# CONTRIBUTION OF ORGANICALLY GROWN SPELT TO THE GRAIN QUALITY

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**Abstract**

Organic agriculture is capable to contribute to the production of healthier food. Organically produced cereals, such as spelt, represent the potential source of quality and healthy components for human food. Spelt wheat is one of the husked hexaploid wheat grown for centuries within a low-input technology. The nutritive value of spelt is high and it contains all the basic components which are necessary for human nutrition. Spelt is high in digestible proteins, vitamins, minerals and antioxidants. Differences may occur due to the growing place and season, cultivation, fertilizers etc. The content of nutritionally important minerals (Fe, Mg, Zn, Ca, Mn) and some antioxidants were analyzed in spelt wheat grown during four different seasons and in semiarid conditions. The spelt wheat was organically grown in the period 2012-2015, at Maize Research Institute Zemun Polje. The crop was sown on the area of 0.33 ha and after harvesting, grain yield was measured from all production area and calculated with 14% of moisture. Then, grains were milled and content of nutrients Mg, Fe, Mn, Ca and Zn, as well as inorganic phosphorus (Pi), phytic phosphorus ($P_{phy}$), phenolics, β-carotene and glutathione (GSH), were determined in grains. Obtained data were processed by analysis of variance (ANOVA) and differences with $p<0.05$ were considered as significant. Among growing seasons, the highest spelt yield was observed in 2012 (4200 kg $ha^{-1}$). The variations in content of minerals and antioxidants followed variations in sum of precipitation, as well as average air temperature. The content of Mg was significantly higher in 2015, while the Ca content was lower. Concentration of Zn and Mn continuously decreased from 2012 to 2015. The highest content of almost all investigated antioxidants was observed mostly in 2013. GSH and β-carotene content variations were also affected by the meteorological conditions of the growing season.

**Keywords:** *Triticum aestivum* subsp. *spelt*, organic, minerals, antioxidants.

## Introduction

Organic agriculture as a component of sustainable systems is capable to contribute healthier food production in comparison to conventional and conservation agriculture (Azadi et al. 2011). This system is holistically defined by the American Public Health Association (APHA, 2007) as "one that provides healthy food to meet current food needs while maintaining healthy ecosystems that can also provide food for generations to come with minimal negative impact to the environment. A sustainable food system also encourages local production and distribution infrastructures and makes nutritious food available, accessible, and affordable to all". Organically produced cereals represent the potential source of quality and healthy components for human food (Dragičević et al. 2014), while conventionally produced row materials carry a continuous risk of unallowed content of pesticide residues or pathogens exudates. Spelt wheat (*Triticum aestivum* subsp. *spelta*) is one of the husked hexaploid wheats which possesses the same genomes as bread wheat (*Triticum aestivum* L.) (Yan et al. 2003). Spelt wheat is an old European crop, grown for centuries, and a low-input plant, suitable for growing without the use of pesticides. Even with low fertilizing, spelt wheat gives a good harvest and has a better mineral uptake in comparison with *Triticum aestivum* L. (Bojnanská and Francáková 2002). Due to the high consumption of wheat in a variety of food products all over the world, wheat is considered an important source of minerals. The nutritive value of spelt wheat is high and it contains all the basic components which are necessary for human beings (Bojnanská and Francáková 2002). Spelt is high in digestible proteins, vitamins and minerals. Differences may occur

due to the growing place and season, cultivation, fertilizers (Puumalainen et al. 2002) and higher levels of several minerals were observed in organically grown spelt in comparison to production carried out in conventional systems. This indicates that organic conditions with agroecologicaly adapted variety may enhance mineral concentration in spelt grain. Compared to wheat, spelt has higher concentration of proteins and vitamins, better content of amino acids, starch and sugar and more desirable fiber content (Kohajdova and Karovičova 2008). On average, spelt has 30-60% higher concentrations of Fe, Zn, Cu, Mg, and P, which is most pronounced in fine bran and coarse bran, where cereal minerals are naturally concentrated (Ruibal-Mendieta et al. 2005). Ranhorta et al. (1995) found that spelt grain was higher in P (by 19%), Fe (by 20%), K (by 7%) and Zn (by 91%) in comparison to the hard red winter wheat. In contrast to minerals, and especially P, the phytic acid content tends to be 40% lower in spelt than in wheat, as indicated by our data obtained in fine brans, where aleuronic cells, which naturally contain phytic acid (Lopez et al. 2002), are the most concentrated (Ruibal-Mendieta et al. 2005). The content of nutritionally important minerals (Fe, Mg, Zn, Ca, Mn) and some antioxidants were analyzed in spelt wheat grain grown during four different seasons and in semiarid conditions.

