

Relationship Between Selected Quality Parameters in Spelt Wheat Grain

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Abstract – Purpose of the paper was to determine influence of size and physical characteristics of spelt wheat grain on some chemical and rheological properties. To perform experiment, three spelt samples were used: Titan, Ostro and an unknown variety. Pearson correlation coefficients were used to explain connection between kernel size and selected physical and chemical characteristic of spelt samples. Unknown cultivar of spelt sample was significantly different from the others related to width and thickness values and was characterized by the highest volume and surface area as consequence of the biggest size of individual kernel. The following correlations between physical spelt wheat parameters and size were found: 1000 kernels weight was in strong correlation with single kernel volume and surfaces area 0.78 and 0.83, respectively, while correlation coefficients between test weight and size of the single kernel were higher: 0.94 for volume; 0.91 for surface area and very strong correlation was found between test weight and volume/surface area of the single kernel (0.98). Very strong correlations were found between starch content and volume and surface area of the individual kernel, and 1000 kernel weight (0.93; 0.96; 0.95, respectively). The strongest negative correlation coefficient was found between starch and wet gluten.

Keywords – Spelt Grain, Size and Shape, Physical Properties, Technological Properties, Starch.

I. INTRODUCTION

Spelt (*Triticum spelta* L.), an ancient wheat species, was one of the major feed and food grains in ancient Europe [1]. For many years, cultivation of spelt declined, but recent interest in use of spelt for ecologically grown foods has led to resurgence in its cultivation [2], [3]. Spelt wheat is a low-input crop, suitable for growing in harsh ecological conditions and in marginal areas of cultivation, without the use of pesticides [2]. Even with low fertilizing spelt wheat gives a good harvest and has a better mineral uptake in comparison with *Tr. aestivum* L. Since it is pest and disease resistant, it is also suitable for organic production [4].

The nutritive value of spelt wheat is high and it contains all the basic components such as starch and nonstarch carbohydrates, proteins, lipids, vitamins and minerals [4]. It is believed that spelt possesses valuable nutritional potential due to its protein content and composition as well as its lipids, crude fibre, vitamin and mineral content [5]-[7]. Even at low fertilization level, spelt grains are reported to have higher contents of protein in range from 16% to 17% thanks to higher portion of aleuron layer, lipids and minerals compared to common wheat [8]-[10]. Grain of spelt is claimed to be naturally higher in fibre, B

vitamins and carbohydrates than wheat, but the results vary greatly [10]. Differences may be due to the growing place and season, cultivation, fertilizers and methods of analysis [11].

The nutritional qualities and technological properties of spelt are being evaluated in various European projects. Most of the investigated spelt varieties demonstrated good milling properties and high baking quality and many researchers claim that the technological potential of spelt for milling, bread making, and pasta production is very promising [2], [4] [6], [10] and [12] and today, more spelt-based products are available including flour, bread and pasta [13] and [12]. The comparison of the bioactive compounds content between spelt breads and wheat showed a similar level of these compounds [3]. In general, milling, baking and nutritional characteristic evaluated on spelt and HRW wheat suggested that spelt wheat may not offer any significant advantage over common bread wheats for use in food products [14] and available data showed that ancient wheats in general differ little from modern wheat species in the content of most bioactive components [15]. However, this should not distract from spelt cultivation because of poorly-drained and low-fertility soil tolerance [14].

Physical characteristics and composition, specially, wet gluten and starch content of any cereal have large influences on the milling and the others processing properties and consequently on final product quality. Numbers study reported that spelt wheat physical quality parameters affected by different variety, ecological and harvest condition. Size and shape of the individual cereal kernel are of a growing interest regarding the post-harvest manipulation, milling efficiency and consequently, baking. The shape of a single seed of wheat is irregular. i.e. does not assume the shape of any regular geometry body such as: cube, cuboid, sphere, pyramid, cone or cylinder [16]. The basic factors that affect the test weight of wheat are kernel size, shape and kernel density [17]. Individual size of the kernel is important factor for manipulation and milling, and some physical quality parameters are determined by size and uniformity of the kernel [18], [19] and determination of physical characteristics of grain and agricultural commodities is important in the design of harvesting, handling, and processing equipment [20]. Same authors reported that grain vitreosity was positively correlated with grain protein content, and test weight increased linearly with a thousand kernel weight increase.

