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Comparison of N and S contents of different winter wheat flour samples

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Abstract. Sulphur is the fourth macro-element, which mostly occurs in crops in organic forms, as components of sulphur-containing amino acids (methionine, cystine, cysteine). In a number of cases, these amino acids together with lysine act as limiting amino acids. Furthermore, in winter wheat, the S-S cross binding of gluten components (cystine) plays a vital role in forming a suitably structured soft part of bread as sulphur deficit may cause serious quality disorders, the decline of the viscoelasticity of dough. In Hungary, the amount of the atmospheric deposition of sulphur and superphosphate application containing 10-11% sulphur has decreased significantly over the past twenty years. Since winter wheat flours can be found in one of the important raw materials for the foods, we considered important to examine the contents of their nitrogen and sulphur. We analysed different wheat varieties for long-term mineral fertilization experiments. The nitrogen and sulphur contents of flours were determined by using the combustion (Dumas) method. We found that both the genotype and the mineral fertilizer treatments had significant effects on the N and S contents of winter wheat flours, but the interaction between these factors was not proved. The N contents varied between 1.90 and 2.85% on dry matter base. The S content of samples was between 0.09 and 0.14% on dry matter base and the pace of changing was similar to the changing of N content. As the overall conclusion, the characteristics of the N/S ratio of four species were established (GK Ati 17.8 to 20; Ukrainka 19 to 20.5, 19 to 23.3 Lupus; Mv Suba 21.8-23.3), the rates of which were higher than the values previously reported for the grain of wheat.

Keywords and phrases: winter wheat, flour, N and S content, mineral fertilization.

1 Introduction

Sulphur is the fourth macro-element, which mostly occurs in crops in organic forms as a component of sulphuric amino acids (metionyne, cystine, cysteine). In a number of cases, these amino acids together with lysine act as limiting amino acids. Furthermore, in winter wheat, the S-S cross binding of the gluten components (cystine) plays a vital role in forming a suitably structured soft part of bread as sulphur deficit may cause serious quality disorders. A close correlation has been established between the sulphur contents of wheat grains and the volumes of bread loaves (*Zhao et al.*, 1999). The reduction in the percentage of polymeric protein in flour as a result of sulphur deficiency was due to a decrease in LMW glutenin subunits, which are normally present in larger amounts than the HMW subunits (*MacRitchie & Gupta*, 1993).

Scherer (2001) described that wheat has a relatively low S requirement (to about 20 kg/ha S necessary to 8 t/ha grain yield) (*McGrath et al.* 1996), but several findings reveal that – as regards the quality of wheat – a good sulphur supply is essential since low sulphur supplies will decrease cystine contents and, as a result, the disulphide bonds on the gluten will not be adequate to ensure a satisfactory resilience. The S deficiency symptoms are not easily identifiable in wheat because they can be confused with those of the N deficiency (*Zhao et al.*, 1996). The marks of sulphur deficiency from barley are the accumulation of amides in roots and the accumulations of asparagine and glutamine in leaves (*Karmoker et al.*, 1991).

When analysing the sulphur contents of wheat varieties in England, *McGrath et al.* (1993) found that sulphur contents had significantly decreased over the ten previous years. The reason for the decrease in Hungary is caused by the decreasing atmospheric deposition and the decreasing mineral fertilization (especially superphosphate). In Hungary, *Győri* (2005) published data from the sulphur contents of different winter wheat varieties in different cropping sites. His results show that the average sulphur content of winter wheat grain is 1500±120 mg/kg in Hungary. Mars et al. (2006) investigated the effect of different sulphur fertilizers on wheat yield and their baking quality. They found that the foliar sulphur (5 kg/ha) fertilization increased both the gluten content and the farinograph (BU) value number. Because the bakery products are among staple foods, it was important to examine the nitrogen and sulphur contents of winter wheat grains and flours.

