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Biological Role of Plant *Lipoxygenases*

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Introduction

Lipoxygenase (LOX) is an enzyme that is widely distributed in plant and animal cells. It catalyzes the oxidation of polyunsaturated fatty acids to fatty acid hydro peroxides. LOX is also involved in the production of aroma substrates, color changes, and changes in physicochemical properties. The reactions involved may or may not be desirable in food production. Understanding the properties and working principles of LOX is essential for using LOX as a natural food ingredient. Legumes are a nutritious food ingredient and also serve as an excellent source of LOX.

It is a kind of oxidoreductase which contain non-heme iron-containing protein that specifically catalyzes polyunsaturated fatty acids with cis, cis 1,4-pentadiene and produces hydrogen peroxide derivatives with conjugated double bonds by intermolecular oxygenation.LOX substrates in plants are mainly linoleic acid and linolenic acid. Arachidonic acid is the major substrate of LOX in animal cells.

Structure of LOX

LOX is typically formed by nonheme iron and a large protein structure. Plant LOX is a one-chain monomer enzyme with a molecular weight of 90–110 kDa. It is formed by two different protein domains. N-terminal region is approximately 25–30 kDa and consists of a betabarrel domain. The function of N-terminal region is unclear. The C-terminal is formed by α helix with a molecular weight of 55–65 kDa. The C-terminal of the enzyme contains a catalytic domain. 9-LOX is a non-heme, iron-containing enzyme with a single polypeptide chain having approximately 741–886 amino acids. 13-LOX is a non-heme, iron-containing single polypeptide composed of approximately 896–941 amino acids (Joo and Oh 2012).

Biological function of LOX

Food applications

The use LOXs in food applications is important and considerable in various aspects. LOX catalyzed lipid oxidation depending on type of food which may be considered as beneficial and harmful. In cereals this may lead to off-flavors formation in the final product. These can also produce nootkatone (grapefruit flavor used in food applications and cosmetics) using soyabean. One of the main commercial applications is co-oxidation of carotenoid pigments in cereal flour. LOXs also play a good role in bread and dairy industry.

Lipoxygenase is used in flour to oxidize flour pigments and whiten flour products. Lipoxygenase oxidizes unsaturated fatty acids to form peroxides, which oxidize the sulfhydryl groups of protein molecules to form disulfide bonds, thereby increasing gluten starch. LOX catalyzes the oxidation of polyunsaturated fatty acids to produce hydroperoxides. It is a compound that forms fruit flavors such as apples, melons and mangoes, and volatile flavors such as fresh fish, oysters, seaweed and overgrown grass. In addition to many fragrance compounds, lipoxygenase can also be used as an intermediate in industrial production of dyes, coatings, detergents, polyvinyl chloride plasticizers, and drug synthesis.

In Abiotic Stress

Few studies have been carried out in plants to establish the role of LOX during abiotic stress. The CaLOX1 plays a crucial role in osmotic, high salinity and drought stress responses through decreased accumulation of H_2O_2, lipid peroxidation. LOXs are present in the seeds, act as vegetative storage proteins (VSPs) and play an important role during seed maturation and seedling growth. During germination, lipids are mobilized by a different set of LOXs. A major LOX L-4 appeared in soybean cotyledons after germination and produced both 13S-HPOD and 9(S)- hydroperoxy-10(E), 12(Z)-octadecadienoic acid from LA (Han *et al.*, 2013).The LOX-derived hydroperoxides and oxylipins have been involved in the local and systemic response to wounding stress.

Numerous studies have specified that a rise in LOX activity is a common feature of senescing plant tissues. During senescence, a LOX activity level were raised and causes the production of superoxide radicals. It leads to an increase in lipid peroxidation levels. These studies proposed that LOX is the key regulator of lipid peroxidation and may contribute to membrane damage during senescence. (Ahmad and Tahir 2018).

In Biotic Stress

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For biting–chewing herbivores, the LOX pathway has been proposed to play a key role in plant defense via major oxylipins such as 12-OPDA by the action of 13-LOXs, 10-OPDA, a positional isomer of 12-OPDA, and 10-oxo-11-phytoenoic acid (10-OPEA) by the action 9-LOXs (Crozier *et al.* 2000).The LOX family is diverse and isozymes often differ in terms of activity, substrate specificity, and product formation, even in the same organism. LOXs and their oxidation products of PUFAs play a major role in metabolism in plants and have an effect on their growth and development and tolerance to biotic and abiotic stresses.

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