In addition, unit energy consumption depends on vitreosity and test weight of grain. Unit energy consumption increases with the increase of vitreosity and test weight, while the grinding efficiency index increases

with increasing vitreosity, test weight and thousand kernel weight. According to Warechowska [21] difference in vitreosity between 6% and 62% resulted in a difference in the grinding energy of about 95%. In addition, energy consumption of cereal grinding is also affected by the kernel weight [21].

The current study was aimed to ascertain the basic physical and selected technological properties in three spelt wheat samples, and determine correlations between size and shape of the individual kernel and some technological parameters.

II. MATERIAL AND METHODS

Three spelt wheat (*Triticum spelta* L.) samples were used: unknown cultivar which is widely domesticated in Bosnia and Herzegovina (S), Titan (TS) and Ostro (OS). Samples were obtained from the experimental field of Faculty of Agriculture and Food Sciences University of Sarajevo, from Butmir locality, season 2014. Samples were cultivated in ecological system without fertilizer and any chemical treatment. Hull-free grains were analyzed.

A. Dimensions and Shape of Individual Seed

Length (a), width (b) and thickness (c) of individual kernel were measured along the three principal axial dimensions by using an electronic caliper with 0.01 mm accuracy (MIB, Germany) and volume (Vol.) and surface area of the single kernel (SKSA) calculated [19]. All measurements were performed in 30 kernels per spelt wheat sample. Mean values with standard deviations (SD) and coefficient of variation (CV) of determined parameters were reported.

The volume (Vol.) of a single kernel was calculated from (1):

$$Vol.(mm^3) = 0,52 \times a \times b \times c \quad (1)$$

Value 0.52 is coefficient for wheat and barley kernel shape. Single kernel surface area (SKSA) calculation made using (2)

$$SKSA(mm^2) = 12,56 \times R(a + 3R) \quad (2)$$

Value R was calculated using (3)

$$R = (5a + 5b) / 60 \quad (3)$$

Ratio between volume and surface area of the single kernel (V/A) was calculated. This parameter depends on the kernel roundness: as the calculated value is higher the kernel is more spherical. Presented calculations based on mean values of individual kernel dimensions.

B. Physical and chemical measurements

Physical properties of wheat samples: test weight (kg/m^3 - 13% moisture basis); 1000 kernels weight on dry matter basis (g), vitreosity (%) were determined [22]. According to vitreosity wheat and spelt could be classified in two groups: vitreous - if the vitreosity is higher than 30% and starchy - if 30% and less [22]. Samples moisture determined by *Farmpoint Moisture Analyser*, calibrated according to ISTA (International Seed Testing Association).

Flour (particles size under $250\mu m$) obtained by milling samples on laboratory roll mill *Milleral N^o-1* used for wet gluten determination by extracting according to AACC

[23] (Method 38-10) and Brabender's Farinograph test (*OHG Duisburg*). Titratable acidity (AACC Method 02-31) [23] and pH value (AACC Method 02-52) [23] on spelt flour samples were determined. Starch determination according to Ewers was done using polarimeter (*Optika microscopes Itay, POL-1, Na lamp*) and α_D^{20} 182.7. Analyses were done in triplicate.

C. Statistical analysis

Mean values with standard deviations (SD) of determined parameters, and coefficients of variation (CV) for single kernel dimensions (%) were reported. Statistical analysis included descriptive analysis, followed by one-way analysis of variance (ANOVA), and used to determine the differences between spelt samples. Differences between means of analysed parameters were tested by Tukey test at a significance level of 0.05.

