Heavy metals and the oxidative stress in some rumen bacteria

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Abstract: Effect of copper (Cu^{2+}) and chromium (Cr^{6+}) on the activity of antioxidant enzymes superoxide dismutase (SOD), glutathione peroxidase (GSHPx) and glutathione reductase was examined in the rumen bacteria: strictly anaerobic *Selenomonas ruminantium* and facultatively anaerobic *Streptococcus bovis* under the anaerobic growth conditions. Both concentrations of copper and chromium (5 or 50 $\mu g \cdot mL^{-1}$ of Cu^{2+} or Cr^{6+}, respectively) produced a significant decrease in the SOD activity in *S. bovis*. The influence of chromium on the glutathione dependent enzyme GSHPx in the bacteria investigated was different. A significant increase in the activity was seen in *S. ruminantium*, while in *S. bovis* this activity was inhibited. Increased thiobarbituric acid reactive substances, an indicator of the oxidative stress, were observed in the presence of both metals. The different changes of the antioxidant enzyme activities evoked by Cu^{2+} and Cr^{6+} in *S. ruminantium* and *S. bovis* suggest that the effect of oxidative stress proceeds differently depending on the mechanisms of toxicity and the bacterial resistance.

Key words: copper, chromium, antioxidant enzymes, *Selenomonas ruminantium*, *Streptococcus bovis*.

Abbreviations: GR, glutathione reductase; GSHPx, glutathione peroxidase; ROS, reactive oxygen species; SOD, superoxide dismutase; TBARS, thiobarbituric acid reactive substances.

Introduction

Heavy metals as important contaminants of the environment generate additional secondary reactive oxygen species (ROS) that can initiate extensive oxidative damage of cell organelles and also of both soluble and bound enzymes (Halliwel & Gutteridge, 1984). All oxygen reactions, being able to evoke DNA mutations, enzyme inactivation, membrane damage and thiols groups depletion, have to be initiated by some catalytic activating steps. In practice, all oxidation reactions proceed through the metal catalysis, most often mediated by transition metal ions. Some metals, such as Fe, Cu, Cr, and V catalyze formation of the ROS by the Fenton reaction (Fenton, 1984), whereas others like Hg, Ni, Pb, and Cd have increased affinity to thiol groups (Stohs & Bagchi, 1995). For this reason, the level of metals in cells is carefully controlled and excess amounts of their ions are sequestered, chelated, expelled or otherwise rendered harmless.

All organisms have developed efficient enzymatic and non-enzymatic mechanisms that work together to reduce the harmful effects of oxidants in the cells (Byung, 1994). The rumen bacteria can modify the heavy metal toxicity for the animal, and their antioxidant enzymes can very efficiently catalyze the decomposition of the ROS, thus forming an essential part of the defensive mechanism against the oxidative stress (Fosberg, 1978; Javorský et al., 1993). The rumen provides an anaerobic environment where both the obligatory and facultative anaerobic bacteria compete and survive. While peroxide and superoxide stress responses have been well described for some facultative aerobic prokaryotes, less is known about the response to the oxidative stress of the strictly anaerobic microorganisms (Trinh et al., 2000).

The present study was carried out in an effort to evaluate the effect of copper (Cu^{2+}) and chromium (Cr^{6+}) on the activities of three antioxidant defensive enzymes – superoxide dismutase (SOD), glutathione peroxidase (GSHPx) and glutathion reductase (GR) – in two rumen bacteria, strictly anaerobic *Selenomonas ruminantium* and facultative anaerobic *Streptococcus bovis*.

Material and methods

Chemicals

All reagents, of the highest purity, were from Sigma, Merck and Boehringer.

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