



## Comparative metabolic profile, antioxidant and antibacterial activities and overall quality of three lettuce (*Lactuca sativa* L.) cultivars biofortified with sulfur

Abdalla, Muna Ali<sup>1</sup>; Li, Fengjie<sup>2</sup>; Wenzel-Storjohann, Arlette<sup>2</sup>;  
Suliman, Saad<sup>1</sup>; Tasdemir, Deniz<sup>2</sup>; Mühling, Karl H.<sup>1\*</sup>

<sup>1</sup>Institute of Plant Nutrition and Soil Science, Kiel University,  
Hermann-Rodewald-Str. 1, 24118 Kiel, Germany.

<sup>2</sup>GEOMAR Centre for Marine Biotechnology (GEOMAR-Biotech),  
Research Unit Marine Natural Products Chemistry, GEOMAR  
Helmholtz Centre for Ocean Research Kiel, Am Kiel-Kanal 44, 24106  
Kiel

\*E-Mail: mabdalla@plantnutrition.uni-kiel.de and  
khmuehling@plantnutrition.uni-kiel.de

Sulfur (S) is an essential element for all living organisms. In plants, it is very important for protein synthesis, in addition to enzymes, vitamins, and chlorophyll formation. Consequently, growth, development, nutritional quality and disease tolerance or resistance can be influenced by S. The effect of sulfur on the overall quality parameters, antibacterial activity, antioxidant potential and secondary metabolites profile in hydroponically grown lettuce was assessed. Three lettuce cultivars Pazmanea RZ (green butterhead) (V1), Hawking RZ (green multi-leaf lettuce) (V2), and Barlach RZ (red multi-leaf) (V3) were subjected to two treatments 0.5 mM MgSO<sub>4</sub>·7H<sub>2</sub>O, and 0.5 mM MgCl<sub>2</sub>·6H<sub>2</sub>O in addition to the basal nutrients, which were supplied to all plants at equal proportion. Significant differences especially among V1 and V2 lettuce cultivars were noticed including yield, elemental composition, soluble sugars, organic acids, and anions. The red multi-leaf lettuce (V3) did not show any significant findings in the overall quality parameters including yield, minerals, primary and secondary metabolites concentrations between S sufficient and S deficient plants. Sixteen metabolites were determined by using HPLC-DAD-MS system such as sesquiterpene lactones, caffeoyl derivatives, caffeic acid hexose, 5-caffeoylquinic acid (5-OCQA), and flavonoids, especially quercetin and luteolin glucoside derivatives. The anthocyanin cyanidin 3-galactoside was found only in the red multi-leaf lettuce, while the sesquiterpene lactone lactucin was detected only in the butterhead lettuce (V1). The red multi-leaf lettuce (V3) was the most potent scavenger of DPPH radicals. Interestingly, both lettuce cultivars V1 and V2 biofortified with S exhibited antibacterial activity against *Staphylococcus aureus* (clinical relevance). Our study emphasizes the role of sulfur in plant growth and development. In addition, sulfur biofortified lettuce plants are promising antimicrobial prototypes for medical as well as agricultural applications.