WINTER WHEAT GRAIN QUALITY IN EASTERN CROATIA

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Abstract. *Wheat is one of the most important and widespread agricultural crop in the world. In Croatia, in terms of production, wheat is a second dominant crop and occupies around 20% of total arable land. Furthermore, in the context of the purchase price, grain quality plays a very important role for producers. The aim of the study was to analyze the parameters of wheat grain quality (protein content, hectoliter mass, moisture content and total impurities) in eastern Croatia and to examine the role of weather conditions during the two winter wheat growing seasons (2017/2018, 2018/2019). Wheat samples from 12 different locations in the east Croatia were collected and analyzed. The protein content was determined using the OmegAnalyzer G (Bruins instruments, USA), moisture and hectoliter mass were done using GAC 2100 (Dickey John, USA) while the determination of total impurities was determined by simple sieving and weighing. Based on the analysis of 17 509 samples taken over two years from the four counties of eastern Croatia (Osjecko-baranjska, Vukovarsko-srijemska, Brodsko-posavska and Pozesko-slavonska), the average values of protein content were 12.74 % with variation from 11.47 % to 14.54 %. At the same time, hectoliter weight was 76.92 kg hl^{-1}, grain moisture 12.78 % and total impurities 4.44 %. Generally, weather conditions during 2018/2019 vegetation period were more favorable for wheat quality compared to the second tested season while differences between sites were connected probably with agrotechnical measures and cultivar. Since there is a lack of information for this topic, novelty of these results will be useful to the scientific community and the general public.*

Keywords*: winter wheat, grain quality, weather characteristics, east Croatia*

INTRODUCTION

Wheat is the most common and one of the oldest cultivated plants originating from the Asia and southern Europe, where it spread to the rest of the world (POSPIŠIL, 2010). Nowadays, wheat is cultivated in more than 120 countries. According to FAOSTAT data base in 1999 to 2019 period, China, India, USA and Russian federation were the biggest wheat producer in the world, while France, Germany and Ukraine were the biggest producers in the Europe (FAOStat, 2021). In Croatia, cereals are the most important category of cultivated plants and wheat is a second dominant crop in terms of harvested area with 166 586 ha in average for the last 20-year period (Croatian Bureau of Statistics, 2018). Wheat is indispensable in human consumption and is the main source of basic food products used in human consumption (bread and bakery products). In addition, wheat is significant in the milling and food processing industry, animal feed production and the pharmaceutical industry (KOVAČEVIĆ AND RASTIJA, 2014).

According to the domestic legislative of quality parameters and quality classes of wheat protein content, moisture, hectoliter mass and impurity content are crucial in determining the final price of grain. The quality of wheat is largely based on the wheat storage proteins which extensively influences the dough properties (BRANKOVIC ET AL. 2018; SHARMA ET AL. 2020). Since the protein content is a decisive factor and is extremely important in the agri-food context, a large number of authors have examined the role of abiotic and biotic factors on its occurrence in wheat grain (JONES ET AL. 2015; ZANIĆ 2017; ILJKIĆ ET AL. 2019). The protein content in Croatia is usually between 10 and 15% depending on the climate, weather conditions, fertilization, growing conditions and varieties. Based on Rulebook on quality parameters and qualitative classes of wheat in purchase, official document of Ministry of agriculture, all produced wheat is categorized in 5 group (NN 62/2019). Protein

content and hectoliter weight for Premium class is >15.00% and 80 kg hl^{-1}, for I. class 14.99-13.50 % and 78 kg hl^{-1}, for II. class 13.49-12.00% and 78 kg hl^{-1}, for III. class 11.99-10.50% and 74 kg hl^{-1} and for IV. class <10.49% and <74 kg hl^{-1}, respectively. Furthermore, for all classes values for grain moisture and total impurities are the same (13.5% and max. 5%).

The aim of this study was to analyze quality indicators (protein content, hectoliter weight, total impurities and moisture content) of wheat samples collected from silos in Eastern Croatia in a two-year period (2018 - 2019), and to show the impact of weather conditions during wheat growing season on examined parameters.