Pearson correlation coefficients were obtained using the statistical computer package StatBox 6.7 (Grimmer Soft, France). Correlation intensity [24] was described by following classification: 0.0 ± 0.20 - no correlation, $\pm 0.20 \pm 0.40$ - weak correlation, $\pm 0.40 \pm 0.70$ - medium strong correlation, $\pm 0.70 \pm 1.0$ - strong and very strong correlation.

III. RESULTS AND DISCUSSION

Length, width and thickness of single kernel of spelt samples were significantly different ($P < 0.05$) and ranged from 7.58 to 8.50mm; 3.04 to 3.84mm and 2.87 to 3.51mm, respectively (Tab.I).

Unknown cultivar of spelt sample (S) was significantly different from the others related to width and thickness values. This sample was represented by kernels which varied widely in size, as coefficients of variation showed (width - 30.5% and thickness - 34.6%). From the other hand, TS and OS samples were more uniform according to kernel size. It can be assumed that the unevenness size kernel of unknown cultivar is consequence of two or more different cultivars presence in this sample. Individual kernel dimensions of all samples are in accordance to defined range for wheat [25] and to results reported by Begić and Oručević [19] for wheat and spelt, but lower than Szymanek and Sobczak [26] reported.

Volume and surfaces area of individual kernels of TS and OS are similar to results for wheat [25] and for wheat and spelt [19] whereas those parameters of S sample were higher than results reported.

Sample S was characterized by the highest volume and surface area (Fig. I, a) as consequence of the biggest size of individual kernels (Tab. I). This feature and high value of ratio volume/surface area make this sample good for milling process. According to ratio volume/surface the samples TS and OS are less spherical (Fig. I, b) and therefore less adequate for milling. However, TS and OS samples were characterized by uniformity regarding kernels size (Tab. I) what is, from the other side, good condition for efficiently milling and processing. Table II summarized physical and chemical characteristic of spelt samples.

Obtained results showed significantly differences between samples in terms of test weight and 1000 kernels weight ($P > 0.05$). The test weight is a crucial parameter of

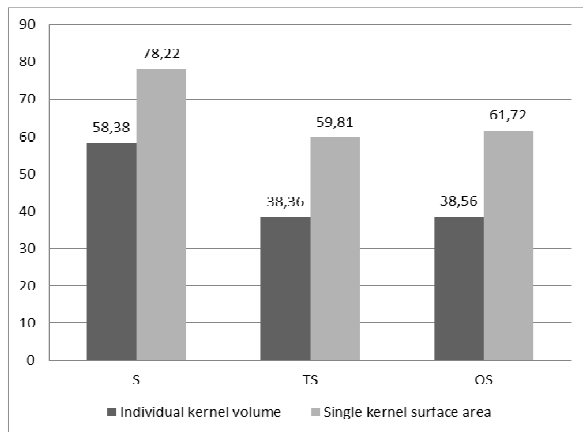
wheat technological value and significantly correlated with variety [21].

TABLE I: Individual kernel basic dimensions of spelt wheat samples

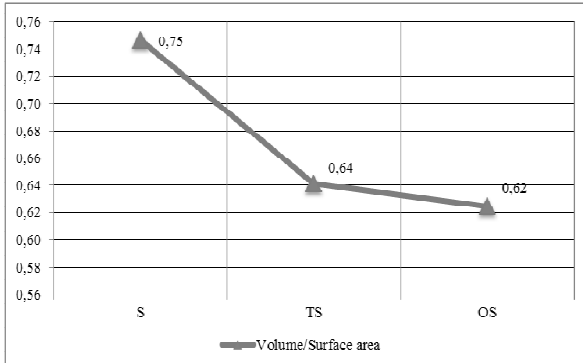
	S		TS		OS	
	$\bar{X} \pm SD$	CV(%)*	$\bar{X} \pm SD$	CV(%)*	$\bar{X} \pm SD$	CV(%)*
Length (mm)	8.33±1.10 ^a	13.3	7.58±0.47 ^b	6.25	8.50±0.56 ^a	6.64
Width (mm)	3.84±1.17 ^a	30.5	3.31±0.15 ^b	4.60	3.04±0.18 ^b	6.04
Thickness (mm)	3.51±1.21 ^a	34.6	2.94±0.14 ^b	4.61	2.87±0.14 ^b	4.99