**Material and methods**

The spelt was organically grown in the period 2012-2015, at Zemun Polje (44°52'N 20°20'E), on a slightly calcareous chernozem, with 53.0 % sand, 30.0 % silt, 17.0 % clay, 3.3 % organic matter, 7.0 pH KCl and 7.17 pH $H_2O$. After conversion of soil, spelt wheat was rotated with maize and soybean. The crop was sown on October 25 2011, November 9 2012, November 14 2013, and again November 14 2014, on the area of 0.33 ha. After harvesting, grain yield was measured from all production area and calculated with 14% of moisture. Then, grains were milled and content of nutrients Mg, Fe, Mn, Ca and Zn, as well as inorganic phosphorus (Pi), phytate (Pphy) – as factor which affect availability of mineral nutrients, phenolics, β-carotene – as factor which promotes availability of mineral nutrients, and glutathione (GSH) were determined. Total glutathione (GSH) was determined by the method of Sari Gorla et al. (1993), water soluble phenolics were determined by the method of Simić et al. (2004) and expressed in µg of *3-hydroxy-4-methoxycinnamic acid* $g^{-1}$ and yellow pigment (YP) was determined by the American Association of Cereal Chemists Method (AACC, 1995) and expressed in µg of β-carotene $g^{-1}$. Significant differences between means of treatments were determined by the Fisher's least significant difference (LSD) test at the 0.05 probability level, after the analysis of variance (ANOVA) which was conducted by using two-factorial RCB design. Differences with $p<0.05$ were considered as significant. Interdependence between the grain yield of spelt and examined antioxidants were processed by regression analysis. *Meteorological conditions:* The vegetative period for spelt production in the first year, 2011-2012, received the lowest amount of precipitation and had the lowest average temperature, Table 1.

Table 1. Meteorological conditions during period of investigation

| Months | X | XI | XII | I | II | III | IV | V | VI | VII | Aver./Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperatures | | | | | | | | | | | |
| 2011-2012 | 12.1 | 4.4 | 5.5 | 2.7 | -2.5 | 10.1 | 14.4 | 17.9 | 24.6 | 27.1 | 11.6 |
| 2012-2013 | 15.4 | 11.1 | 2.0 | 3.3 | 4.6 | 6.6 | 14.9 | 19.7 | 21.9 | 23.8 | 12.3 |
| 2013-2014 | 15.3 | 10.1 | 3.2 | 5.3 | 7.8 | 10.8 | 13.7 | 17.4 | 21.1 | 23.2 | 12.8 |
| 2014-2015 | 14.1 | 9.7 | 3.8 | 3.3 | 4.2 | 8.1 | 12.9 | 19.1 | 22.1 | 26.4 | 12.4 |
| Precipitation | | | | | | | | | | | |
| 2011-2012 | 26.7 | 2.7 | 41.9 | 64.3 | 33.5 | 10.7 | 56.2 | 58.5 | 14.8 | 19.8 | 329.1 |
| 2012-2013 | 41.3 | 24.6 | 47.1 | 80.8 | 51.9 | 96.2 | 14.9 | 93.9 | 37.8 | 16.0 | 504.5 |
| 2013-2014 | 21.9 | 25.4 | 5.2 | 30.7 | 19.9 | 46.9 | 84.8 | 192.5 | 71.2 | 187.4 | 685.9 |
| 2014-2015 | 56.6 | 10.5 | 41.3 | 46.7 | 44.0 | 99.1 | 19.7 | 97.8 | 31.1 | 7.2 | 454.0 |