MATERIAL AND METHODS

Grain wheat samples collected from silos and warehouses from 12 different locations (Bošnjaci, Đakovo, Gundinci, Korođ, Kutjevo, Mikluševci, Osijek, Otok, Požega, Stari Jankovci, Šljivoševci and Valpovo) in Eastern Croatia (counties of Brodsko-posavska, Osječko-baranjska, Požeško-slavonska and Vukovarsko-srijemska) were used (Picture 1). Protein content (%), moisture (%), hectoliter mass (kg ha^{-1}) and impurities (%) of total 17 509 samples from two wheat growing season (2017/2018 and 2018/2019) were analyzed.

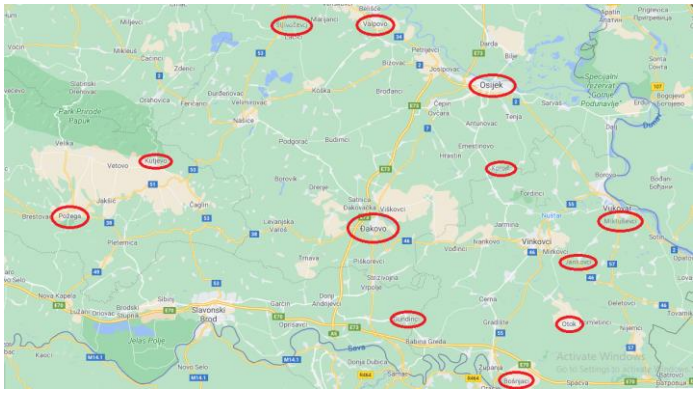

Fig. 1. Silos and warehouses locations in eastern Croatia (www.google.com/maps/)

The OmegAnalyzer G (Bruins instruments, USA) device is used for rapid determination of protein content based on the NIR technology while moisture content and hectoliter mass were measured using GAC 2100 (Dickey John, USA). Percentage of total impurities was determined by simple sieving and weighing according to the official domestic legislation.

Data of monthly precipitation amounts (mm) and average monthly air temperatures (°C) during wheat vegetation 2017/2018 and 2018/2019, as well as long term mean (LTM, from 2007 to 2016) were used. All data were collected at the meteorological stations of Osijek, Đakovo, Valpovo, Vukovar, Vinkovci, Gradište, Požega and Kutjevo of the State Hydrometeorological Institute of the Republic of Croatia and represents weather conditions for all tested locations.

The obtained results were processed in the MS Office software package, i.e. computer programs Excel and Word. Since there were no elements for the analysis of variance, the presented data represent average values.

RESULTS AND DISCUSSIONS

Weather conditions have decisive effect on wheat grain yield, as well as quality. Generally, eastern Croatia have favorable conditions for wheat production in context of precipitation amount and air temperatures. The highest yields and the best quality of wheat

grains are achieved in areas with 650-750 mm of precipitation per year, with a favorable distribution during the vegetation (KOVAČEVIĆ AND RASTIJA, 2014). However, success of each vegetation season is a combination of many factors such as soil fertility, agrotechnical management, especially fertilizers application, variety selection, etc.

Average precipitation amount and air temperatures (LTM) for tested sites were 612.3 mm and 10.75 °C, respectively. Vegetation season 2017/2018 are characterized as wet year because precipitation was higher for 20%, while 2018/2019 was some drier with 10% less precipitation. FLAGELLA ET AL. (2010) found that water deficiency affects the increase in protein content in wheat grain. At the same time, air temperatures for both tested years was quite similar, while in comparison to the LTM it was higher for 0.47°C.