Different letters in rows from a to c for each parameter indicate significantly different values among spelt samples at $p < 0.05$;

*Coefficient of variation (%)



(a)



(b)

Fig. 1. Individual kernel volume (mm³) and surface area (mm²) of spelt grain samples (a); Ratio between volume and surface area of single kernel (b)

According to vitreosity TS was significantly different to the other spelt samples. Thousand kernels weight is good indicator of kernel size [23] and an important yield forming parameter [27]. Obtained results of thousand kernels weight were higher when compare to results reported by Oručević *et al* [28] lower than Lacko-Bartošová and Rédlová [29] reported and in accordance to results obtained by Lacko *et al* [27]. This parameter is high influenced by variety and weather condition [27]. Obtained test weight values were similar to results reported by Zieljiski *et al* [3] and Oručević *et al* [28]. However, the vitreosity was higher than results reported by Zieljiski *et al* [3] and lower than results reported by Oručević *et al* [28].

Test weight and 1000 kernel weight are parameters strongly correlated to moisture content (19, 28 and 29) but this influence was avoided as results were calculated on dry mater basis - 1000 weight and on 13% moisture - test weight. According to vitreosity all spelt samples could be classified in a starchy grain group. The starch content in spelt samples was higher than results reported in several researches [6], [29], [30], [31]. From the other side, wet gluten (Tab. II) as indicator closely connected to baking quality, was considerably lower when compared to results obtained by different authors. Higher wet gluten content than 30% reported in different studies. It is believed that wet gluten content of minimum 25% is required for good baking wheat products quality. However, spelt gluten is more dispersed with less flexibility and more extensible than ordinary wheat flour and therefore, characterized by weak gluten quality.

TABLE II: Physical and chemical properties of spelt samples

	S	TS	OS
1000 kernels weight (g – d.m. basis)	48.46 ± 0.14 ^b	40.34 ± 0.25 ^c	45.86 ± 0.12 ^a
Test weight (kgm ⁻³ - 13% moisture basis)	748.85 ± 0.50 ^a	736.36 ± 0.11 ^b	730.23 ± 0.23 ^c
Vitreosity (%)	34.50 ± 3.54 ^a	17.00 ± 1.41 ^b	33.50 ± 0.71 ^a
Titrateable acids (mmolkg ⁻¹)	44.0 ± 0.00	42.0 ± 0.28	43.0 ± 0.14
pH value	6.75 ± 0.01	6.65 ± 0.39	6.30 ± 0.02
Starch (%)	71.35 ± 1.56	67.14 ± 1.92	68.69 ± 2.17
Wet gluten (%)	19.50 ± 0.71 ^b	22.87 ± 0.35 ^a	21.50 ± 0.71 ^{ab}

Different letters in rows from a to c for each parameter indicate significantly different values among spelt samples at $p < 0.05$

TABLE III: Farinograph characteristics of spelt samples

	S	TS	OS
Water absorption (%)	55.6±0.2	56.8±0.3	55.4±1.4
Dough development (min)	2.0±0.3	1.50±0.3	1.5±0.3
Softening degree (BU)	110±4.3	120±4.6	105±2.6
Quality number	52.8±5.3	50.0±2.8	48.1±3.2
Quality group	B2	B2	B2

TABLE IV: Correlation coefficient of selected quality parameters of spelt wheat samples