2 Materials and methods

The samples examined were taken to the Experimental Station of the University of Debrecen at Látókép in 2004. The type of soil was a calcareous chernozem soil. In the experiment, we applied the following treatments: control, 30 kg ha^{-1} nitrogen (as ammonium nitrate), 22.5 kg ha^{-1} P_2O_5 (as superphosphate) and 26.5 kg ha^{-1} K_2O (as potassium chloride) and the double, triple, four- and fivefold amounts of these doses in four repetitions.

For the milling process, we used a FQC-106 laboratory mill (MSZ 6367/9-1989) with a 250 μm sieve (InterLab Kft., Budapest). We examined the quality parameters of four winter wheat varieties (GK Ati, Ukrainka, Mv Suba and Lupus). The determination of the N and S contents of the flours was done with Elementar VarioMax equipment (Hanau, Germany), based on the combustion method by Dumas (*AACC 046– 0, 2000*) in the Central Laboratory of the University of Debrecen, Centre for Agricultural Sciences. The certified sample was BCR CRM 189 wheat. Statistical analyses were performed using Microsoft Excel 2007 and SPSS 22.0 for Windows.

3 Results and discussion

The adequate sulphur supply of wheat is an important task even after the atmospheric deposition of sulphur pollution has decreased significantly. By using superphosphate, which contains sulphur during fertilization, the essential question is how to develop the composition of wheat flour. Gluten properties and their sulphur-protein compounds play an important role in the bread making process and its quality. The quantity and quality of these compounds, different for each variety and fertilizer treatment, may bring about different responses. We found that both the genotype and the mineral fertilizer treatments had significant effects on the N and S contents of winter wheat flours, but the interaction between these factors was not proved (*Table 1*).

There were significant differences between the nitrogen contents of the varieties even as regards the control treatments, as they showed the following readings: Ukrainka 1.9%, Gk Ati 2.18%, Lupus 2.3% and Mv Suba 2.5%. The N contents varied between 1.9 and 2.85% on dry matter base (*Figure 1*). The responses of these varieties to the increasing fertilizer ratios were diverse; the N content of GK Ati variety increased continuously with the treatments, while the other genotypes showed maximum values at lower nutrient levels (Ukrainka at 120 kg ha^{-1} N+PK, Mv Suba at 60 kg ha^{-1} N+PK, Lupus at 30 kg ha^{-1} N+PK), which were followed by slow decreases.

Table 1: Results of the two-way ANOVA of the grain N and S content showing the F values and P levels of the main effects and the interaction

	N content		S content		N/S ratio	
	F value	P level	F value	P level	F value	P level
Genotype	50.741	0.0000	7.585	0.0010	11.296	0.0001
Mineral fertilizer treatment	27.504	0,0000	4.449	0.0052	1.637	0.1886
Genotype x mineral fertilizer treatment	1.768	0.1034	0.580	0.8618	0.500	0.9167

