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Research article

Accumulation characteristics and correlation analysis of five ginsenosides with different cultivation ages from different regions

Dan Xiao [1,2,3], Hao Yue [3], Yang Xiu [3], Xiuli Sun [3], YiBo Wang [3], ShuYing Liu [1,3,*]

[1] Changchun Center of Mass Spectrometry, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, 5625 Renmin Street, Changchun 130022, China
[2] Changchun University of Technology, 2055 Yan'an Street, Changchun 130000, China
[3] Jilin Ginseng Academy, Changchun University of Chinese Medicine, 1035 Boshuo Street, Changchun 130117, China

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ABSTRACT

Background: Ginseng (the roots of *Panax ginseng* Meyer) is a well-known traditional Oriental medicine and is now widely used as a health food. It contains several types of ginsenosides, which are considered the major active medicinal components of ginseng. It has recently been reported that the qualitative and quantitative properties of ginsenosides found in ginseng may differ, depending on cultivation regions, ages, species, and so on. Therefore, it is necessary to study these variations with respect to cultivation ages and regions.

Methods: In this study, 3–6-yr-old roots of *P. ginseng* were collected from three different cultivation regions. The contents of five ginsenosides (Rb1, Rd, Rc, Re, and Rgl) were measured by rapid resolution liquid chromatography coupled with quadruple–time-of-flight mass spectrometry. The Kruskal–Wallis Rank sum test and multiple *t* test were used for comparative analysis of the data to evaluate the dynamic changes in the accumulation of these ginsenosides affected by cultivation regions and ages.

Results: The content and composition of ginsenosides varied significantly among specimens collected from different cultivation regions and having different cultivation ages. For all samples, the content of Rg1 and Re ginsenosides increases with age and this rate of increase is different for each sample. The contents of Rb1, Rc, and Rd varied with cultivation ages in samples from different cultivation regions; especially, Rb1 from a 6-yr-old root showed approximately twofold variation among the samples from three cultivation regions. Furthermore, the content of Rb1 highly correlated with that of Rd ($r = 0.89$ across all locations and ages).

Conclusion: In our study, only the contents of ginsenosides Rg1 and Re were affected by the root age. Ginsenosides Rb1, Rc, and Rd varied widely with ages in samples from different cultivation regions.

1. Introduction

Ginseng (the roots of *Panax ginseng* Meyer) is a valuable agricultural commodity used for thousands of years as a traditional Oriental medicine in many Oriental countries [1]. *P. ginseng* has wide pharmacological properties, such as antifatigue, antidiabetes, vasodilation, and antidepressant effects, and is effective in stimulating the memory as well as in the prevention of cancer and the aging process [2]. Ginsenosides are the main active constituents in *P. ginseng*. To date, more than 80 kinds of ginsenosides have been isolated from *P. ginseng*. Based on the differences in their chemical constitutions, most ginsenosides are generally classified into the following three types: protopanaxadiol (PPD), protopanaxatriol, and oleanolic acid [3]. The main ginsenosides isolated from *P. ginseng* (Rb1, Rc, Rd, Re, and Rg1) typically account for more than 70% of the total ginsenoside content [4–8]. These ginsenosides are often used as markers for quality assessment of ginseng products [9]. However, the bioactive properties of ginsenosides differ with

* Corresponding author. Changchun Center of Mass Spectrometry, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, 5625 Renmin Street, Changchun 130022, China.
E-mail address: syliu@ciac.jl.cn (S.Y. Liu).

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respect to individual ginsenoside and biological system [10]. American and Asian ginsengs have contradictory effects on the vascular system [11] and acute glycemia [12]. Recent laboratory studies have verified that the different bioactivities are due to the variation in the ratio of major ginsenosides. Mochizuki et al reported that Asian ginseng had a high Rg1:Rb1 ginsenoside ratio and Rg1 was shown to promote wound healing. By contrast, American ginseng had a low Rg1:Rb1 ratio and Rb1 was shown to inhibit tumor growth [13]. The heterogeneity of ginsenosides is a remarkable and significant property because this has different or even totally opposite pharmacological activities. The changes in the content of ginsenosides with age are related to the cultivation region of ginseng; for example, Osinski et al [14] determined and compared the major ginsenosides in American ginseng root, which showed changes based on cultivation region and age. Zhang Kun et al [15] demonstrated that the content of ginsenosides Rg1, Re, Rbl, Rc, Rb2, Rb3, and Rd in ginseng increased with the age of the plant.

