Differential responses to copper-induced oxidative stress in the marine macroalgae Lessonia nigrescens and Scytosiphon lomentaria (Phaeophyceae)

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Abstract

In order to help explain the absence of the brown kelp *Lessonia nigrescens*from a coastal environment chronically enriched with copper, we characterized the biochemical responses induced by copper stress in this kelp and compared them with those displayed by the copper tolerant brown alga *Scytosiphon lomentaria*. These algae were cultivated with increasing concentrations of copper (20, 40 and 100 μg L^{-1}) for 96 h and the temporal production of hydrogen peroxide, superoxide anions and lipoperoxides as well as the activities of antioxidant enzymes catalase (CAT), glutathione peroxidase (GP), ascorbate peroxidase (AP), dehydroascorbate reductase (DHAR) and glutathione reductase (GR) and the activity of the defense enzyme lipoxygenase (LOX) were determined. In *L. nigrescens* and *S. lomentaria*, a single peak of hydrogen peroxide was detected, with similar maxima after 3 h of copper exposure, although in *L. nigrescens* buffering took longer. Superoxide anions, on the other hand, were only detected in *L. nigrescens*. The production of lipoperoxides in *L. nigrescens* increased steadily at higher copper levels, in a pattern clearly different to their rapid stabilization in *S. lomentaria*. We suggest that the accumulation of lipoperoxides might be related to LOX, whose activity also increases with exposure time. Furthermore, activities of the antioxidant enzymes CAT, GP, AP and DHAR were lower in *L. nigrescens* than in *S. lomentaria*, and GP and DHAR were completely inhibited at higher copper concentrations. Since these enzymes also detoxify fatty acid hydroperoxides, their inhibition, together with the activation of LOX, may explain the persistent and copper-dependent levels of lipoperoxides in *L. nigrescens*. Based on terrestrial plant models demonstrating toxic effects of lipoperoxides, and on our results on organellar ultrastructural changes, we suggest that copper toxicity induced an uncontrolled lipoperoxide accumulation which may lead to cell damage and dysfunction in *L. nigrescens*, explaining at least partially, the absence of this kelp in a copper-enriched coastal environment.