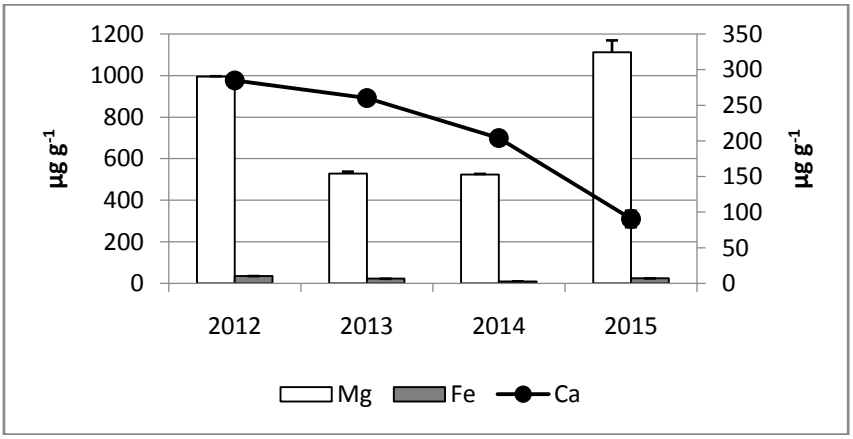
The 2011 year could be considered as a relatively moderate, with lower average temperatures and higher amounts of monthly precipitation than in 2012. The specific year, 2012, was unfavourable for

plant production generally and with unequal distribution of precipitation followed by the high average temperatures i.e. drought stress. Years 2013 and 2014 were pretty different and especially 2013-2014 period of spelt growth received a high amount of precipitation. Oppositely, 2015 could be considered as a relatively dry.

**Results and discussion**

The highest spelt yield was observed in 2012 (4200 kg per ha) while in three other years it was 3656.7 kg per ha in 2013, 2011.3 t per ha in 2014 and only 1800.0 kg per ha in 2015. The growing conditions of the cultivation year were segregating factor for grain yield and mineral content of elements (Mg, Fe, Ca, Mn and Zn) in spelt grain. This is also observed in previous studies (Wojtkowiak and Stepien 2015). Spelt wheat was observed to have significantly higher values for minerals and antioxidants in grains as a result of crop rotation and meteorological conditions, Figure 1 A and B.

A




B

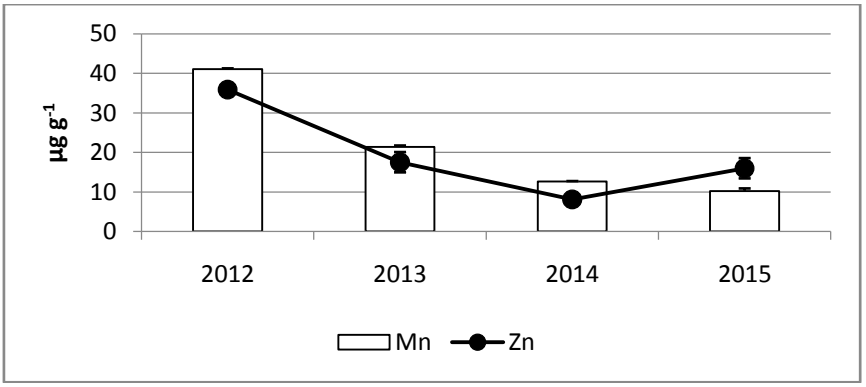
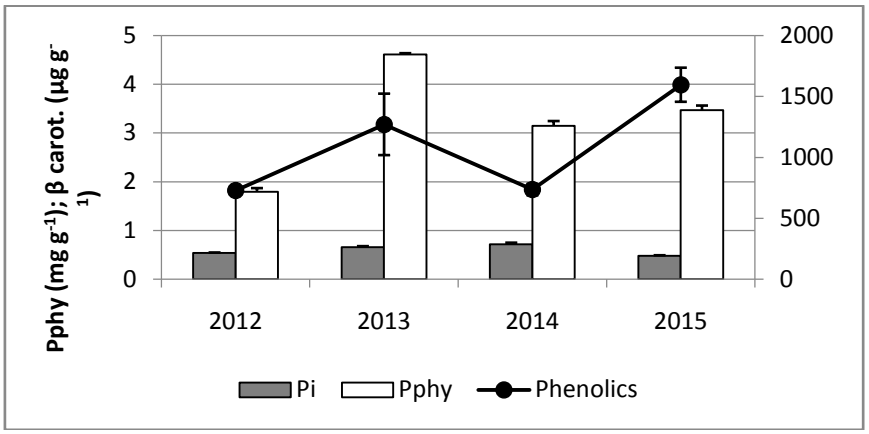