Variations in the content of total and individual ginsenosides have been reported between populations and even among individual roots within a single ginseng population [16]. Because the efficacy and bioactive components of ginseng roots may differ depending on the cultivation region and age, it is important to know the components of ginsenosides in ginseng roots from different sources. The study on the variation of the main ginsenosides in ginseng could lead to a better understanding of the natural effects on ginsenosides contributed by cultivation regions and age. Moreover, the results of this research have potential contribution to quality assessment of ginseng products.

In this study, we used rapid resolution liquid chromatography coupled with quadruple–time-of-flight mass spectrometry method for the acquisition and analysis of the accumulation characteristics of monomer ginsenosides (Rb1, Rc, Rd, Re, and Rg1) in ginseng roots aged between 3 yr and 6 yr and from different cultivation regions. The objective of this research was to determine the relative contribution of age or location to the ginsenoside levels in *P. ginseng* collected from a geographically limited region.

2. Experimental analysis

2.1. Standard preparation

All ginsenoside standards were obtained from the Chinese Medical and Biological Products Institute (Changchun, China). The standards of ginsenosides Rg1, Re, Rb1, Rc, and Rd (1.01 mg, 1.02 mg,

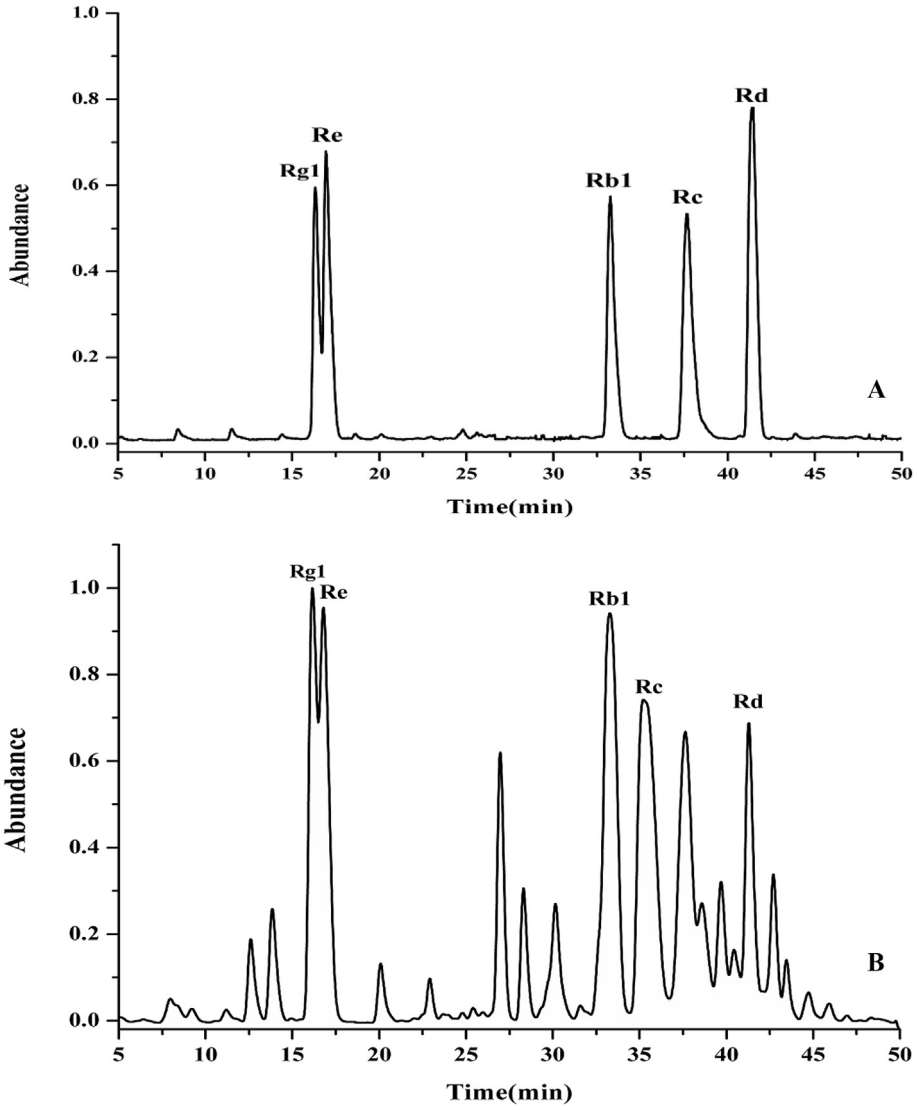

Fig. 1. Rapid resolution liquid chromatography coupled with electrospray ionization quadruple–time-of-flight mass spectrometry total ion chromatograms of (A) ginsenoside standard mixture and (B) alcohol extracts from the ginseng roots cultivated in Changchun. The five ginsenosides were identified by the retention time and qualitative fragments.