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**Kwi-Sik Bae, Shadi Rahimi, Yu-Jin Kim, Balusamy Sri Renuka Devi, Altanzul Khorolragchaa, Johan Sukweenadhi, Jeniffer Silva, et al.**

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# Molecular characterization of lipoxygenase genes and their expression analysis against biotic and abiotic stresses in *Panax ginseng*

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**Abstract** Lipoxygenase (LOX) belongs to a family of non-heme-iron-containing fatty acid dioxygenases that are widely distributed in plants and animals. LOX involved in the synthesis of jasmonic acid and six-carbon (C6) volatiles which is necessary for plant growth and responses to a wide range of biotic and abiotic stresses. We have isolated and characterized LOX cDNA clones from *Panax ginseng* Meyer. From their deduced amino acid sequences, two diverse classes of 9-LOX (LOX1, LOX2, and LOX3) and 13-LOX (LOX4, LOX5) are defined in *P. ginseng*. A GenBank Blast X search revealed that the deduced amino acid of *PgLOXs* share a high degree of homology with LOX from other plants and mammals especially in three distinct motifs; motif1 harboring iron binding regions, motif2 and motif3.

Kwi-Sik Bae and Shadi Rahimi contributed equally to this work.

**Electronic supplementary material** The online version of this article (doi:10.1007/s10658-015-0847-9) contains supplementary material, which is available to authorized users.

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Chloroplast localization was predicted for *PgLOX5*. *PgLOXs* displayed organ-specific expression, highly expressed in aerial parts of the plant such as 3-year old flower, stem and leaf tissues. *PgLOXs* mRNAs were elevated strongly by bacterial infection. Expression of *PgLOXs* was differentially induced in ginseng not only by mechanical damage and methyl jasmonate but also after exposure to withholding water. Ginseng 13-LOXs positively respond to wounding that may involve in production of C6 volatiles and jasmonic acid at the wounded sites. However, the higher expression of *PgLOX3* by water deficit and 82 % of the nucleotide sequence identity with the EST from severe drought-stressed leaves of *Populus* (CU229089.1) at +6371 bp downstream of *PgLOX3* genomic DNA structure can suggest drought tolerance role for *PgLOX3*. Ginseng LOX genes have different expression pattern which may suggest different specific function against various environmental stresses.

**Keywords** Abiotic stress · Biotic stress · Gene expression · Jasmonic acid · Lipoxygenase · *Panax ginseng*

## Abbreviations

AOC	allene oxide cyclase
AOS	allene oxide synthase
EST	expressed sequence tag
HPL	hydroperoxide lyase
13-HPOD	(13S)-hydroperoxyoctadecadienoic acid
9-HPOD	(9S)-hydroperoxyoctadecadienoic acid
IBA	indole-3-butyric acid