantage of that grading procedure is that majority of samples were classified irregularly, i.e. by subjective judgment based on experience. This statement is supported by great share of improving varieties in the group having 3 quality parameters within limiting values and two with lower values. All these point at the need of upgrading and finding the more reliable system of wheat grading according to the technological quality. At this stage of investigation, hard work of wheat breeder has to be regularly judged. It is worth highlighting that of a particular interest is to adequately assess the genetic potential of a new wheat variety, by objective grading those varieties that partly meet limiting values listed in Table 1 into a certain technological group. One attempt to solve the problem of grading varieties into technological groups is

applying score analysis. Flour extraction, as being very high, can be considered as non-selective parameter.

Table 2. Minimum and maximum values of selected quality parameters of 48 wheat varieties

Quality parameter	Minimum value	Maximum value
Test mass (kg/hl)	73.65	84.00
1000 kernel mass (g)	28.5	43.3
Vitreousness (%)	26.2	82.8
Protein content (% d.m. basis)	9.5	13.3
Zeleny sedimentation value	19	44
Wet gluten content (%)	15.0	31.2
Flour extraction (%)	67.4	74.3
Falling number (s)	164	459
Farinograph water absorption (%)	52.7	64.1
Farinograph number of quality	30.3	81.7
Extensograph area (cm ²)	26	135
Yield of bread volume (ml/100g)	357.6	549.0
Bread crumb quality	1.0	6.8

Therefore score analysis is carried out on 4 parameters (Score₄) listed in Table 1, which showed to be the most important for grouping of varieties (also assuming yield of bread as facultative). Data presented in supplementary material point that Score₄ analysis contributed to objective grading of those varieties (77.1 %) listed in tab. 1 which don't fully fit into limiting values. In both cases, only percent of varieties graded as bread varieties is the same, but the share of improving varieties significantly decreased. Score₄ analysis also showed that the assumption that either protein content or crumb quality is responsible for grouping is not enough reliable. By Score₄ analysis more than 50 % of varieties are graded as basic varieties, while 6.2 and 10.4 % of varieties belong to group of improving varieties and varieties out of lower limiting values, respectively. High percent of varieties classified by Score₄ as basic varieties was the main reason of applying Score analysis to all selected 13 parameters (Score₁₃) which characterize flour milling and baking attributes, also dough rheology, Table 2. Outcoming scoring is presented in Table 4. In the case score analysis is carried on 13 quality parameters (Score₁₃), contribution of test weight, thousand kernel weight, vitreousness, flour extraction, wet gluten content, falling number, water absorption, farinograph number of quality and extensograph area is obvious. By comparing Score₄ and Score₁₃, it can be stated that percent of varieties graded in the groups changed. Percent of improving and basic varieties decreased contrary to the percent of bread varieties and varieties characterized with low quality. Close insight in Score₁₃ order and label of each variety (data enclosed in supplementary) point that the influence of 9 parameters of quality is very high, even so high, that can disrupt grading of those varieties which have all quality parameters within limiting values. This observation also pointed at good wheat varieties differentiation according to technological quality, emphasizing that among tested samples there is a small number (4.2%) of samples from the group of improving varieties, though lower values for yield of volume and score for crumb quality, Table 1, were used in the statistics, thus pointing to the great contribution of those 9 parameters. Those parameters also contributed to changing limiting score values. Therefore, Score₁₃ point to the need of score analysis improving, too. One possibility is grading varieties by Score₁₃ and discuss limiting score values for technological groups and the other is presented by score₄₊₉ Table 4.

Calculation of score₄₊₉ is assuming that 4 limiting values for parameters of quality experienced in score₄ are of primary importance (contributing with 80% of the significance to the quality grading) and other 9 parameters (contributing with 20 % of the significance to the quality grading) help in better differentiation in case all limits are not met. As expected, by applying score₄₊₉ percent of wheat varieties in technological groups changed and contribution of those 9 parameters is evidents.

Concerning score analysis, Table 4, it must be emphasized that limiting values for scores vary. For each score calculation (score₄, score₁₃ or score₄₊₁₃), limiting values are determined based on the score values for those 22.9 % of varieties that were safely classified into technological groups of quality Table 3 and limiting values cited in Table 1.

Presented possibilities of wheat grading applying score analysis are a solid base for further hard work using much more varieties

Table 3. Wheat varieties grading into technological groups based on five parameters of quality

Number of varieties having all quality parameters within limiting values		
Improving varieties	1	22.9 %
Bread varieties	3	
Basic varieties	7	
Varieties out of lower limiting values	0	
Number of varieties having 4 quality parameters within limiting values and 1 with higher value		
Improving varieties	0	22.9 %
Bread varieties	5	
Basic varieties	4	
Varieties out of lower limiting values	2	
Number of varieties having 4 quality parameters within limiting values, 1 with lower value		
Improving varieties	1	22.9 %
Bread varieties	6	
Basic varieties	4	
Varieties out of lower limiting values	0	
Number of varieties having 3 quality parameters within limiting values and 2 with higher values		
Improving varieties	0	14.6 %
Bread varieties	1	
Basic varieties	2	
Varieties out of lower limiting values	4	
Number of varieties having 2 quality parameters within limiting values and 2 with lower values		
Improving varieties	4	12.5 %
Bread varieties	0	
Basic varieties	2	
Varieties out of lower limiting values	0	
Number of varieties having 2 quality parameters within limiting values, 1 with higher and 1 with lower value		
Improving varieties	0	4.2 %
Bread varieties	1	
Basic varieties	1	
Varieties out of lower limiting values	0	

Table 4. Wheat varieties grading into technological groups of quality applying score analysis

Technological group	Existing system (%)	Score analysis					
		Score ₄		Score ₁₃		score ₄₊₉ *	
		(%)	score	(%)	score	(%)	score
Improving varieties	18.8	6.2	>0.80	4.2	>0.75	8.3	>0.75
Bread varieties	31.2	31.3	>0.50	37.5	>0.50	29.2	>0.50
Basic varieties	33.3	52.1	>0.25	45.8	>0.30	50.0	>0.25
Varities out of lower limiting values	16.7	10.4	<0.25	12.5	<0.30	12.5	<0.25

CONCLUSION

Based on data presented in this study it can be stated:

Wheat variety grading in technological groups of quality based on protein content, Zeleny sedimentation value, flour extraction, yield of bread volume and scores for bread crumb quality is difficult. Only 22.9 % of tested samples met all limiting values, meaning that safely could be classified in an adequate technological group.

Due to high percent of samples that are partly meeting limiting values there arise the need for finding the more reliable system of wheat grading in technological groups of quality.

Objective grading may encourage breeders to create more varieties meeting limiting values for the group of improving varieties and also milling and baking industry to support.

Applied Score analysis, as an objective method, has been estimated as a helpful mathematical tool for wheat grading, particularly for those varieties which are not meeting all limiting values.

Applied Score analysis pointed at good wheat varieties differentiation according technological quality and genetic potential. There is the need of score analysis improving, also to testing greater number of samples.

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