	Vol. (mm ³)	SKSA (mm ²)	V/A	TKW (g)*	TW (kgm ⁻³)**	V (%)	Starch (%)	WG (%)	w.a. (%)
TKW (g)*	0.78	0.83	0.67	1	0.53	0.95	0.95	-0.96	-0.88
TW (kgm ⁻³)**	0.94	0.91	0.98	0.53	1	0.24	0.76	-0.74	nc
V (%)	0.55	0.62	0.42	0.95	0.24	1	0.81	-0.84	-0.98
Starch (%)	0.93	0.96	0.87	0.95	0.76	0.81	1	-1.00	-0.69
WG (%)	-0.92	-0.95	-0.85	-0.96	-0.74	-0.84	-1.00	1	0.72
w.a. (%)	-0.39	-0.47	-0.25	-0.88	nc	-0.98	-0.69	0.72	1
DD (min)	1.00	1.00	0.99	0.77	0.95	0.54	0.93	-0.91	-0.38
SD (BU)	nc	-0.28	nc	-0.77	nc	-0.93	-0.53	0.57	0.98
QN	0.91	0.87	0.96	0.45	1.00	0.16	0.71	-0.68	nc

* Dry mater basis; **13% moisture basis

Abbreviations: nc – no correlation; Vol. – volume of the single kernel; SKSA – single kernel surface area; V/A - Volume/Surface area; TKW – thousand kernels weight; TW – test weight; V – vitreosity; WG – wet gluten w.a. – water absorption; DD – dough development; SD – softening degree; QN – quality number.

According to farinograph parameters all spelt samples belonged to B2 quality group (Tab III), characterized with relatively low baking characteristics. When flour B2 is used for industrial bread making, adding a kind of flour improver is necessary. Spelt samples farinograph parameters were generally in agreement to researches conducted by several authors [30], [7], [12]. It was noticed that spelt dough samples were very soft and sticky during kneading. This fact can be explained thereby that rheological properties of spelt gluten are predominated by gliadins as a very sticky monomeric plasticizer, while those of common wheat gluten by glutenins as a networking polymeric factor [7].

An analysis of the obtained results found a correlation between starch content and the physical and technological properties of spelt grain. Besides, correlation between spelt single kernel feature and technological properties, such as test weight and 1000 kernel weight, was also found.

Strong positive correlations between TKW and single kernel volume (0.78) and surfaces area (0.83) were observed. Results are in accordance to results obtained by Begić and Oručević [19]. Obtained results were expected because those parameters are indicators of kernel size in general, while TW is indicator of compactness and fullness of grain rather than kernel size. Higher positive correlations were found between TW and single kernel volume (0.94) and surfaces area (0.91) when compare to correlation between TKW and same parameters. Very strong positive correlation (0.98) was found between TW

and volume/surfaces area ratio. This value indicates shape and sphericity of the kernel and presents one of the factors influences the test weight [17]. Medium strong positive correlation between TW and TKW of spelt samples (0.53) was also observed, what is in accordance to results obtained by Warechowska *et al* [20]. Strong positive correlation was found between starch content and single kernel volume and ratio between volume and surface area (0.93 and 0.87, respectively) and very strong correlation between starch and SKSA and TKW (0.96 and 0.95, respectively) while lower correlation coefficient was found between starch and TW (0.76). Those results indicate that starch content is affected by kernel size more than by shape and compactness.

From the other side, strong negative correlations were found between wet gluten content and kernel size (for Vol: -0.92, for SKSA: -0.95 and for V/A: -0.85) and physical properties as TW (-0.74) and TKW (-0.96). Weak negative correlation between protein content in wheat and spelt and Vol. and SKSA, and medium strong negative correlation between protein and TW and HKW were reported by Begić and Oručević [19].

Quality number (QN) represents farinograph quality, and obtained results showed strong correlation between QN and Vol. and SKSA and very strong correlation between QN and volume/surface area ratio (0.91, 0.87 and 0.96, respectively). The strongest negative correlation (-1) was found between starch and wet gluten.

IV. CONCLUSIONS

Strong correlations were found between size and shape of the single kernel from one side and physical characteristics of spelt grain from the other. According to obtained results it can be concluded that the size and specially, shape of the single kernel play an important role in evaluation of the physical characteristics of spelt grain and therefore, the technological quality of the spelt grain in general.

V. ACKNOWLEDGMENT

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