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Hydrogen peroxide mediates the oxidative inactivation of enzymes following the switch from anaerobic to aerobic metabolism in Klebsiella pneumoniae.

M Chevalier, E C Lin and R L Levine

[+] Author Affiliations

Abstract

Klebsiella pneumoniae utilizes distinct pathways for the anaerobic and aerobic metabolism of glycerol. During anaerobic growth, glycerol is first converted to dihydroxyacetone by glycerol dehydrogenase; subsequent phosphorylation yields dihydroxyacetone phosphate. During aerobic growth, glycerol is initially phosphorylated to yield glycerol 3-phosphate; subsequent reduction then gives dihydroxyacetone phosphate. A coordinated response occurs when anaerobically growing cells are switched to aerobic conditions. Synthesis of glycerol dehydrogenase is repressed, glycerol dehydrogenase is inactivated, and the protein is degraded. Ethanol dehydrogenase and propanediol oxidoreductase are also inactivated when cells are exposed to oxygen (Johnson, E. A., Levine, R. L., and Lin, E. C. C. (1985) J. Bacteriol. 164, 479-483). Exposure of anaerobically growing cells to low concentrations of hydrogen peroxide also inactivated these three enzymes and led to rapid degradation of glycerol dehydrogenase. Glycerol dehydrogenase was purified and characterized after in vivo oxidative modification initiated by hydrogen peroxide. No differences in molecular weight, amino acid composition, or Km were detected between the native and oxidatively modified forms, although the modified enzyme had only 10% of the catalytic activity of the native form. The oxidatively modified enzyme was very susceptible to degradation by subtilisin while the native enzyme was resistant. Chloramphenicol prevented the inactivation and degradation of glycerol dehydrogenase caused by exposure to oxygen but did not block that caused by hydrogen peroxide. Thus, protein synthesis appears necessary for in vivo oxidative modification caused by exposure to oxygen but is not necessary when the process is initiated by exposure to hydrogen peroxide. The newly synthesized protein(s) presumably catalyzes the production of hydrogen peroxide which is required for the metal-catalyzed oxidative modification of susceptible enzymes.

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