Suppression of Radical-Induced Lipid Peroxidation in a Model System by Alkyl Esters of Cinnamate Quaternary Ammonium Salts

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Three new groups of phenolic antioxidants, quaternary ammonium salts with a phenol ring and alkyl chains of different length (pyrrolidine ethyl esters of 3,5-di-*t*-butyl-4-hydroxy-dihydrocinnamic acid n-alkoxymethylchlorides (PYE-n) or n-alkylbromides (PYA-n) and 2-dimethylaminoethyl ester n-alkylbromides (PPA-n), were synthesized. Some of them were previously found to efficiently protect yeast cells against oxidants and to inhibit the production of thiobarbituric acid-reactive substances in whole yeast cells and in isolated membrane lipids. The new antioxidants (at 1–100 μM) abolished or diminished peroxidation of oliwe oil emulsions caused by the $OH^{\bullet}$-producing Fe^{2+} and $RO^{\bullet}$ and $ROO^{\bullet}$-producing *tert*-butylhydroperoxide (TBHP) and the azo compounds 2,2′-azobis-(amidinopropane)dihydronitrile (AAPH) and 1,1′-azobis-(1-cyclohexanecarbonitrile) (ACHN): all present at 10 mM. The efficiency of individual both antioxidants was examined in relation to the type of lipid peroxidation inducer, the site of antioxidant incorporation into the emulsion lipid phase, the length of the alkyl chain, and the maximum concentration of effective antioxidant monomers given by its critical micelle concentration. PYA-n class compounds were highly efficient against all peroxidation inducers and their efficiency did not depend on the position of their molecules in the lipid phase and/or on the aliphatic chain length. In contrast, the efficiency of PYE-n and PPA-n class compounds depended both on the type of oxidant and on the length of their aliphatic chain. Their potency against Fe^{2+} and ACHN increased with increasing alkyl chain length whereas with AAPH it dropped with increasing alkyl chain length. A similar pattern was found with the action of PYE-n against TBHP whereas in the PPA-n group an extending alkyl chain reduced the anti-TBHP efficiency. These relationships may not be entirely straightforward and other factors (chemical nature of each compound, its possible interaction with fluorescent probes used for diagnostics, etc.) may play a considerable and not yet quite clear role. PPA-n class antioxidants have the lowest critical micelle concentration, which may limit their efficiency. Nevertheless, these phenolic antioxidants can be conveniently employed as highly efficient inhibitors of lipid peroxidation.