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RESEARCH PAPER

PgLOX6 encoding a lipoxygenase contributes to jasmonic acid biosynthesis and ginsenoside production in *Panax ginseng*

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Abstract

Ginsenosides, the valuable pharmaceutical compounds in *Panax ginseng*, are triterpene saponins that occur mainly in ginseng plants. It was shown that *in vitro* treatment with the phytohormone jasmonic acid (JA) is able to increase ginsenoside production in ginseng plants. To understand the molecular link between JA biosynthesis and ginsenoside biosynthesis, we identified a JA biosynthetic 13-lipoxygenase gene (*PgLOX6*) in *P. ginseng* that promotes ginsenoside production. The expression of *PgLOX6* was high in vascular bundles, which corresponds with expression of ginsenoside biosynthetic genes. Consistent with the role of *PgLOX6* in synthesizing JA and promoting ginsenoside synthesis, transgenic plants overexpressing *PgLOX6* in Arabidopsis had increased amounts of JA and methyl jasmonate (MJ), increased expression of triterpene biosynthetic genes such as *squalene synthase* (*AtSS1*) and *squalene epoxidase* (*AtSE1*), and increased squalene content. Moreover, transgenic ginseng roots overexpressing *PgLOX6* had around 1.4-fold increased ginsenoside content and upregulation of ginsenoside biosynthesis-related genes including *PgSS1*, *PgSE1*, and *dammarenediol synthase* (*PgDDS*), which is similar to that of treatment with MJ. However, MJ treatment of transgenic ginseng significantly enhanced JA and MJ, associated with a 2.8-fold increase of ginsenoside content compared with the non-treated, non-transgenic control plant, which was 1.4 times higher than the MJ treatment effect on non-transgenic plants. These results demonstrate that *PgLOX6* is responsible for the biosynthesis of JA and promotion of the production of triterpenoid saponin through up-regulating the expression of ginsenoside biosynthetic genes. This work provides insight into the role of JA in biosynthesizing secondary metabolites and provides a molecular tool for increasing ginsenoside production.

Key words: Ginsenoside, jasmonic acid, lipoxygenase, *Panax ginseng*, squalene, secondary metabolite, triterpene, vascular bundles.

Introduction

Panax belongs to the family Araliaceae and contains at least 17 species (Kim *et al.*, 2015). Since ancient time, *Panax ginseng* (known as Korean or Asian ginseng) has been considered as a healing drug and health tonic in China, Japan, and other Asian countries (Radad *et al.*, 2006). The pharmacological effects of ginseng are correlated with ginsenosides, bioactive