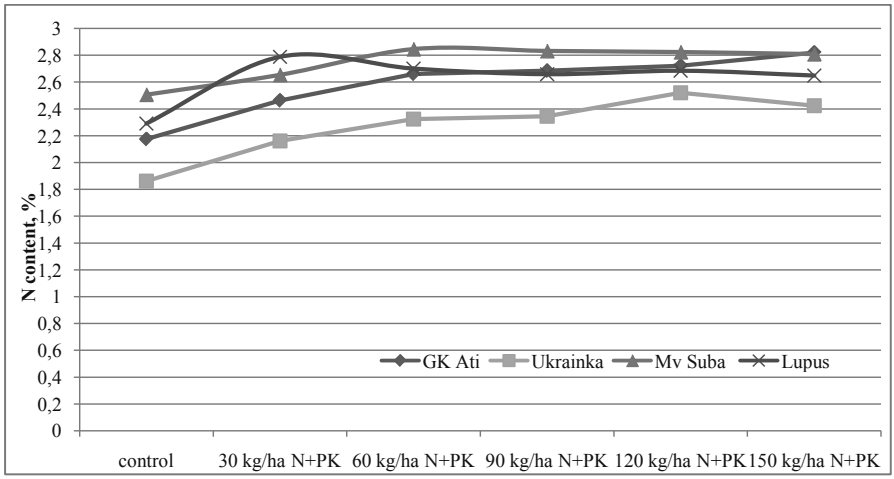

Figure 1: Effect of mineral fertilization on the N content of wheat flours

The S contents of the samples were between 0.09 and 0.14% on dry matter base (*Figure 2*) and the rate of change was similar to the changes in the N contents; so, winter wheat variety Ukrainka showed the strongest fertilizer response and Mv Suba showed the most stable quality in the response to the different levels of mineral fertilization. In the case of variety Lupus, the S content showed a peak with the highest N content at 30 kg ha^{-1} N+PK and the higher NPK doses resulted in a decline, but at the N150+PK dose the sulphur content of 1,400 mg/kg was the highest.

An important parameter indicating the nutritional status of winter wheat is the N:S ratio in the grains.

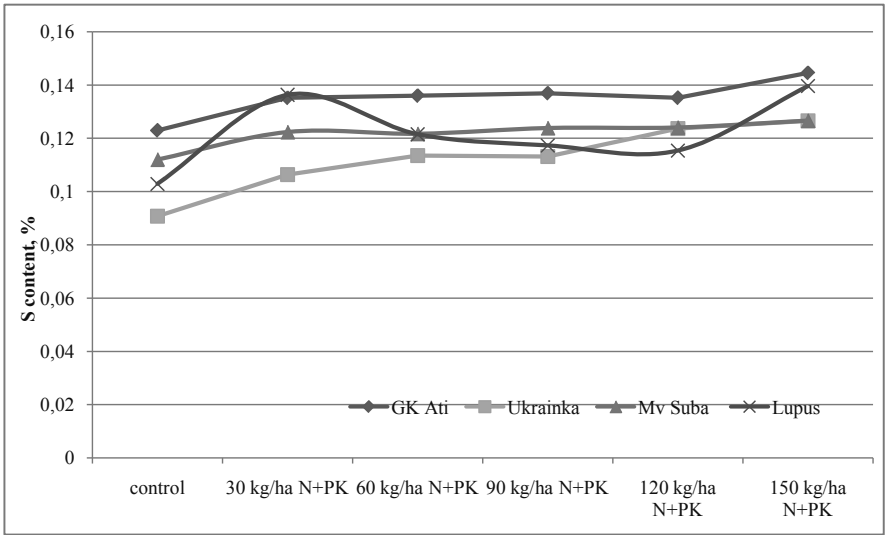

Figure 2: Effect of mineral fertilization on the S content of wheat flours

According to the data reported in my previous article (*Győri*, 2005), the values of this ratio were around 15, in accordance with the values in the literature for the case of good plant nutrition. The N/S ratios of flours, as the statistical analysis suggested, were stable values by genotypes (Figure 3).