Figure 1 A and B. The content of analyzed minerals Fe, Mg, Zn, Ca and Mn in spelt grain in the period of 2012 to 2015

This study showed that a very high mineral concentration, close to daily requirements, can be produced by growing specific traditional wheat genotypes in an organic farming system. Thanks to spelt grain composition, the the main minerals are concentrated in fine bran and coares bran. Their content is 30-60% higher than in wheat (Riubal-Mendieta et al. 2005). The content of Mg was significantly increased in 2015 while the content of Ca was lowered. Fe was present in spelt grain at almost the same concentration in each year and had a lowest concentration together with Mg in 2014. The content of other two elements, Zn and Mn continuously decreased from 2012 to 2015 and Mn was the lowest in the last year. Lower Zn concentration in 2014 and 2015 was possible induced by better P absorption (Ryan et al., 2004), what is evidenced by the highest $P_{phy}$ and Pi concentration in maize grain (Dragičević et al. 2014). Results also showed that even though phosphorus content

was higher phytic acid content showed the opposite trend and was 40% lower in spelt versus wheat fine bran, which may suggest that spelt has either a higher endogenous phytase activity or a lower phytic acid content than wheat (Riubal-Mendieta et al. 2005). Antioxidants level followed variations in sum of precipitation as well as average air temperature. The highest content of almost all investigated antioxidants was observed mostly in 2013. $P_{phy}$ had the highest value in 2013 and phenolics in 2015, Figure 2 A. The concentration of phenolics and $P_{phy}$ in spelt grain were increased in 2013 and 2014 compared to 2012 and 2015 which is probably connected with meteorological conditions and drought occurrence in 2012 and 2015. The concentration of inorganic phosphorus (Pi) in spelt grain was similar in all years but pretty lower than content of other two phytic components. GSH and β-carotene contents were also induced by the meteorological conditions of the year, Figure 2 B.

A




B

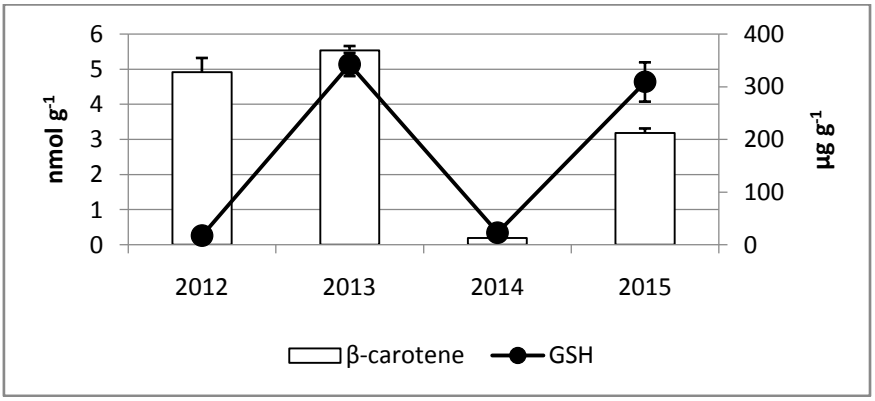



Figure 2 A and B. The content of analyzed minerals Fe, Mg, Zn, Ca and Mn in spelt grain in the period of 2012 to 2015