Table 1

Precipitation and air temperatures during 2017/2018 and 2018/2019 vegetation season and long term mean (LTM, 2007-2016) for tested sites

Location/Year	Osijek	Đakovo	Valpovo	Vukovar	Vinkovci	Kutjevo	Požega	Gradište
	Precipitation (mm)							
2017/2018	675.5	669.1	714.1	659.2	687.7	823.5	817.7	781.4
2018/2019	531.3	589.8	513.3	459.8	538.0	591.2	612.9	584.1
LTM	574.4	629.1	604.2	542.9	582.0	747.4	642.9	575.3
	Air temperatures (°C)							
2017/2018	11.1	11.4	10.9	11.8	11.6	11.2	10.7	11.6
2018/2019	10.9	11.1	10.6	11.8	11.5	11.4	10.5	11.4
LTM	10.7	10.8	10.4	11.2	10.8	10.7	10.3	11.1

In 2018, a total of 8838 samples collected in eastern Croatia were analyzed. The largest number was analyzed in Osijek-Baranja County (49.1%), then by Vukovar-Srijem County (27.7%), followed by Požega-Slavonia County (19.6%) and Brod-Posavina County with only 3.6% of samples. In 2019 similar number of samples were analyzed. Of the total samples (8671), 46.6% were processed in Osijek-Baranja County, 29.0% in Vukovar-Srijem County, 20.5% in Požega-Slavonia County and only 3.9% in Brod-Posavina County (Table 2). The main reason for this distribution of analyzed samples is silo and warehouses capacity in the eastern Croatia region.

For both tested years average protein content in this region of Croatia was 12.73% with relatively large variations between years and locations. The average protein content in 2018 was 12.14%. In the Vukovar-Srijem County, the highest value of protein content was achieved, while Brod-Posavina and Požega-Slavonia County had the lowest value. The highest protein content in 2018 (12.99%) was achieved in Otok, while the lowest value was recorded at the location Jankovci of only 11.47% or 1.52% less.

In terms of wheat quality, the average protein content in vegetation 2019 was higher for 1.18% in comparison with first tested year. Compared to all analyzed counties, the highest value of protein content was achieved in Brod-Posavina County (14.54%), and the lowest protein content was recorded in Osijek-Baranja County (12.95%) which is opposite to the first year. At the same time, the highest protein content (14.54%) was achieved at Gundinci location, while Jankovci had the 2.10% lower value or 12.40% protein.

Based on this data, the lower amount of precipitation in vegetation season 2018/2019 achieved higher protein content. Similar results confirmed HORVAT ET AL. (2012), ĐEKIĆ ET AL. (2015), ŠPANIĆ (2016), ILJKIĆ ET Al. (2019). Furthermore, VOLLMER AND MUßHOFF (2018) analyzed 148 800 winter wheat samples from Germany between 2004 and 2015 and concluded that weather conditions (precipitation, temperature, number of hours of sunshine) have different effects on grain protein content. High temperatures in May and July lead to an increase in protein content in the grain as well as higher precipitation in April and

June. DUPONT ET AL. (2006) states that day / night temperatures (24/17 ° C) have a positive effect on protein accumulation while higher temperatures (37/28 ° C) increase protein but reduce grain weight by 50%.

In both observed years, on average, the highest protein content was determined in Brod-Posavina County, and the lowest in Osijek-Baranja County. However, it should be noted that the proportion of samples examined was irregular and with the same number of samples in both counties the results might have been completely different.

Observed by individual locations in both years, in general at the location Jankovci the lowest protein content was achieved, while the highest values were also found in the same county at the location Otok and Mikluševci (13.43% and 13.42%).

Differences of protein content between year and location, with aspects of purchase wheat grain, are very important. The higher protein content results in a higher wheat class at purchase which leads to the higher price.

Table 2

Numbers of tested samples and protein content in wheat grain by counties and years

Counties	Location	Number of samples	Protein content (%)	Number of samples	Protein content (%)	Protein average
		2017/2018		2018/2019		
Osjecko-baranjska	Osijek	1055	11.72	743	12.79	12.26
	Đakovo	1927	12.52	1589	13.32	12.92
	Valpovo	812	11.92	1269	12.93	12.42
	Šljivoševci	549	12.13	440	12.77	12.45
Counties average		4343	12.07	4041	12.95	12.51
Vukovarsko-srijemska	Bošnjaci	342	12.40	346	13.57	12.99
	Otok	581	12.99	603	13.86	13.43
	Jankovci	705	11.47	812	12.40	11.94
	Mikluševci	445	12.76	393	14.07	13.42
	Korođ	374	12.10	359	13.16	12.63
Counties average		2447	12.34	2513	13.41	12.88
Brodsko-posavska	Gundinci	320	11.98	340	14.54	13.26
Counties average		320	11.98	340	14.54	13.26
Požeško-slavonska	Požega	1034	12.07	1053	13.07	12.57
	Kutjevo	694	11.91	724	13.30	12.61
Counties average		1728	11.99	1777	13.18	12.59
Average		8838	12.14	8671	13.32	12.74