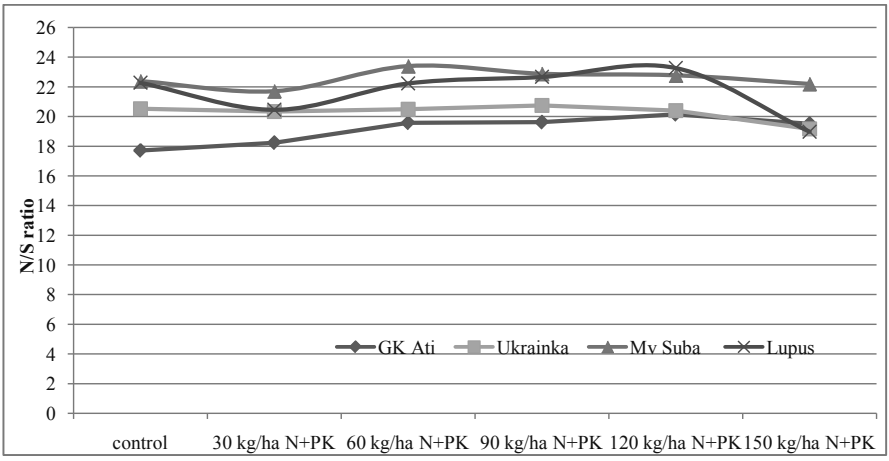

Figure 3: Effect of mineral fertilization on the N/S ratio of wheat flours

In all of the four varieties analysed, the S:N ratios decreased in the case of the highest ratios of fertilizer application to either a smaller (GK Ati) or a larger extent (Lupus) in relation to the other treatments. The effect of increasing fertilizer doses resulted in no changes in the N/S ratio of Ukrainka to a N120 + PK kg/ha treatment, but in contrast, in the case of GK Ati, the rate increased. In the case of Lupus and Mv Suba varieties, the rate was higher than in the previous two varieties, but the effects of the fertilizers were also more varied.

As the overall conclusion, the characteristics of the N/S ratios in four species were established (GK Ati 17.8 to 20; Ukrainka 19 to 20.5, 19 to 23.3 Lupus; Mv Suba 21.8-23.3), the rates of which were higher than the values previously reported for the grain of wheat (*Győri*, 2005; *Byers & Bolton*, 2006).

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References

[1] American Association of Cereal Chemists Approved Methods of the AACC. 10th edition Method 46-30, final approval 1961, reapproval 1999, The Association: St. Paul, MN (2000).

[2] M. Byers, & J. Bolton, Effects of nitrogen and sulphur fertilisers on the yield, N and S content, and amino acid composition of the grain of spring wheat. *Journal of the Science of Food and Agriculture*. 30. 3. (2006) 251–263.

[3] Z. Győri, Sulphur content of winter wheat grain in long term field experiments. *Com. in Soil Sci. and Plant Anal.*, 36. 1–3. (2005) 373–382.

[4] S. Haneklaus, E. Schnug, Baking Quality and Sulphur Content of Wheat II: Evaluation of the relative importance of genetics and environment including sulphur fertilization. *Sulphur in Agriculture*. 16. (1992) 889–892.

[5] J. L. Karmoker, D. T. Clarkson, L. R. Saker, J. M. Roney, J. V. Purves, Sulphate deprivation depresses the transport of nitrogen to the xylem and the hydraulic conductivity of barley roots. *Planta*, 185. (1991) 269–278.

[6] E. Mars, P. Sipos, Á. Tóth, Z. Győri, Quality and yield of winter wheat with sulphur content formulations. *Cer. Res. Com.*, 34. 1. (2006) 577–580.

[7] S. P. McGrath, F. Zhao, A. R. Crosland, S. E. Salmon, Sulphur status of British wheat grain and its relationship with quality parameters. *Aspects of Applied Biology*, 36. Cereal Quality III. (1993) 317–326.

[8] S. P. McGrath, F. Zhao, P. T. A. Withers, Development of sulphur deficiency in crops and its treatments. *Proc. of the Fertilizer Soc.*, 379, The Fertilizer Society, Peterborough.

[9] F. MacRitchie & R. B. Gupta, Functionality-Composition relationships of wheat flour as a result of variation in sulphur availability. *Australian Journal of Agricultural Research*, 44. 8. (1993) 1767–1774.

[10] MSZ 6367/9-1989, Lisztminták előállítása. (Milling process).

[11] H. W. Scherer, Sulphur in crop production – Invited paper. *European Journal of Agronomy*, 14. (2001) 81–111.

[12] F. T. Zhao, M. T. Hawkesford, A. G. S. Warrilow, S. P. McGrath, D. T. Clarkson, Responses of two wheat varieties to sulphur addition and diagnosis of sulphur deficiency. *Plant Soil*, 181. (1996) 317–327.

[13] F. T. Zhao, S. E. Almon, P. T. A. Withers, J. M. Monaghan, E. J. Evans, P. R. Shewry, S. P. McGrath, Variation in the bread making quality and rheological properties of wheat in relation to sulphur nutrition under field conditions. *J. Cereal Sci.*, 30. (1999) 19–31.