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Workshop Papers and Authors

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Lipid Peroxidation and Plant Tissue Disorders: Introduction to the Workshop

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Among the lipid peroxidation reactions, the addition of molecular O_2 to polyunsaturated fatty acids (PUFAs) is of particular interest in biological systems. The lipoxygenase pathway is the most-studied enzymatic pathway for oxidizing PUFAs, but nonenzymatic reactions have also been characterized. When one considers the significance of lipid peroxidation, it is surprising to discover the many diverse areas that are affected. In fact, whether one considers the process beneficial or detrimental depends on the circumstances. In situations where lipid peroxidation has been implicated in tissue damage, controversy exists over whether it is involved in the primary events causing injury or merely a by-product.

Lipid peroxidation is involved with normal developmental processes, including production of flavor and odor volatiles, formation of compounds with growth-regulator-like activities, and senescence. Characteristic flavors and aromas, such as those associated with cucumber (*Cucumis sativus* L.) and tomato (*Lycopersicon esculentum* Mill.), are due in part to the presence of various enzymes in the respective lipoxygenase pathways (Gardner, 1989). Although desirable characteristics may be imparted to foods by oxidized lipids, rancidity and other off-flavors can also develop (Perkins, 1989).

Induced defenses, including the hypersensitive response associated with resistance to pathogens and herbivore defense involving proteinase inhibitors, rely in part on oxidation of PUFAs (Farmer and Ryan, 1992). These authors proposed that methyl jasmonate, formed from linolenic acid, may serve as a secondary messenger in the lipid-based signaling pathway. A direct role of aldehydes formed from PUFAs in inhibiting fungal growth also has been established (Hamilton-Kemp et al., 1992).

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Lipid peroxidation via free-radical-mediated reactions has been implicated in abiotic stresses. Evolution of ethane, a breakdown product of linolenic acid, was detected after temperature stresses (Harber and Fuchigami, 1986; Nanaiah and Anderson, 1992) and exposure to gaseous pollutants (Kimmerer and Kozlowski, 1982). Extensive peroxidation of membrane lipids may impair function and structure, possibly through the formation of gel-phase domains in the membrane (Pauls and Thompson, 1980). A similar decrease in membrane fluidity observed in senescing tissues was blocked by a lipoxygenase inhibitor (Fobel et al., 1987), but factors such as sterol content also may be important in determining membrane lipid viscosity (Duxbury et al., 1991).

Plant cells combat the formation of free radicals with antioxidants and free-radical scavengers. Leaf senescence mediated by free radicals was related to a decrease in superoxide dismutase and catalase activity (Dhindsa et al., 1981)—enzymes that detoxify superoxide and hydrogen peroxide, respectively. Purvis and Shewfelt (1993) proposed that an accumulation of stress-triggered oxidizing agents may overcome the defensive capabilities of the cell, leading to injury.

Lipid peroxidative reactions play key roles in plant responses to biotic and abiotic stresses, developmental processes, and food quality. The papers from this workshop cover many of these areas, beginning with an overview of the lipoxygenase pathway, focusing on the biochemistry and biological roles of the two branches of the lipoxygenase pathway. Presentations dealing with specific disorders are followed by a comprehensive model addressing the question of cause and effect.

Literature Cited

Dhindsa, R.S., P. Plumb-Dhindsa, and T.A. Thorpe. 1981. Leaf senescence: Correlated with increased levels of membrane permeability and lipid peroxidation, and decreased levels of superoxide dismutase and catalase. J. Expt. Bot. 32:93–101.