Average grain moisture in this research was 12.78% with variation from 12.35% in 2019 to 13.21% in 2018 (Table 3). The lower moisture was achieved in drier year which is expected. Generally, in both years and all locations grain moisture was below limit (14.00%) for safe storage in silo.

Hectoliter weight, after protein content, is a dominant parameter for purchase wheat grain. For both years average value was 76.92 kg hl^{-1} with certain variation between years and location. Like as for protein and moisture content, a higher value was found in the dryer year. In 2018, the highest value of hectoliter weight was achieved in Vukovar-Srijem County (76.95 kg hl^{-1}), while the lowest was achieved in Požega-Slavonia County 75.90 kg hl^{-1} or 0.75 kg hl^{-1} less than the average. In 2019, Vukovar-Srijem County had the highest value of hectoliter weight (78.43 kg hl^{-1}), while Brod-Posavina County achieved the lowest value (75.88 kg hl^{-1}) which is 1.31 kg hl^{-1} less than the average (Table 3).

Average total impurities for both years and locations were 4.44% which is in accordance to the domestic legislative of quality parameters and quality classes. Total impurities in 2019 were higher compared to 2018 by 0.31%.

Table 3

Other quality parameters in wheat grain by counties and years

Counties	Location	Grain moisture (%)	Hectoliter mass (kg hl^{-1})	Impurities (%)	Grain moisture (%)	Hectoliter mass (kg hl^{-1})	Impurities (%)
		2017/2018			2018/2019		
Osjecko-baranjska	Osijek	13.24	76.45	3.60	12.47	75.24	4.14
	Đakovo	13.33	76.15	4.16	12.72	76.22	4.57
	Valpovo	14.00	75.61	3.99	12.57	74.97	3.96
	Šljivoševci	13.05	77.40	3.71	12.54	77.48	4.96
Counties average		13.41	76.40	3.87	12.58	75.98	4.41
Vukovarsko-srijemska	Bošnjaci	13.10	77.33	4.91	11.90	79.04	4.72
	Otok	13.27	78.59	3.89	12.19	79.70	4.14
	Jankovci	13.54	75.60	5.14	12.71	77.71	6.31
	Mikluševci	12.94	77.48	5.04	12.04	77.93	5.17
	Korođ	12.88	75.77	4.36	12.42	77.77	3.98
Counties average		13.15	76.95	4.67	12.25	78.43	4.86
Brodsko-posavska	Gundinci	12.76	76.07	4.09	11.98	75.88	4.38
Counties average		12.76	76.07	4.09	11.98	75.88	4.38
Požeško-slavonska	Požega	13.32	75.95	5.10	12.79	76.29	4.84
	Kutjevo	12.94	75.84	4.33	12.36	77.49	4.66
Counties average		13.13	75.90	4.76	12.58	76.90	4.75
Average		13.21	76.65	4.29	12.35	77.19	4.60

CONCLUSIONS

According to the domestic regulation and based on this research, wheat samples analyzed from eastern Croatia belongs to class II. Since that the decisive parameter for classifying wheat into qualitative classes is the percentage of protein, special attention should be paid to increasing the level of protein in wheat grain. Although differences were found between the counties of eastern Croatia in terms of protein, in general, none of the counties stood out, while the differences between locations and year were somewhat more pronounced. Furthermore, weather conditions, especially precipitation and temperature regimes, as well as location influenced wheat quality parameters. Whit that aspect, vegetation season 2018/2019 has shown higher value. However, it must be emphasized that the interaction of a large number of biotic and abiotic factors play a final role in achieving wheat grain quality.

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