β-carotene which promotes bioavailability of mineral elements, was present in spelt grain in the higher content in 2012 and 2013, while its content significantly decreased in 2014 which was the season with the highest amount of precipitation – 685.9 mm. During next season, 2014-2015 content of β-carotene in spelt grain, have increased again. Plant products usually contain inhibitors, like phytate, polyphenolics, etc., which obstruct the absorption or utilization of mineral elements. According to results obtained from organic production of maize in the agroecological conditions of Zemun Polje, very important is to decrease content of inhibitors in foods and to increase content of promoters and the good way for that is balanced and adequate application of specific fertilizers (Dragičević et al. 2014).

Table 2. The significance of relations between investigated minerals and antioxidants in spelt grain (average 2012-2015)

| Variables | Yield | Pi | Pphy | Phen. | GSH | β-carot. | Ca | Mg | Fe | Zn | Mn | Temp. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pi | -0.008 | | | | | | | | | | | |
| Pphy | -0.245 | 0.344 | | | | | | | | | | |
| Phen. | -0.377 | -0.506* | 0.620* | | | | | | | | | |
| GSH | -0.143 | -0.253 | 0.816* | 0.924* | | | | | | | | |
| B - carot. | 0.779* | -0.400 | 0.117 | 0.284 | 0.455 | | | | | | | |
| Ca | 0.880* | 0.435 | -0.220 | -0.690* | -0.403 | 0.428 | | | | | | |
| Mg | -0.044 | -0.975 | -0.519* | 0.346 | 0.048 | 0.245 | -0.433 | | | | | |
| Fe | 0.711* | -0.708* | -0.455 | 0.055 | 0.034 | 0.808* | 0.323 | 0.663* | | | | |
| Zn | 0.684* | -0.692* | -0.626* | -0.099 | -0.159 | 0.683* | 0.341 | 0.693* | 0.979 | | | |
| Mn | 0.912* | -0.187 | -0.620* | -0.539* | -0.439 | 0.601* | 0.787* | 0.214 | 0.790* | 0.838* | | |
| Temp. | -0.791* | 0.578* | 0.588* | 0.177 | 0.178 | -0.735* | -0.481 | -0.570* | -0.973 | -0.987 | -0.904* | |
| Precip. | -0.645* | 0.768* | 0.472 | -0.099 | -0.045 | -0.774* | -0.240 | -0.728* | -0.996 | -0.979 | -0.746* | 0.958 |

*- Values significant according to LSD-test

Statistical analysis showed positive and negative correlations between investigated components of spelt grain under the influence of meteorological parameters, Table 2. The content of almost all investigated antioxidant except β-carotene negatively correlated with grain yield of spelt while microelements content was positively connected with grain yield, except Mg concentration. Very interesting is that, in average for all years of investigation, content of Mg and inorganic phosphorous in spelt grain was negatively correlated (- 0.975) which suggested that if inorganic phosphorus is present in higher concentration, the content of Mg is lower. Concentration of Zn and Fe were correlated positively (0.979). And, concentrations of Zn and Fe were negatively correlated with average air temperature (-0.973 and -0.978) and sum of precipitation (-0.966 and -0.979) during period of investigation. It was already mentioned that GSH and phenolics play an important role in spelt nutritional quality (Dragičević et al. 2013). Phenolics and phytate participation in spelt grain were in significant, positive correlation (0.620*) while GSH content was significantly and highly connected to Pphy and phenolics (0.816* and 0.924*).

**Conclusions**

Organic conditions with agro-ecologically suitable variety may enhance mineral and antioxidants concentration in spelt wheat grain. The growing conditions of the cultivation year were segregating factor for grain yield, mineral content of elements (Mg, Fe, Ca, Mn and Zn) and content of antioxidants (Pi, Pphy, phenolics, β-carotene and GSH) in spelt grain. Statistical analysis showed positive and negative correlations between investigated components of spelt grain and under the influence of meteorological parameters such as Zn and Fe concentrations which were negatively correlated with average air temperature and sum of precipitation.

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